Министерство образования Республики Беларусь

БЕЛОРУССКИЙ НАЦИОНАЛЬНЫЙ ТЕХНИЧЕСКИЙ

УНИВЕРСИТЕТ

Кафедра «Английский язык №2»

В.А. Радиевская

Л.А. Парменова

МОСТЫ. ТОННЕЛИ

пособие по английскому языку

Минск 2007

УДК
ББК

Рецензенты

кандидат филологических наук, заведующая кафедры иностранных языков БНТУ, доцент *Васильева Т.И.*;

кандидат филологических наук, доцент кафедры английского языка № 2 БНТУ *Колосова Т.В.*

Настоящее учебное пособие является частью учебно-методического комплекса по английскому языку. Основу пособия составляют 8 разделов, построенных по единому принципу. Особое внимание отводится изучению специальной терминологии и развитию умений составления реферата.

Основная цель пособия—развить навыки устной и письменной речи по специальности.

Данное учебное пособие предназначено для студентов второго курса БНТУ по специальности «Строительство мостов и тоннелей», а также для всех, кто стремится совершенствовать навыки общения на английском языке.

Unit 1: THE HISTORY OF BRIDGE BUILDING

Lead-in

1. What is a bridge? How can you describe it?
2. What obstacles are usual to cross?
3. How long can bridges be?

Find the following terms and memorize their meaning.

bridge	cantilever
cross	suspension
obstacle	drawbridge
highway	expand
waterways	truss
range	reinforced concrete
resist	slab
roadway	cofferdam
span	design
abutments	clapper bridge
pier	rock foundations
single-span bridges	tension
multi-span bridges	pointed arch
pontoon bridge	thrust
performance	obstructions
efficiency	rib
logs	load

Text 1: Bridge

Bridge is a structure used by people and vehicles to cross areas that are obstacles to travel. Engineers build bridges over lakes, rivers, canyons, and busy highways and railroad tracks. Without bridges, people would need boats to cross waterways and would have to travel around such obstacles as canyons and ravines.

Bridges range in length from a few feet or meters to several miles or kilometers. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. It also must resist natural occurrences, including earthquakes, strong winds, and changes in temperature. Most modern bridges have a concrete, steel, or wood framework and an asphalt or concrete *roadway.* The roadway is the part of a bridge on which people and vehicles travel.

Most bridges are held up by at least two supports set in the ground. The distance between two adjacent supports is called a *span* of a bridge. The supports at each end of the bridge are called *abutments,* and the supports that stand between the abutments are called *piers.* The total length of the bridge is the distance between the abutments. Most short bridges are supported only by abutments and are known as *single-span bridges.* Bridges that have one or more piers in addition to the abutments are called *multi-span bridges.* Most long bridges are multi-span bridges. The *main span* is the longest span of a multi-span bridge.

The prototypical bridge is quite simple—two supports holding up a beam—yet the engineering problems that must be overcome even in this simple form are inherent in every bridge: the supports must be strong enough to hold the structure up, and the span between supports must be strong enough to carry the loads. Spans are generally made as short as possible; long spans are justified where good foundations are limited—for example, over estuaries with deep water. A *pontoon bridge* has no piers or abutments. It is supported *by pontoons* (flat-bottomed boats) or other portable floats.

Some special types of bridges are defined according to their function. An overpass allows one transportation route, such as a highway or railroad line, to cross over another without traffic interference between the two routes. The overpass elevates one route to provide clearance to traffic on the lower level. An aqueduct transports water. Aqueducts have historically been used to supply drinking water to densely populated areas. A viaduct carries a railroad or highway over a land obstruction, such as a valley.

All major bridges are built with the public's money. Therefore, bridge design that best serves the public interest has a threefold goal: to be as efficient, as economical, and as elegant as is safely possible. Efficiency is a scientific principle that puts a value on reducing materials while increasing performance. Economy is a social principle that puts value on reducing the costs of construction and maintenance while retaining efficiency. Finally, elegance is a symbolic or visual principle that puts value on the personal expression of the designer without compromising performance or economy. There is little disagreement over what constitutes efficiency and economy, but the definition of elegance has always been controversial.

Modern designers have written about elegance or aesthetics since the early 19th century, beginning with the Scottish engineer Thomas Telford. Bridges ultimately belong to the general public, which is the final arbiter of this issue, but in general there are three positions taken by professionals.

The first principle holds that the structure of a bridge is the province of the engineer and that beauty is achieved only by architecture.

The second idea insists that bridges making the most efficient possible use of materials are by definition beautiful.

The third case holds that architecture is not needed but that engineers must think about how to make the structure beautiful. This last principle recognizes the fact that engineers have many possible choices of roughly equal efficiency and economy and can therefore express their own aesthetic ideas without adding significantly to materials or cost.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Bridge is a structure used by people and vehicles to facilitate traveling.
2. To build a long bridge is very difficult and expensive, so a majority of bridges nowadays don’t range in length more than some hundred meters.
3. Single-span bridges are supported only by two abutments.
4. The main span in the multi-span bridge is the shortest one carrying the main load.
5. Aqueducts were used to provide people with drinking water.
6. Efficiency of a bridge is a scientific principle that takes into account the quantity of people and vehicles passing along the bridge.
7. The definition of elegance is not disputable.

II. Answer the questions:

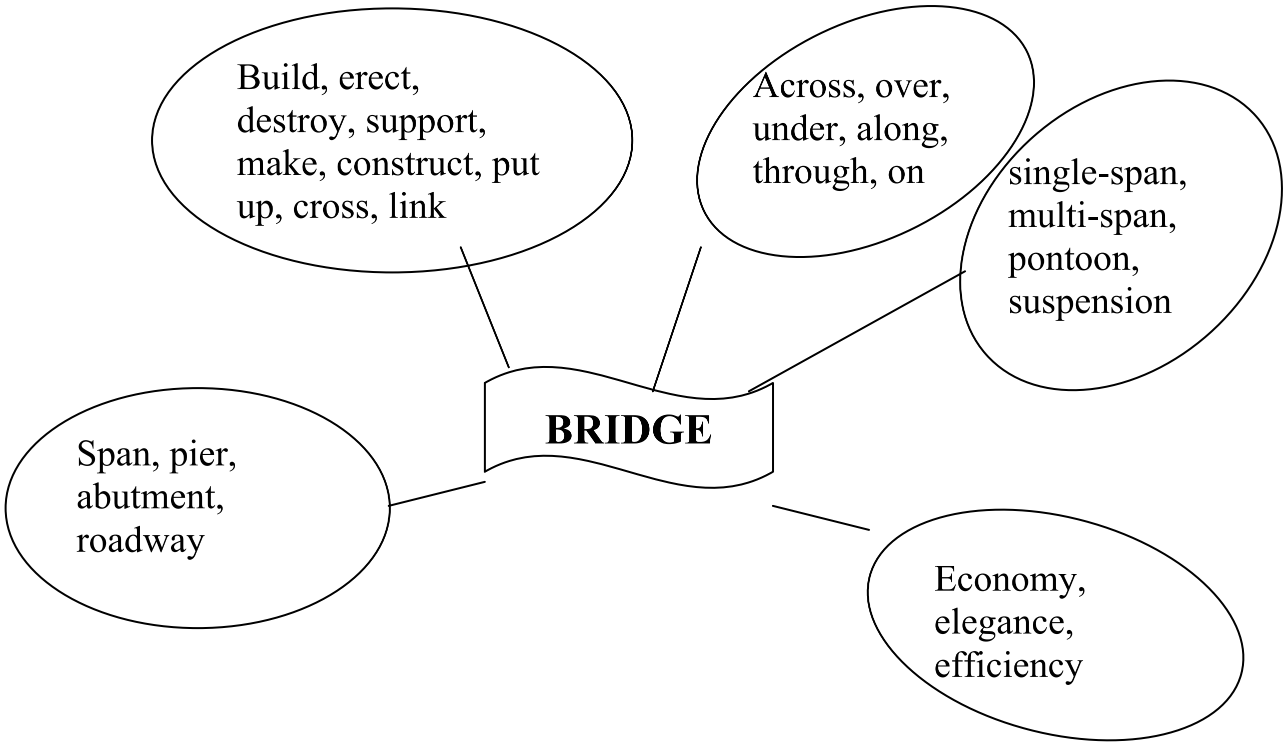
1. What is a purpose of a bridge?
2. What is the difference between abutments and piers?
3. Why are spans made as short as possible?
4. What types of bridges according to their function can you name?
5. What do you know about a threefold goal of bridge design?
6. Describe three positions in bridge building taken by professionals.

LANGUAGE FOCUS

III. What definition of a bridge is correct?

1. a way with a prepared surface, for vehicles, pedestrians, etc.
2. place for crossing a street, water etc.
3. a structure providing a way across a river, road, railway, etc.
4. underground passage dug through a hill or under a road, river, etc.

IV. Make the collocations with the word *bridge* using the words in ovals and put them into the sentences below. With the rest not used make your own sentences:



1. Bridge is a structure to …
2. A part of a bridge intended to vehicles and pedestrians is called…
3. We can describe … as an each part of a bridge between supports (that are also called as …)
4. According to the quantity of abutments and piers bridges can be … and …
5. A bridge without any abutments or piers is called …
6. A threefold goal to be taken into account while building a bridge is …
7. The road goes … the old railway bridge.

8. The new bridge will … the Thames at this point.
9. Can you see that pontoon bridge … the river?
10. Three positions taken by professionals in bridge building are …
11. The types of the bridge are …, …, … .
12. … means reducing the costs of construction and maintenance.
13. … is putting a value on reducing materials

V. Make the following sentences shorter replacing a set of words with one:

Bridges have always been used by people. They have to be strong and long enough. They also must *withstand the action or effect of* natural occurrences. Most bridges are held up by *supports at each end of the bridge* set in the ground. Some bridges have also *the supports that stand between the abutments*. We can say that there *are bridges supported only by abutments* (most short bridges) and *bridges having one or more piers in addition to the abutments* (*the longest span* of such bridges can be quite long). There is also *a bridge with no piers or abutments.* While building a bridge engineers discuss *the principle that puts a value on reducing materials* and *the principle that puts value on reducing the costs of construction and maintenance. The principle that puts value on the personal expression of the designer* is indisputable.

VI. Choose the following role and make a small report covering the problem mentioned:

- you are a chief engineer and you have to discuss with your team a goal of building a bridge
- you are a modern designer who insists on the principle that beauty is achieved only by architecture, you should promote your ideas to public
- you are a modern designer who insists on the principle bridges making the most efficient use of materials are by definition beautiful
- you are an engineer who thinks that architecture is not needed but that engineers must think about how to make the structure beautiful
- you are a university teacher and you have to make an introduction into speciality of bridge building (you may use the blackboard or cards if necessary)

VII. Write key words of the text so that you can give the main information about bridges.

Text 2: The History of Bridge Building (General Information)

Lead-in

1. How long have people use such a structure as bridge?
2. What materials served as first bridges?

Logs or vines that extended across streams probably served as the first bridges. From this at a later stage, a bridge on a very simple bracket or cantilever principle was evolved. Timber beams were embedded into the banks on each side of the river with their ends extending over the water. These made simple supports for a central beam reaching across from one bracket to the other. Bridges of this type are still used in Japan, and in India. A simple bridge on the suspension principle was made by early man by means of ropes, and is still used in countries such as Tibet. Two parallel ropes suspended from rocks or trees on each bank of the river, with a platform of woven mats laid across them made a secure crossing. Further ropes as handrails were added. When the Spaniards reached South America, they found that the Incas of Peru used suspension bridges made of six strong cables, four of which supported a platform and two served as rails.

The first bridge known to historians was an arch bridge built in Babylon about 2200 B.C. The ancient Chinese, Egyptians, Greeks, and Romans also built arch bridges, using bricks and stone as building materials.

During the Middle Ages, moveable bridges called drawbridges were built across the moats of many castles in Europe. Truss bridges were developed in the 1500’s. Most bridges were made of stone or wood until the late 1700's, when cast iron and wrought iron were first used for bridges. Many suspension bridges that hung from wrought iron chains were built in the early 1800's. Between 1830 and 1880, as railroad building expanded throughout the world, bridge design and construction were aimed to carry these heavy vehicles over new obstacles.

Designers experimented with a wide variety of bridge types and had to meet the demand for greater heights, spans, and strength. Locomotives were heavier and moved faster than anything requiring stronger bridges. The basic beam bridge was strengthened by adding support piers underneath and by reinforcing the structure with elaborate scaffolding called a truss. During the period of railroad expansion iron trusses replaced stone arches as the preferred design large bridges.

The first plate girder bridge was completed in 1847, and the modern cantilever bridge was introduced about 1870. In the late 1800s, steel became the chief material used in bridge construction.

In 1855 British inventor Sir Henry Bessemer developed a practical process for converting cast iron into steel. This process increased the availability of steel and lowered production costs considerably. The strength and lightness of steel revolutionized bridge building. In the late 19th century and the first half of the 20th century, many large-scale steel suspension bridges were constructed over major waterways in the late 19th century, engineers began to experiment with concrete reinforced with steel bars for added strength. More recently, reinforced concrete has been combined with steel girders, which are solid beams that extend across a span. When the Interstate Highway System in the United States and similar road systems in other countries were constructed in the mid- to late 20th century, the steel-and-concrete girder bridge was one of the most commonly used bridge designs. The last three decades of the 20th century saw a period of large-scale bridge building in Europe and Asia. Current research focuses on using computers, instrumentation, automation, and new materials to improve bridge design, construction, and maintenance.

COMPREHENSION CHECK

I. What can it be?

Cnosurtcniot, ceniveratl, beidgr, grried, tsrsu, peri, snespsionu

II. Decide whether the following statements are true or false according to the text:

1. Logs or vines across streams served as the first bridges.
2. A bridge on the suspension principle was made by people in the Middle Ages by means of handrails.
3. The Incas of Peru used beam bridges made of six strong cables.
3. An arch bridge is known to be the first bridge.
4. Another name for a drawbridge is a cantilever bridge.
5. Designers of the 19^{th} century had to meet the demand for greater heights, spans, and strength.
6. Railroads expansion made iron trusses be replaced by stone arches.

7. Since late 1800s reinforced concrete has been chiefly used in bridge construction.
8. A steel-and-concrete girder bridge was one of the most commonly used bridge designs in the 20th century.

III. Answer the following questions:

1. What are the earliest types of bridges?
2. What periods in bridge construction can you distinguish?
3. What is the principle of a suspension bridge?
4. How can you explain the fact that drawbridges were mainly built in the Middle Ages?
5. What was the reason of adding additional support to a basic beam bridge in the 19th century?
6. What was Sir Henry Bessemer famous for? In what way did his invention develop bridge construction?
7. When did large-scale bridge building start? What are the reasons?
8. What does current research focus on?

LANGUAGE FOCUS

IV. Match the meanings of these terms with their definition:

drawbridge	*suspension bridge*		*pier*
obstacle	*steel*	*bridge girder*	*log*

1. unhewn piece of a felled tree; any large rough piece of wood
2. a structure providing a way across a river, road, railway, etc.
3. iron or steel beam or compound structure for bridge-building etc.
4. hinged retractable bridge, esp. over a moat.
5. bridge with a roadway suspended from cables supported by towers
6. strong malleable alloy of iron and carbon
7. a support of an arch or of the span of a bridge; pillar
8. thing that obstructs progress, stands in the way

V. Match the period with the description:

1. many large-scale steel suspension bridges were constructed over major waterways 2. drawbridges were built across the moats of many castles in Europe 3. arch bridges were built of bricks and stone as building materials. 4. bridge design and construction were aimed to carry these heavy vehicles over new obstacles 5. a practical process for converting cast iron into steel was developed 6. period of large-scale bridge building in Europe and Asia	1. the 20^{th} century 2. ancient Rome 3. between 1830 and 1880 4. the second half of the 19^{th} century 5. late 19^{th} 6. the Middle Ages

VI. Can you decipher the message?

L..s that extended across streams probably served as the first b…..s. That was a c……..r bridge. A simple bridge on the s……..n principle was made by early man by m…s of ropes. A platform of w…n mats was laid across ropes to make a secure c……g. The first bridge k…n to historians was an a..h b….e built in Babylon about … . Romans used b….s and s…e as building materials.

During the M….e Ages, m……e bridges called d………s were built. In the 1500's t…s bridges were d…….d.

During the period of railroad e…….n iron trusses r……d stone a….s. In the late 1800s, s…l became the chief m……l used in bridge c……….n. This s….g and l…t material revolutionized bridge b……g.

In the 20^{th} c…..y the steel-and-c……e g….r bridge was one of the most commonly u..d bridge d…..s. New materials are being looked for to i…..e bridge design, construction, and m………e.

VII. Make the word combinations using the derivatives from the words in brackets:

(strong) of the material, bridge (construct), (suspend) bridges, (available) of steel, to be (embed) into the banks, (addition) support, ropes (suspend) from rocks, elaborate (scaffold), period of railroad (expand), to cost (consider), one of the most (common) used, concrete (reinforce) with steel bars.

VIII. Find the synonyms to the words in italics:

Wood beams were *set* into the banks on each side of the river. Moveable bridges called drawbridges were *constructed* across the *ditches* of many castles in Europe. Truss bridges were *made* in the 1500's. The basic *girder* bridge was *made stronger* by adding support piers underneath and by *intensifying* the structure with elaborate *falsework* called a truss. As *railway* building expanded *all over* the world, bridge design and *building* were aimed to carry these heavy vehicles over new *obstructions*.

IX. Find key-words in the text to give general information about the history of bridge construction. How many of them do you need?

X. Make a short summary of the text.

Text 3: The ancient world

Lead-in

1. What civilizations can you recollect as the ancient world?
2. What materials were the first to be used in bridge construction?
3. What were the first types or kinds of bridges?

Read the text bellow to grasp the main information.

Beam bridges.

The first bridges were simply supported by beams, such as flat stones or tree trunks laid across a stream.

For valleys and other wider channels—especially in East Asia and South America, where examples can still be found—ropes made of various grasses and vines tied together were hung in suspension for single-file crossing.

Materials were free and abundant, and there were few labour costs, since the work was done by slaves, soldiers, or natives who used the bridges in daily life.

Some of the earliest known bridges are called clapper bridges (from Latin *claperius,* "pile of stones"). These bridges were built with long, thin slabs of stone to make a beam-type deck and with large rocks or blocklike piles of stones for piers. Postbridge in Devon, Eng., an early medieval clapper bridge, is an oft-visited example of this old type, which was common in much of the world, especially China.

Roman arch bridges.

The Romans began organized bridge building to help their military campaigns. Engineers and skilled workmen formed guilds that were dispatched throughout the empire, and these guilds spread and exchanged building ideas and principles. The Romans also discovered a natural cement, called pozzolana, which they used for piers in rivers. Roman bridges are famous for using the circular arch form, which allowed for spans much longer than stone beams and for bridges of more permanence than wood. Where several arches were necessary for longer bridges, the building of strong piers was critical. This was a problem when the piers could not be built on rock, as in a wide river with a soft bed. To solve this dilemma, the Romans developed the cofferdam, a temporary enclosure made from wooden piles driven into the riverbed to make a sheath, which was often sealed with clay. Concrete was then poured into the water within the ring of piles. Although most surviving Roman bridges were built on rock, the Sant'Angelo Bridge in Rome stands on cofferdam foundations built in the Tiber River more than 1,800 years ago.

Ponte Saint-Martin (c 25 BC) near Torino (Italy). *Shunsuke Baba, photographer*

Asian cantilever and arch bridges.

In Asia, wooden cantilever bridges were popular. The basic design used piles driven into the riverbed and old boats filled with stones sunk between them to make cofferdam-like foundations. When the highest of the stone-filled boats reached above the low-water level, layers of logs were crisscrossed in such a way that, as they rose in height, they jutted farther out toward the adjacent piers. At the top, the Y-shaped, cantilevering piers were joined by long tree trunks. By crisscrossing the logs, the builders allowed water to pass through the piers, offering less resistance to floods than with a solid design. In this respect, these designs presaged some of the advantages of the early iron bridges.

In parts of China many bridges had to stand in the spongy silt of river valleys. As these bridges were subject to an unpredictable assortment of tension and compression, the Chinese created a flexible masonry-arch bridge. Using thin, curved slabs of stone, the bridges yielded to considerable deformation before failure.

COMPREHENSION CHECK

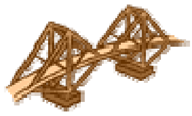
I. Decide whether the following statements are true or false according to the text:

1. The first bridges were upheld by arches, such as flat stones or tree trunks laid across a stream.
2. Materials to construct first bridges were available and ample.
3. Clapper bridges were built with long slabs of stone and with rocks or blocklike piles of stones.
4. Bridge construction work in the Roman Empire was done by slaves, soldiers, or natives, so labour costs were few.
5. Circular arch form used by the Romans served to make spans much longer than stone beams.
6. The Romans developed the cofferdam allowing piers to be built on rocks.
7. Crisscrossing of the logs helped to reach adjacent piers.
8. Old boats filled with stones were used as cofferdam-like foundations.

II. Answer the following questions:

1. What are the main types of bridges in the ancient world?
2. What was the principle of a simple beam bridge?
3. What is a clapper bridge?
4. The Romans developed bridge construction. In what way?
5. What was the purpose of the cofferdam? The construction of what type of bridges requires the cofferdam?
6. What is the basic design of a cantilever bridge in the Ancient Asia?

III. Define the type of the bridge:



a) beam
b) cantilever
c) arch

a) beam
b) cantilever
c) arch

a) beam
b) cantilever
c) arch

LANGUAGE FOCUS

IV. Match the meanings of these terms with their definition:

1. beam	1. flat thick esp. rectangular piece of solid material, esp. stone
2. slab	2. place where things cross.
3. crossing	3. long sturdy piece of squared timber or metal
4. pier	4. watertight enclosure pumped dry to permit work below the waterline, e.g. building bridges
5. cofferdam	5. a preliminary plan or sketch for making something
6. adjacent	6. a support of an arch or of the span of a bridge
7. design	7. lying near; adjoining

V. Fill in the correct prepositions:

for, than, with, of, into, across, of, in, by, on, through, in, into

To be supported … beams, to be poured … the water, to be laid … a stream, to be constructed … long slabs … stone, to rise … height, to be hung … suspension … single-file crossing, to be … more permanence … wood, to pass … the piers, to be built … rock, to be driven … the riverbed

VI. Read the text and say what following words are key ones in each part consequently:

1. Beam, trunk, stones, channels, ropes, suspension, clapper bridges, few labour costs, single-file crossing

2. Military campaigns, pozzolana, circular arch form, strong piers, bridges of more permanence, the cofferdam, engineers and skilled workmen, guilds

3. Wooden cantilever bridges, old boats filled with stones, iron bridges, layers of logs, less resistance to floods, masonry-arch bridge, failure

VII. Using the key words describe three ancient types of bridges.

VIII. Complete the following table:

№	The period and the country	Type of the bridge	Materials used	Difficulties
1.		Beam bridge		
2.			stones	
3.	Ancient Asia			

Text 4: The Middle Ages and The Renaissance

Lead-in

1. What kinds of bridges were in the Ancient World?

2. What are the purposes of bridges in the Middle Ages? Were they still the same?

3. What countries in the Middle Ages and the Renaissance were first to develop bridge building?

After the fall of the Roman Empire, progress in European bridge building slowed considerably until the Renaissance. Fine bridges sporadically appeared, however. Medieval bridges are particularly noted for the ogival, or pointed arch. With the pointed arch the tendency to sag at the crown is less dangerous, and there is less horizontal thrust at the abutments. Medieval bridges served many purposes. Chapels and shops were commonly built on them, and many were fortified with towers and ramparts. Some featured a drawbridge, a medieval innovation. The most famous bridge of that age was Old London Bridge, begun in the late 12th century under the direction of a priest, Peter of Colechurch, and completed in 1209, four years after his death. London Bridge was designed to have 19 pointed arches, each with a 24-foot span and resting on piers 20 feet wide. There were obstructions encountered in building the cofferdams, however, so that the arch spans eventually varied from 15 to 34 feet. The uneven quality of construction resulted in a frequent need for repair, but the bridge held a large jumble of houses and shops and survived more than 600 years before being replaced. A more elegant bridge of the period was the Saint-Benezet Bridge at Avignon, Fr. Begun in 1177, part of it still stands today. Another medieval bridge of note is Monnow Bridge in Wales, which featured three separate ribs of stone under the arches. Rib construction reduced the quantity of material needed for the rest of the arch and lightened the load on the foundations.

During the Renaissance, the Italian architect Andrea Palladio took the principle of the truss, which previously had been used for roof supports, and designed several successful wooden bridges with spans up to 100 feet. Longer bridges, however, were still made of stone. Another Italian designer, Bartolommeo Ammannati, adapted the medieval ogival arch by concealing the angle at the crown and by starting the curves of the arches vertically in their springings from the piers. This elliptical shape of arch, in which the rise-to-span ratio was as low as 1:7, became known as basket-handled and has been adopted widely since. Ammannati's elegant Santa Trinita Bridge (1569) in Florence, with two elliptical arches, carried pedestrians and later automobiles until it was destroyed during World War II; it was afterward rebuilt with many of the original materials recovered from the riverbed. Yet another Italian, Antonio da Ponte, designed the Rialto Bridge (1591) in Venice, an ornate arch made of two segments with a span of 89 feet and a rise of 21 feet. Antonio overcame the problem of soft, wet soil by having 6,000 timber piles driven straight down under each of the two abutments, upon which the masonry was placed in such a way that the bed joints of the stones were perpendicular to the line of thrust of the arch. This innovation of angling stone or concrete to the line of thrust has been continued into the present.

COMPREHENSION CHECK

I. Answer the following questions:

1. What are medieval bridges noted for?
2. What are the advantages of a pointed arch?
3. There were many purposes of medieval bridges. What were they?
4. What was interesting about Monnow Bridge (in Wales) construction? What was rib construction necessary for?
5. What is a basket-handled arch? What is it for?
6. While building the Rialto Bridge Antonio da Ponte faced a problem. What was it? How was it overcome?

LANGUAGE FOCUS

II. Match the meanings of these terms with their definition:

1. ogive 2. to sag 3. abutment 4. crown 5. load 6. drawbridge 7. span 8. truss 9. pier 10. arch	1. Part of a structure which supports the end of a span or accepts the thrust of an arch 2. pointed arch 3. a point at the top of an arch. 4. have a downward bulge or curve in the middle 5. The horizontal space between two supports of a structure 6. what is carried or to be carried 7. hinged retractable bridge, esp. over a moat. 8. A vertical structure which supports the ends of a multi-span superstructure at a location between abutments 9. A structural form which is used in the same way as a beam, but because it is made of an web-like assembly of smaller members it can be made longer, deeper, and therefore, stronger than a beam or girder while being lighter than a beam of similar dimensions. 10. A curved structure which supports a vertical load mainly by axial compression

III. Put the words in correct forms into the text:

Monnow Bridge is the only remaining … fortified river bridge in Great Britain with its gate tower still standing on the bridge. It is … in the town of Monmouth, which stands at the … of the Wye and the Monnow rivers. The Monnow Bridge, as its name suggests, stands over the River Monnow. The bridge was built late in the 13th century, … in 1272. The gatehouse on Monnow Bridge called Monnow Gate, which gives it is remarkable and noteworthy … , was added to the bridge in the 14th century. In 1297, Edward I to provided a murage grant in favour of Monmouth to enable the people of Monmouth to build the medieval town walls and gates. The work was still … in 1315, or it was in need of repair, since the authority of 1297 was renewed on June 1, 1315.	Middle Ages location, confluent complete appear incompletion

IV. Read the following text to find information on:

1) the shape of medieval bridges
2) the purpose of cutwaters
3) the characteristics of spans
4) subsidiary arches
5) adjacent structures

The Characteristics of Medieval Bridges

They have projecting piers, triangular in shape, known as cutwaters. These are found on the upper side with the point towards the stream their purpose being to protect the pier from the force of the current and from the impact of trees and other objects borne along by the water.

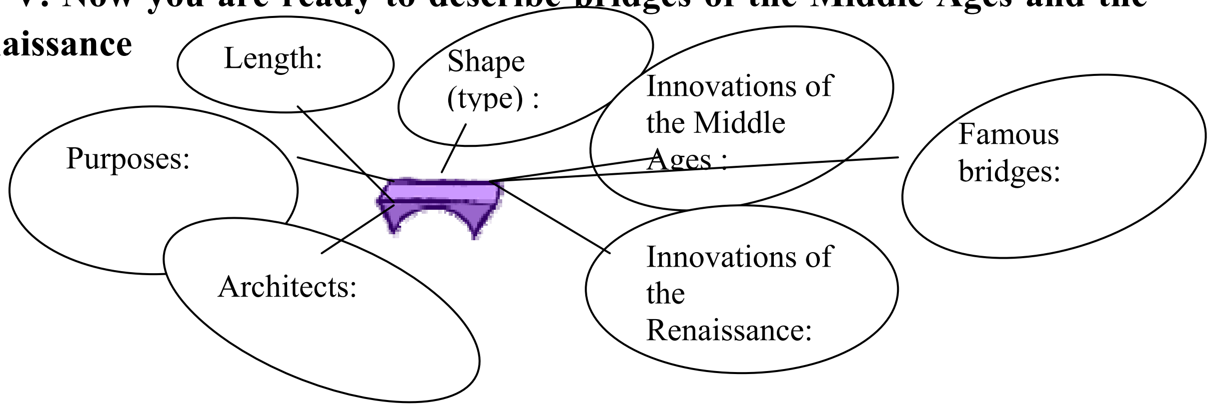
The spans varied from five feet in the case of small bridges to twenty feet or more in a few cases. The first were semicircular with a barrel vault. In the 13th century pointed arches replaced these arches and groined vaults replaced barrel vaults. Here the main weight was taken on ribs of stone.

Many medieval bridges are humped, especially where the roadway rose over pointed Gothic arches. The gradually flattening of the Gothic arch had the effect of reducing the hump and a somewhat flatter roadway appears in the 15th century.

Often a medieval bridge is extremely long and included a long stone causeway which leads up to it across a flood plain. This is pierced by subsidiary arches which do not regularly have channels of water flowing through them. They are used, however, at times of flood to allow the swollen waters to escape away, instead of ponding up behind the bridge.

Further structures connected with bridges include chapels built for bridge hermits. Gateways and drawbridges were also found.

V. Now you are ready to describe bridges of the Middle Ages and the Renaissance



VI. Continue completing the table:

№	The period and the country	Type(s) of the bridge	Materials used	Difficulties
1.		Beam bridge		
2.			stones	
3.	Ancient Asia			
4.	The Middle Ages			
5.	The Renaissance			

Text 5:The 18th and the 19th centuries

Lead-in:

1. What types of bridges were developed in the 18th-19th centuries?
2. In what way did Industrial Revolution influenced bridge building?
3. What were the main purposes of bridges in the 18th-19th centuries?

By the middle of the 18th century, bridge building in masonry reached its zenith. Jean-Rodolphe Perronet, builder of some of the finest bridges of his day (Pont de Neuilly (1774), Pont Sainte-Maxence (1785), Pont de la Concorde (1791)), developed very flat arches supported on slender piers. In London the young Swiss engineer Charles Labelye evolved a novel and ingenious method of sinking the foundations, employing huge timber caissons that were filled with masonry after they had been floated into position for each pier. The 12 semicircular arches of Portland stone, rising in a graceful camber over the river, set a high standard of engineering and architectural achievement for the next generation and stood for a hundred years. Also in London, John Rennie built the first Waterloo Bridge with level-topped masonry arches.

In the 18th century, designs with timber, especially trusses, reached new span lengths. In 1755 a Swiss builder, Hans Grubenmann, used trusses to support a covered timber bridge with spans of 171 and 193 feet over the Rhine at Schaffhausen. One of the best long-span truss designs was developed by Theodore Burr, of Tonington, Conn., and based on a drawing by Palladio; a truss strengthened by an arch, it set a new pattern for covered bridges in the United States. Burr's McCall's Ferry Bridge (1815; on the Susquehanna River near Lancaster, Pa.) had a record-breaking span of 360 feet. Another successful design was the "lattice truss," patented by Ithiel Town in 1820, in which top and bottom chords were made of horizontal timbers connected by a network of diagonal planks.

Early trusses were built without precise knowledge of how the loads are carried by each part of the truss. The first engineer to analyze correctly the stresses in a truss was Squire Whipple, an American who published his theories in 1869. Understanding precisely how loads were carried led to a reduction in materials, which by then were shifting from wood and stone to iron and steel.

During the Industrial Revolution the timber and masonry tradition was eclipsed by the use of iron, which was stronger than stone and usually less costly. The first bridge built solely of iron spanned the River Severn near Coalbrookdale, Eng. Designed by Thomas Pritchard and built in 1779 by Abraham Darby. the Coalbrookdale Bridge, constructed of cast-iron pieces, is a ribbed arch whose nearly semicircular 100-foot span imitates stone construction by exploiting the strength of cast iron in compression. Iron bridges were judged to be technically the best of their time. The use of relatively economical wrought iron freed up the imaginations of designers, and one of the first results was Telford's use of chain suspension cables to carry loads by tension. His eyebar cables consisted of wrought-iron bars of 20 to 30 feet with holes at each end. Each eye matched the eye on another bar, and the two were linked by iron pins. The first of these major chain-suspension bridges and the finest of its day was Telford's bridge over the Menai Strait in northwestern Wales. At the time of its completion in 1826, its 580-foot span was the world's longest. In 1893 its timber deck was replaced with a steel deck, and in 1940 steel chains replaced the corroded wrought-iron ones. The bridge is still in service today.

The rise of the locomotive as a mode of transportation during the 19th century spurred the design of new bridges and bridge forms strong enough to handle both the increased weight and the dynamic loads of trains. The most significant of these early railway bridges was Robert Stephenson's Britannia Bridge, also over the Menai Straits. Completed in 1850, Stephenson's design was the first to employ the hollow box girder. The hollow box gave the deck the extra stiffness of a truss, but it was easier to build and required less engineering precision— at the cost, however, of extra material. The wrought-iron boxes through which the trains ran were originally to be carried by chain suspension cables, but, during the building, extensive theoretical work and testing indicated that the cables were not needed; thus the towers stand strangely useless.

Among the most important railway bridges of the latter 19th century were those of Gustave Eiffel. Between 1867 and 1869 Eiffel constructed four viaducts of trussed-girder design along the rail line between Gannat and Commentry, west of Vichy in France. The most striking of these, at Rouzat, features wrought-iron towers that for the first time visibly reflect the need for lateral stiffness to counter the influence of horizontal wind loads. Lateral stiffness is achieved by curving the towers out at the base where they meet the masonry foundations (Eiffel's famous Parisian tower of 1889).

Niagara Bridge (USA), whose completion in 1855 vindicated John Roebling's conviction that the suspension bridge would work for railroads, lasted nearly half-a-century before it had to be replaced in 1896. At mid-century, it was the only form capable of uniting the 821ft (250m) gorge in a single span. This half-stereoscopic viewshows the massive stiffening trusses and the wire-cable stays that tied the deck superstructure to the walls of the gorge.

In 1855 Roebling completed an 821-foot-span railway bridge over the Niagara River in western New York state. Wind loads were not yet understood in any theoretical sense, but Roebling recognized the practical need to prevent vertical oscillations. He therefore added numerous wire stays, which extended like a giant spiderweb in various directions from the deck to the valley below and to the towers above. The Niagara Bridge confounded nearly all the engineering judgment of the day, which held that suspension bridges could not sustain railway traffic. The 1874 Eads Bridge was the first major bridge built entirely of steel, excluding the pier foundations. Designed by James Buchanan Eads, it has three arch spans, of which the two sides are each 502 feet and the middle is 520 feet. The Eads bridge was given added strength by its firm foundations, for which pneumatic caissons, instead of cofferdams, were used for the first time in the United States. Another innovation carried out by Eads, based on a proposal by Telford, was the construction of arches by the cantilevering method. The arches were held up by cables supported by temporary towers above the piers, all of which were removed when the arches became self-supporting.

COMPREHENSION CHECK

I. Answer the following questions:

1. How did the method of sinking the foundations work?
2. What was the reason for making spans longer?
3. Who set a new pattern for covered bridges in the United States? What was it?
4. Why is it necessary to know stresses in trusses? Who was the first to analyze it?
5. How is lateral stiffness achieved?
6. How can you prove that Niagara Bridge confounded nearly all the engineering judgment of the day?

LANGUAGE FOCUS

II. Match the meanings of these terms with their definition:

deck, wrought iron, cantilever, lattice, caisson, truss, stress, masonry, girder

1. a stonework
2. watertight chamber for underwater construction work
3. framework supporting a roof, bridge
4. pressure or tension
5. tough malleable form of iron suitable for forging or rolling, not cast.
6. a horizontal structure member supporting vertical loads by resisting bending. 7. an assembly of smaller pieces arranged in a gridlike pattern; sometimes used a decorative element or to form a truss of primarily diagonal members.
8. the top surface of a bridge which carries the traffic.
9. a structural member which projects beyond a supporting column or wall and is counterbalanced and/or supported at only one end.

III. Choose the correct preposition:

Bridge building (for, in, with, by) masonry, arches supported (on, with, through, in) slender piers, the construction (on, with, by, of) arches (as, in, with, by) the cantilevering method, a viaduct (in, by, of, across) trussed-girder design (along, according to, with, on) the rail line, timber deck was replaced (into, by, with, instead of) a steel deck, the strength (in, of, off, by) cast iron (in, with, on, through) compression, horizontal timbers connected (with, by, in, without) a network (of, with, across, in) diagonal planks.

IV. Put the correct form of the words into the sentences:

Though extremely…, wood has one obvious disadvantage – it… . Wernwag's Colossus, destroyed by fire in 1838, is but one example of many … wooden bridges lost in this manner throughout history.	versatility burning outstand
There was another material, however, whose use at the end of the 18th century offered bridge engineers an … to the traditional materials of timber, stone, and brick.	alternate
Although it had first been used in antiquity, iron was the miracle material of the … Revolution. The Greeks and Romans had used it to … stone pediments and columns in their temples and iron links had been forged by the Chinese and used in … bridges.	industry reinforcement suspend

V. Every person whose name was mentioned in the text contributed much into bridge building history. Try to recollect their achievements: *Squire Whipple, Hans Grubenmann, Charles Labelye, Roebling, James Buchanan Eads, Robert Stephenson*

VI. Continue completing the table:

№	The period and the country	Type(s) of the bridge	Materials used	Difficulties
1.		Beam bridge		
2.			stones	
3.	Ancient Asia			
4.	The Middle Ages			
5.	The Renaissance			
6.	The 18th century			
7.	The 19th century			

FOLLOW UP ACTIVITIES

Speak on:

1. The history of bridge construction

2. The history of bridge construction in Belarus

Unit 2: KINDS OF BRIDGES

Lead in

What parts does a bridge consist of?
How do bridges differ?

Find the following terms and memorize their meaning.

truss bridge	spandrel columns
suspension bridge	tied arch bridge
cable stayed bridge	continuous truss bridge
girder bridge	simple span truss bridge
reinforced	anchor arm
framework	cantilever arm
roadway	suspended span
deck truss bridge	side span
through truss bridge	anchorage
cantilever bridge	cable
stiffening girder	main cable
radiating pattern	suspension cable
fan pattern	bascule bridge
star pattern	swing bridge
viaduct	vertical lift bridge
aqueduct	

Text 1. BASIC FORMS

There are six basic bridge forms: the beam, the truss, the arch, the suspension, the cantilever, and the cable-stay. Figure 11 illustrates these forms and indicates the way loads are carried by showing the approximate location of compression (where material is squeezed together) and tension (where material is stretched).

Beam. The beam bridge is the most common bridge form. A beam carries vertical loads by bending. As the beam bridge bends, it undergoes horizontal compression on the top. At the same time, the bottom of the beam is subjected to horizontal tension. The supports carry the loads from the beam by compression vertically to the foundations.

When a bridge is made up of beams spanning between only two supports, it is called a simply supported beam bridge. If two or more beams are joined rigidly together over supports, the bridge becomes continuous.

Truss. A single-span truss bridge is like a simply supported beam because it carries vertical loads by bending. Bending leads to compression in the top chords (or horizontal members), tension in the bottom chords, and either tension or compression in the vertical and diagonal members, depending on their orientation. Trusses are popular because they use a relatively small amount of material to carry relatively large loads.

Arch. The arch bridge carries loads primarily by compression, which exerts on the foundation both vertical and horizontal forces. Arch foundations must therefore prevent both vertical settling and horizontal sliding. In spite of the more complicated foundation design, the structure itself normally requires less material than a beam bridge of the same span.

Suspension. A suspension bridge carries vertical loads through curved cables in tension. These loads are transferred both to the towers, which carry them by vertical compression to the ground, and to the anchorages, which must resist the inward and sometimes vertical pull of the cables. The suspension bridge can be viewed as an upside-down arch in tension with only the towers in compression. Because the deck is hung in the air, care must be taken to ensure that it does not move excessively under loading. The deck therefore must be either heavy or stiff or both.

Cantilever. A beam is said to be cantilevered when it projects outward, supported only at one end. A cantilever bridge is generally made with three spans, of which the outer spans are both anchored down at the shore and cantilever out over the channel to be crossed. The central span rests on the cantilevered arms extending from the outer spans; it carries vertical loads like in the supported beam or a truss -that is, by tension forces in the lower chords and compression in the upper chords. The cantilevers carry their loads by tension in the upper chords and compression in the lower ones. Inner towers carry those forces by compression to the foundation, and outer towers carry the forces by tension to the far foundations.

Cable-stay. Cable-stayed bridges carry the vertical main-span loads by nearly straight diagonal cables in tension. The towers transfer the cable forces to the foundations through vertical compression. The tensile forces in the cables also put the deck into horizontal compression.

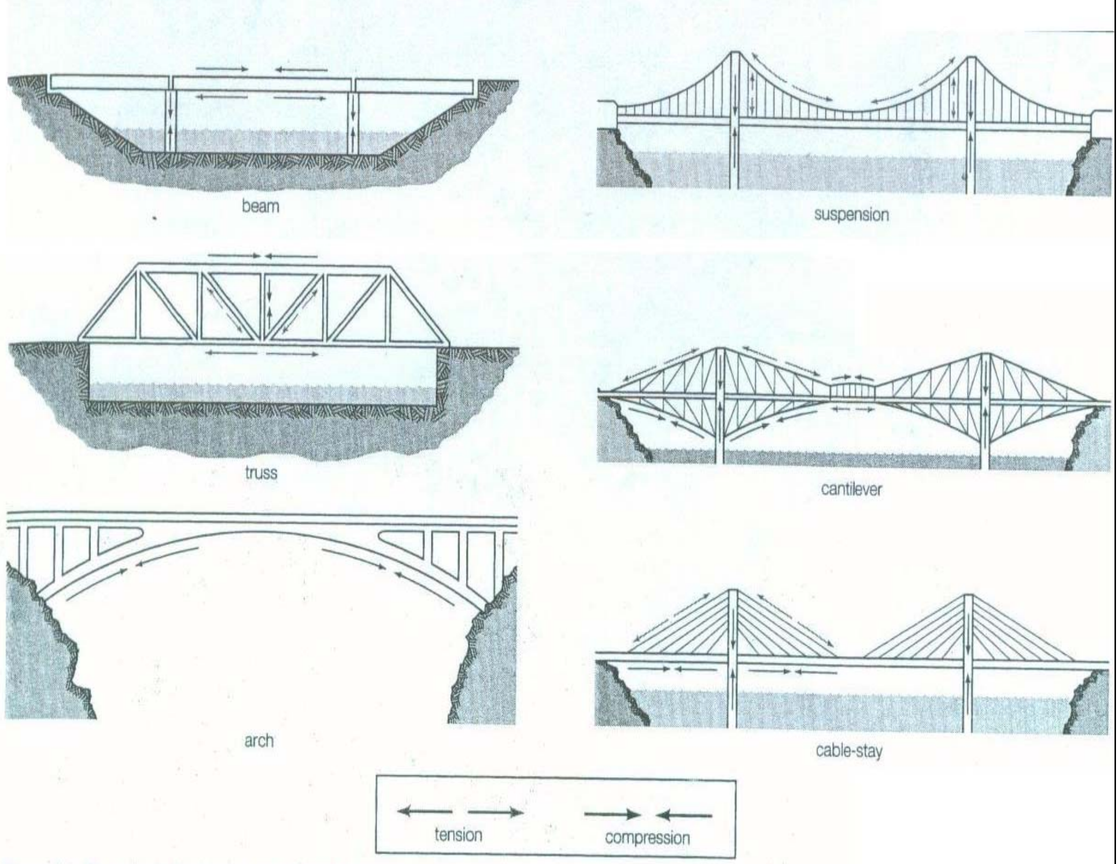


Figure 11: Six major bridge types, with forces of tension represented by light arrows and forces of compression by dark arrows.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. There are four basic forms: the beam, the arch, the truss and the suspension.
2. A beam carries horizontal loads by bending.
3. The bottom of the beam is subjected to vertical tension.
4. If two or more beams are joined rigidly together over supports, the bridge is called a simply supported beam bridge.
5. A single – span truss bridge carries vertical loads by bending.
6. Trusses are popular because they use a great amount of material to carry large loads.
7. The arch bridge requires more material than a beam bridge of the same span as it has the more complicated foundation design.
8. The deck of the suspension bridge must be either heavy or stiff or both.

9. A cantilever bridge is generally made with two spans.
10. The tensile forces in the cables also put the deck into horizontal compression.

II. Answer the following questions:

1. What are basic bridge forms?
2. What loads does a beam carry by bending?
3. What is the bottom of the beam subject to?
4. When is a bridge called a simply supported beam bridge?
5. When does the bridge become continuous?
6. Why are trusses popular?
7. How does the arch bridge carry loads?
8. What parts of the suspension bridge are subject to compression?
9. Where does the central span rest in a cantilever bridge?

LANGUAGE FOCUS

III. Match the meanings of these terms with their definition:

beam, truss, arch, suspension, cantilever

1. A support on which something is suspended.
2. A large projecting bracket or beam that is supported at one end only.
3. A large long piece of timber ready for use in building or any of the main horizontal supports of a building.
4. A framework of beams or other supports usually connected in a series of triangles and used to form a support for a bridge.
5. A curved structure capable of bearing the weight of the material above it.

IV. Match the words with their synonyms:

1. common	5. exert	a) base	e) hard
2. carry	6. curved	b) strain	f) rope
3. foundation	7. cable	c) bent	g) bear
4. rigid		d) usual	

V. Fill in the correct prepositions:

1) the location …sth   2) the bottom …sth   3) … the same time
4) to depend … sth   5) a small amount …sth

6) to exert … sth 7) to be transferred …sth 4) to rest …sth

VI. Read the sentences and translate the words in brackets:

1. Engineers (проектируют) bridges of great length and strength to cross the widest rivers.
2. Arches often (образуют) the tops of doors, windows and gateways.
3. The Romans used the semicircular (арки) in bridges, aqueducts and large-scale architecture.
4. Large (балки) carrying the ends of other beams perpendicular to them are usually called girders.
5. For weight reduction beams of metal are formed as an I or other shape having a thin vertical web and thicker horizontal flanges where most of the (нагрузка) appears.

VII. Make the precis of the text

Text 2. TYPES OF BRIDGES

Introduction

Bridge designs differ in the way they support loads. These loads include the weight of the bridges themselves, the weight of the material used to build the bridges, and the weight and stresses of the vehicles crossing them. There are basically eight common bridge designs: beam, cantilever, arch, truss, suspension, cable stayed, movable, and floating bridges. The types of bridges vary in total length, the length of their spans, and the weight they can support. Before deciding which kind to build at a particular place, engineers determine the length of the structure and of each span. They also must consider the maximum load the bridge will carry and the materials available to construct the bridge.

Combination bridges may incorporate two or more of the above designs into a bridge. Each design differs in appearance, construction methods and materials used, and overall expense. Some designs are better for long spans. Beam bridges typically span the shortest distances, while suspension and cable-stayed bridges span the greatest distances.

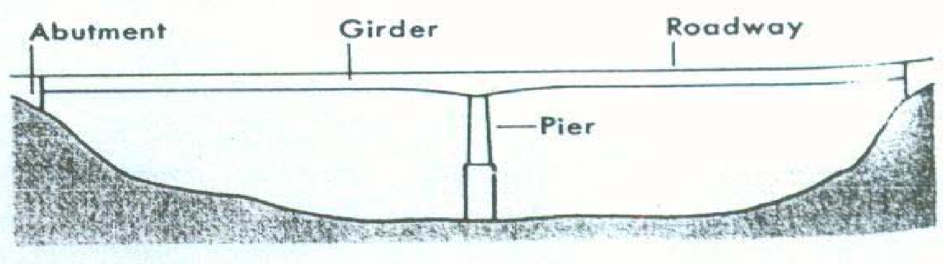
Beam Bridges

Beam bridges represent the simplest of all bridge designs. A beam bridge consists of a rigid horizontal member called a beam that is supported at both ends, either by a natural land structure, such as the banks of a river, or by vertical posts called piers. Beam bridges are the most commonly used bridges in highway construction. Single-piece, rolled-steel beams can support spans of 15 to 30 m (50 to 100 ft). Heavier, reinforced beams and girders are used for longer spans.

Girder Bridges

Girder bridges, which include many highway bridges, are made of beams called *girders* whose ends simply rest on piers or abutments. These bridges may be used to cross most areas. The span length of girder bridges ranges up to about 1.000 feet (300 meters).

There are two main types of girder bridges. In one type, called a *box girder bridge,* each girder looks like a long box that lies between the piers or abutments. The top surface of the bridge is the roadway. Box girder bridges are built of steel or concrete. In the other type of girder bridge, the end view of each girder looks like an I or a T. Two or more girders support the roadway. This type of bridge is called *a plate girder bridge* when made of steel, a *reinforced* or *prestressed concrete girder bridge* when made of concrete, and a *wood girder bridge* when made of wood.



Girder bridge

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. These loads include the weight and the stresses of the vehicles crossing them.
2. The kinds of bridges vary in the length of their spans.
3. It is very important to consider the maximum load the bridge will carry.
4. Each bridge incorporates two or more of the designs into a bridge.

5. Beam bridges typically span the greatest distance.
6. A beam bridge consists of a rigid horizontal member.
7. Beam bridges are rarely used in highway construction.
8. Girders are supported at both ends by natural land structure.
9. The span length of girder bridges ranges up to about 500 metres.
10. There are two types of girder bridges: a box girder bridge and a plate girder bridge.

II. Answer the following questions:

1. How do bridge designs differ?
2. What do these loads include?
3. What should engineers determine before deciding which kind of bridge to build?
4. What is a combination bridge?
5. What is the difference between beam bridges and suspension bridges?
6. What does a beam bridge consist of?
7. Where are beam bridges most commonly used?
8. What are the two main types of girder bridges?
9. Why is a box girder bridge called so?
10. When is a bridge called a plate girder bridge and when a reinforced?

LANGUAGE FOCUS

III. Choose the contextual meaning of the word:

load	1)груз 2) вагон 3) нагрузка 4) бремя
stress	1) нажим2) напряжение3) давление4) ударение
span	1) период времени 2) длина моста 3)перегон 4) пролет
rigid	1) жесткий 2) твердый 3) неподвижный 4) стойкий
abutment	1) межа 2) береговой устой 3) контрфорс 4) опора

IV. Match the meanings of these terms with their definition:
span, design, girder, load, pier, roadway;

1. The weight or force supported by a structure or any part of it.
2. Each arch or part of a bridge between piers or supports.

3. A drawing, plan or sketch made to serve as a pattern from which to work.
4. One of the solid supports on which the arch of a bridge rest.
5. A main supporting beam made of steel, concrete or wood.
6. The part of a road used by wheeled vehicles.

V. Fill in the correct prepositions:

to be made…, to vary…sth, to be better…sth, to consist…,
to be supported… sth, to be used…sth, to differ…sth

VI. Fill in the missing words from the list:

bridge design, supports, to carry, short, loads, to hold, long, public's, spans, goal

A bridge is a structure that … horizontally between supports and its function is to carry vertical … .The prototypical bridge is quite simple – two … holding up a beam. The supports must be strong enough … the structure up and the span must be strong enough … loads. Spans are generally made as … as possible; … spans are justified where good foundations are limited. All major bridges are build with the … money. Therefore … that best serves the public interest has a threefold … efficiency, economy, elegance.

VII. Make the precis of the text

Text 3. TRUSS BRIDGES

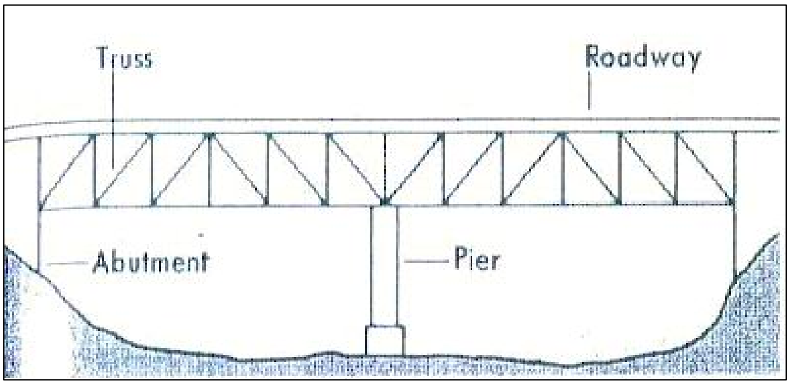
Truss bridges are supported by frameworks called trusses. The parts of the trusses are arranged in the form of triangles. Such bridges are built over canyons, rivers, and other areas. A truss bridge may have a main span that extends more than 1,000 feet (300 meters).

Each truss consists of steel or wood parts that are connected to form one or more triangles. The simplest truss consists of three parts fastened together at their ends to form a triangle.

Most truss bridges have one set of trusses on each side of the roadway. The majority of modern truss bridges have the roadway on top of the trusses and are called *deck truss bridges.* The roadway of a *through truss bridge* runs between the trusses.

In a *simple span truss bridge,* each truss extends between two abutments or piers. In a *continuous truss bridge,* each truss has three or more such supports.

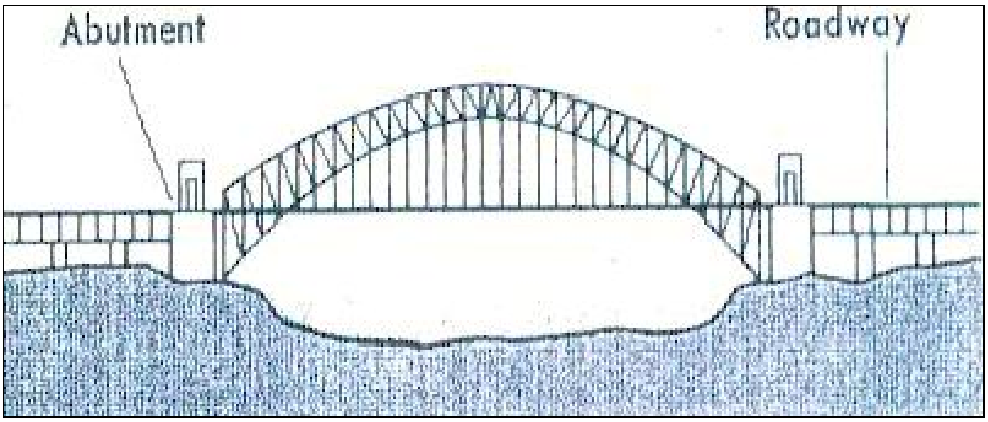
Some locations are suitable for either a truss bridge or a girder bridge. In such cases, some engineers choose to build a truss bridge because it requires less construction material than the girder type. However, many engineers prefer a girder bridge because it is more attractive and easier to construct and maintain.



Arch bridges

Arch bridges are structures in which each span forms an arch. The spans range up to about 1,700 feet (518 meters) long. The arch bridge is one of the oldest types of bridges. Early arch bridges consisted of large stone blocks wedged together to form an arch. Today, the majority of arch bridges that have short spans are made of concrete or wood. Arch bridges with long spans are built of concrete or steel.

Engineers must design arch bridges so that the sides of the arch do not spread apart and collapse the bridge. The roadway of some arch bridges lies on top of the arch and is supported by vertical columns called *spandrel columns.* These columns transfer the load of the roadway to the arch, which bears the weight of the bridge. The roadway of a *tied arch bridge* is below the curve of the arch. The roadway is supported by girders or other types of beams that hang from the arch. The girders or beams also connect to the ends of the arch to prevent the ends from spreading out. The abutments support the weight of the bridge.



COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text.

1. Truss bridges are supported by frameworks called girders.
2. The parts of the trusses are arranged in the form of rectangles.
3. A main span may attend more than 300 metres.
4. Most truss bridges have two sets of trusses.
5. The roadway of a through truss bridge runs on the top of the trusses.
6. Each truss extends between two abutments in a simple span truss bridge.
7. Truss bridges require less construction material than the girder type.
8. Early arch bridges consisted of stone blocks in the form of an arch.
9. The road of arch bridges can lie both on the top of the arch and below the curve on the arch.
10. The roadway is supported by the abutments.

II. Answer the following questions:

1. What is a truss?
2. Where are truss bridges built?
3. How are the parts of the trusses arranged?
4. What may the length of a main span be?
5. What does each truss consist of?
6. What is the difference between a deck truss bridge and a through truss bridge?
7. Why do engineers prefer to build truss bridges?
8. Why are arch bridges called so?
9. What were early arch bridges made of?
10. How must arch bridges be designed?
11. Where can the roadway of arch bridges lie?
12. How is the roadway supported?
13. What is done to prevent the ends from spreading out?
14. What weight do the abutments support?

LANGUAGE FOCUS

III Match the meanings of these terms with their definition:
truss bridge, arch bridge framework, girder bridge

1. A support or skeleton; stiff part that gives shape to a thing
2. A bridge supported wholly or chiefly by trusses.
3. A bridge made of large iron or steel beams for bearing load.
4. A bridge made of curved structures as a support.

IV. Match the word with its translation. Find the corresponding pairs of words:

1. truss	a) надсводная стойка
2. deck truss bridge	b) мост со сплошными или сквозными фермами
3. through truss bridge	c) мост с разрезными пролетами
4. simple span truss bridge	d) закругление
5. continuous truss bridge	e) арка
6. girder bridge	f) проезжая часть
7. arch	g) мост с решетчатыми фермами с ездой поверху
8. span	h) мост со сквозными фермами
9. roadway	i) береговой устой
10. spandrel columns	j) скрепленный арочный мост
11. tied arch bridge	k) пролет
12. curve	l) балочный мост
13. abutment	m) ферма

V. Read the passage and answer the question:

What functions have had bridges?

In addition to providing a passage for traffic, bridges have often had other functions, including service as fortifications and as business districts. The Old London Bridge, for example, which stood from the 13^{th} to the 19^{th} century, was a crowded thoroughfare, full of shops and houses. The original functions of bridges have also been modified for new uses.

VI. Fill in the missing words from the list:

beams, light, weight, stability, trusses, steel, frameworks, triangular, inexpensive, outward, concrete, gap, abutments

1. Truss bridges utilize strong, rigid … that support these bridges over a span. …are created by fastening … together in a … configuration. The truss framework distributes the … of the bridge so that each beam shares a portion of

load. Truss bridges can carry heavy loads and are relatively …. They are also … to build.

2. Arch bridges are characterized by their … In an arch, the force of the load is carried … from the top to the ends of the arch, where … keep the arch ends from spreading apart … and … arches are particularly well suited for bridging ravines or chasms with steep, solid walls.

VII. Make the precis of the text

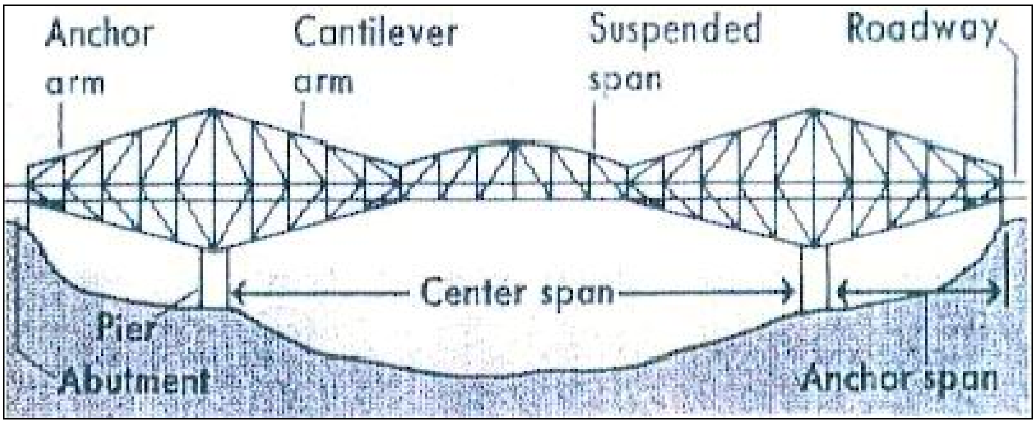
Text 4. CANTILEVER BRIDGES

Cantilever bridges consist of two independent beams called *cantilevers* that extend from opposite banks of a waterway. The two cantilevers are joined together above the middle of the waterway by a beam, girder, or truss. Cantilever bridges may have spans as long as about 1,800 feet (549 meters).

Each cantilever has two sections, an *anchor arm* and a *cantilever arm.* The anchor arm extends between an abutment and a pier. One end of the cantilever arm is supported by the pier, and the other end extends freely over the waterway. The free ends of the two cantilevers are joined together by a *suspended span.*

Most cantilever bridges have two *anchor spans* and one *center span.* Each anchor span consists of an anchor arm. The suspended span and the two cantilever arms make up the center span.

Many cantilever bridges have truss frameworks. Most bridges of the cantilever type are made of steel or prestressed concrete.



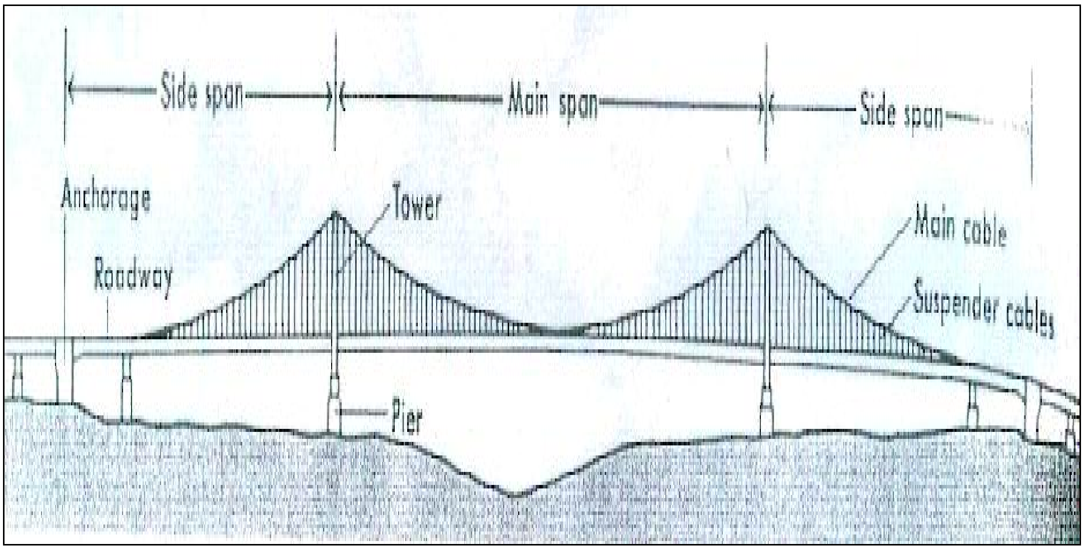
Suspension bridges

Suspension bridges are perhaps the most impressive type of bridge because of their long main span and especially attractive appearance. These bridges have a roadway that hangs from steel cables that are supported by two high towers. Suspension bridges are used to span great distances. Most suspension bridges have a main span more than 1,000 feet (300 meters) long. Some have a main span longer than 4,000 feet (1,200 meters). Suspension bridges also are used to cross deep water or steep canyons, and in other places where the construction of piers is especially difficult and expensive. These bridges require only two piers, each of which supports a tower.

The main span of a suspension bridge stretches between the two towers. Each of two *side spans* extends between a tower and an *anchorage.* Most anchorages are huge blocks of concrete set at the ends of the bridge.

The cables that are supported by the towers are called the *main cables.* A suspension bridge has at least two main cables. Each of these cables extends from one end of the bridge to the other and is secured at each end by an anchorage. The main cables are connected to the top end of vertical *suspender cables.* The bottom end of each suspender cable attaches to the roadway of the bridge.

A suspension bridge may sway in a strong wind. To minimize such movement, most suspension bridges have a thick structure that supports the roadway. This type of structure helps stiffen the bridge and is called a *stiffening girder* or *stiffening truss.*



COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The two cantilevers are joined together in the form of an arch.
2 The span length of cantilever bridges is 1000 feet.
3. Each cantilever has an anchor arm, a cantilever arm and a suspended span.
4. Most cantilever bridges have one center span and two anchor spans.
5. Two anchor arms and suspended span make up the centre span.
6. Suspension bridges are the most impressive type of bridges because of their huge arches.
7. These bridges have a roadway below the curve of the arch.
8. Suspension bridges require only two piers each of which supports as tower.
9. A suspension bridge has at least four main cables.

II. Answer the questions:

1. What do cantilever bridges consist of?
2. How are the two cantilevers joined together?
3. What are the two sections of each cantilever?
4. How are the free ends joined together?
5. What does a center span consist of?
6. What are cantilever bridges made of?
7. Why are suspension bridges considered to be the most impressive type of bridges?
8. What is the length of the main span?
9. Where are suspension bridges built?
10. How many cables does a suspension bridge have?

LANGUAGE FOCUS

III. Match the meanings of these terms with their definition:

suspension bridge, anchor arm, cable, cantilever bridge, suspender, anchorage

1. A bridge made of two cantilevers whose projecting ends meet but do not support each other.
2. A bridge that has its roadway hung on cables and chains between towers.

3. A part of a cantilever bridge between the shore and the pier.
4. A place to anchore.
5. A strong thick rope, now usually made of wires twisted together.
6. A thing that suspends

IV. Translate:

A refinement of the beam, called a cantilever, is used to construct bridges with even longer spans. In simple cantilever bridges, such as those that are found in many parts of Asia, the structure rests on crisscrossed log foundations with narrow bases that flare outward as they rise to support the roadway. A modern cantilever bridge may use only two intermediate piers set a short distance from either bank. The main support members of a suspension bridge are parallel cables composed of thousands of individual strands of wire. These run, supported by each tower and curving at the middle, the entire length of the bridge and are anchored on either end.

V Insert the words from the list:
cables, roadway, diagonal, railroad, tower,

cantilevered, load, beam-bridge, outward,

self-supporting, suspended span, scaffolding, rigidity, trains

1. Cantilever bridges are a more complex version of a design. In a cantilever design, a … is built on each side of the obstacle to be crossed and the bridge is built … or … from each tower. The towers support the entire … of the cantilevered arms. The arms are spaced so that a small: can be inserted between them. Cantilever bridges are … during construction. They are used in situations in which the use of … or other temporary supports would be difficult.

2. Suspension bridges consist of two large or main … that are hung from towers. The … is suspended from smaller vertical cables that hang down from the main cables. In some cases … cables run from the towers to the roadway and add … to the structure. Suspension design is rarely used for … bridges, because … are heavier and can travel faster than highway traffic.

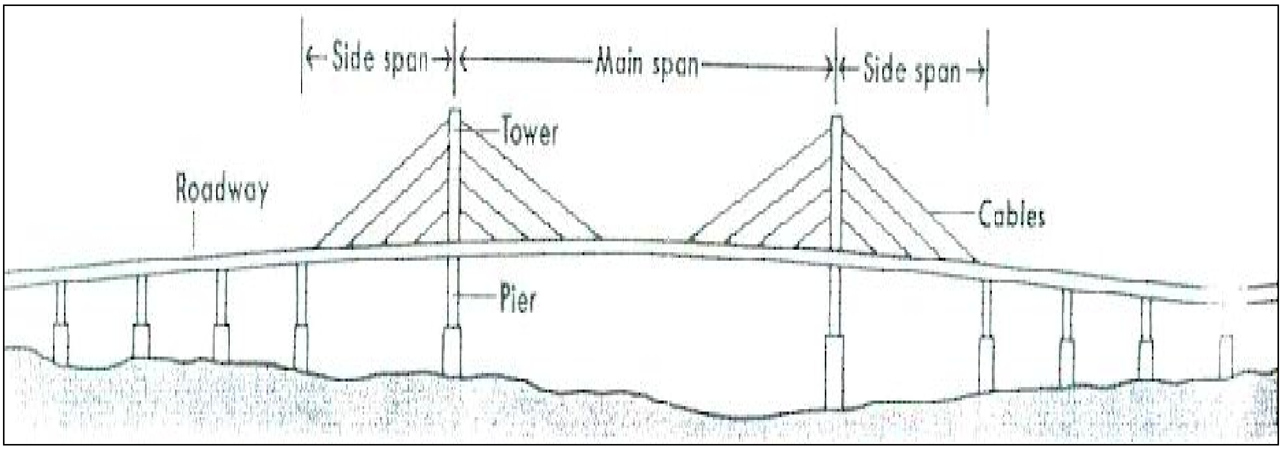
VI. Make the precis of the text

Text 5. CABLE-STAYED BRIDGES

Cable-stayed bridges resemble suspension bridges. Both have roadways that hang from cables, and both have towers. In a cable-stayed bridge, however, the cables that support the roadway are connected directly to the towers.

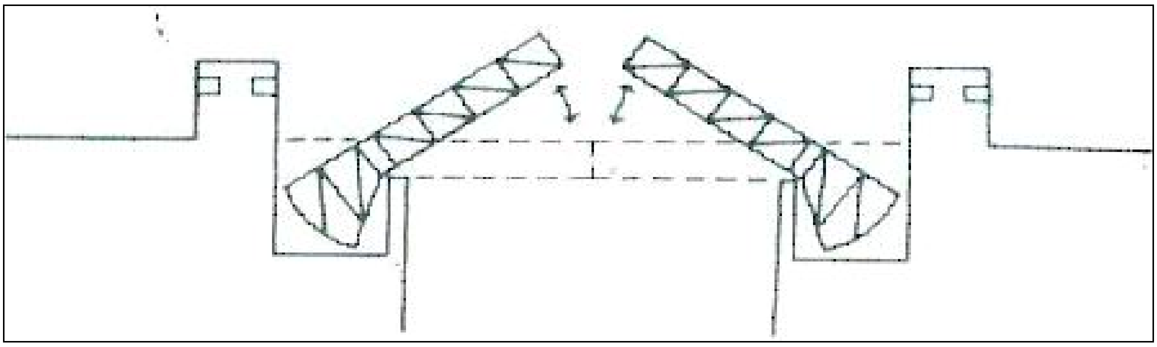
A cable-stayed bridge may be used if its foundation can support only one tower. Most cable-stayed bridges have three spans, but some have one tower and two spans. The most efficient cable-stayed bridges have a main span about 700 feet (210 meters) long.

The cables of a cable-stayed bridge may be linked from the roadway to the towers in several ways. The cables may extend from various points on the roadway to the tops of the towers, forming a *radiating pattern.* The cables form a *fan pattern,* also called a *harp pattern,* if they are connected from a variety of points on the roadway to several points on the towers. It the cables are attached from one point on the roadway to various points on the towers, they form a *star pattern.*

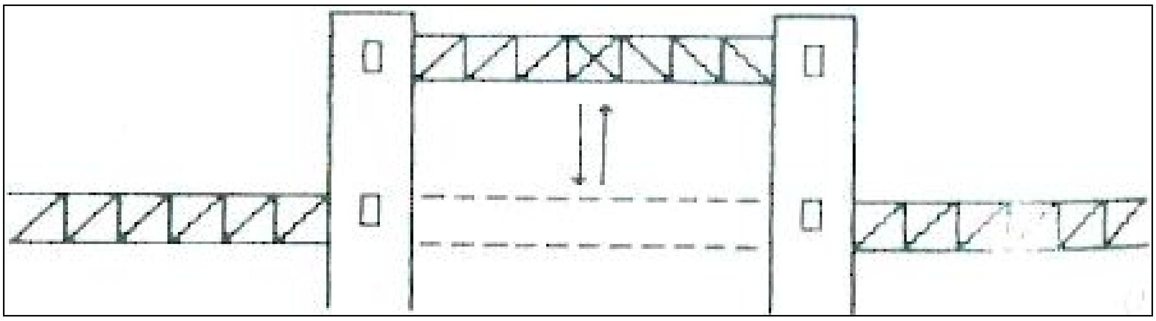


Moveable bridges

Moveable bridges have a roadway that is moved entirely or partially to provide enough clearance for large ships to pass. There are three types of moveable bridges, *bascule bridges, vertical lift bridges,* and *swing bridges.* A bascule bridge tilts upward to open. Some bascule bridges open at one end, and others the middle. A vertical lift bridge has a roadway that extends between two towers. The roadway rises between the towers, and ships pass underneath. A swing bridge is mounted on a central pier. The bridge swings sideways to enable ships to pass.



Bascule bridge



Vertical lift bridge

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Cable-stayed bridges resemble cantilever bridges.
2. In cable-stayed bridge the cables that support the roadway are connected to the towers.
3. A cable-stayed bridge may be used when its foundation can support two towers.
4. Most cable-stayed bridges have 3 spans and two towers.
5. The cables may be linked from the roadway to the towers in several way.
6. If the cables are connected from a variety of points on the roadway to several points on the towers, they form a star pattern.
7. There are four types of moveable bridges.
8. A bascule bridge tilts backward to open.
9. A vertical lift bridge has a roadway that extends between two towers.
10. A swing bridge is mounted on a central tower.

II. Answer the questions:

1. What type of bridge do cable-stayed bridges resemble?
2. How are cables connected?
3. What is the design of most cable-stayed bridges?
4. When do the cables form a fan pattern?
5. When do the cables form a star pattern?
6. What are the types of moveable bridges?
7. How do bascule bridges operate?
8. Where is a roadway situated in a vertical lift bridge?
9. Where is a swing bridge mounted?
10. Why does it move sideways?

LANGUAGE FOCUS

III. Insert the words from the list:

cables, speed, anchorages repair, waterways, impractical, intermediate-length, variation, lower cost, replacement, traffic, costly, frame, spans

1. Cable-stayed bridges represent a ... of the suspension bridge.
2. A cable- stayed bridge is constructed in much the same way as a suspension bridge is, but without the main … .
3. Cable-stayed designs are used for … spans.
4. Advantages the cable-stayed bridge has over a standard suspension bridge include a … construction and … since … are not necessary.
5. There are no massive cables, as with suspension bridges, making cable … or …simpler.
6. Movable bridges are usually found over heavily traveled ….
7. A vertical-lift bridge consists of a rigid … held between two tall towers.
8. Moveable bridges are generally constructed over waterways where it is either … or too … to build bridges with high enough clearances for water … to pass underneath.
9. Vertical-lift bridges are useful for longer …, but they must be built so they can be lifted high enough for tall ships to pass underneath.

IV. Fill the correct preposition:

to hang … sth, to be connected … sth, to be linked … sth, to extend … sth, the top … sth, to be attached … sth … sth, to be mounted … sth

V. Fill in the gaps with a suitable derivations of the word given on the right:

Cable-stayed bridges offer a … of possibilities to the designer regarding the … arrangement of the cables. Early examples used just two cables fastened at … the same point high on the tower and fanning out to support the deck at … separated points. By contrast in the Oberkasseler Bridge the four cables were placed in a parallel …. The Bonn-Nord Bridge was the first to use a large number of … cables instead of relatively few but … ones. The … advantage being that, with more cables a thinner deck might be used. Such multicable arrangements … became quite common. The Pasco-Kennewick Bridge in Washington state was designed in … with the German firm. Its cost was not significantly… from those of other … with more … design.	vary geometry near wide arrange thin heavy, technique subsequent collaborate differ, propose, convection

VI. Read the passage and answer the question: How has the classical drawbridge been improved?

The drawbridge or bascule, originally used for protection against intruders, has been turned into a means for allowing the passage of water traffic. The classic drawbridge, in which the bridge leaf is hoisted by rope or chain, has been improved by the development of pears and counterweights. Design variations include leaves that roll back on tracks, bridges whose entire span is lifted vertically by cables run over tall towers to counterweights and bridges that swing on a central turntable.

VII. Make the precis of the text

Text 6. VIADUCT. AQUEDUCT.

Viaduct is like a bridge, except that it crosses over dry land instead of water. Some viaducts do cross water, but they also cross dry land instead of merely extending from one bank to the other as a bridge does.

Most viaducts consist of a series of supports under beam-and-slab or arch construction. Viaducts carry railroad tracks over valleys and gorges. Some viaducts are built higher than the general level of the land to carry railroads over highways or to make a safe crossing for highways over railroads. The ancient Romans built the first viaducts. The aqueducts they built to carry water to cities often also served as roadways. One of the longest viaducts ever built was a portion of the 110-mile (177-kilometer) Key West extension of the Florida East Coast Railway. Viaducts that extended over the open sea formed 30 miles (48 kilometers) of this extension. Parts were destroyed by a hurricane in 1935, but these were rebuilt as a highway a few years later. The main part of the pier viaduct over the mouth of the River Tay in Scotland has 84 steel spans and is over 2 miles (3.2 kilometers) long. The Tunkhannock viaduct on the Lackawanna Railway is one of the largest steel and concrete viaducts in the world. The Tunkhannock viaduct is 2,375 feet (724 meters) long and includes 10 spans of 180 feet (55 meters) each. Another famous viaduct is the 3-mile (5.6-kilometer) Pulaski Skyway between Newark and Jersey City. Other well-known viaducts are the Pecos River viaduct in Texas and the Landwasser viaduct across Albula Pass, in the canton of Craubunden, Switzerland.

Historically, many agricultural societies have constructed aqueducts to irrigate crops. Archimedes invented the water screw to raise water for use in irrigation of croplands, Another widespread use for aqueducts is to supply large cities with clean drinking water Some of the famed Roman aqueducts still supply water to Rome today. In California, USA, three large aqueducts supply water over hundreds of miles to the Los Angeles area. Two are from the Owens River area and a third is from the Colorado River. In more recent times, aqueducts were used for transportation purposes to allow canal barges to cross ravines or valleys. During the Industrial Revolution of the 18th century, many aqueducts were constructed as pan of the general boom in canal-building. In modern civil engineering projects, detailed study and analysis of open channel how is commonly required to support flood control, irrigation systems, and large water supply systems when an aqueduct rather than a pipeline is the preferred solution. The aqueduct is a simple way to get water to other ends of a field. In the past, aqueducts often had channels made of dirt or other porous materials. Significant amounts of water arc lost through such unlined aqueducts. As water gets increasingly scarce, these canals are being lined with concrete, polymers or impermeable soil. In some cases, a new aqueduct is built alongside the old one because it cannot be shut down during construction. The Central Arizona Project Aqueduct, the largest and most expensive aqueduct system ever constructed in the United States.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Viaducts like bridges cross water.
2. Viaducts cross water and dry land instead of merely extending from one bank to the other.
3. Viaducts carry railroad tracks over valleys.
4. Viaducts are built on the same level on the land to carry railroads.
5. The Greeks built the first viaducts.
6. Parts of the longest viaducts were destroyed by an earthquake in 1925.
7. The spans of the viaduct over the River Tay are over 2 miles long.
8. Many agricultural societies have constructed aqueducts to supply large cities with water.
9. The famous Roman aqueducts were ruined long ago.
10. In California large aqueducts supply water to New-York.

II. Complete the sentences with the best answer:

1. Some viaducts can cross
a) water b) dry land c) cross water and dry land.
2. Most viaducts consist of a series of supports under
a) beam construction b) arch construction c) beam-and slab or arch construction.
3. Some viaducts are built higher than the level of the land to carry
a) bridges b) roads c) railroads or to make a safe crossing over railroads
4. The Tunkhannock viaduct is
a) 2,375 feet long b) 1,947 feet long c) 2,357 feet long.
5. Archimedes invented the water screw
a) to irrigate crops b) to supply large cities with drinking water
c) for transportation purposes
6. In California two aqueducts are from
a) the Colorado River b) the Oven River c) Mississipi River
7. In the past aqueducts often had channels made of
a) concrete b) polymers c) dirt.
8. In some cases a new aqueduct is built
a) alongside the old one b) over the old one c) under the old one.

III. Answer the questions:

1. What do viaducts cross?
2. What do they carry?
3. Why are some viaducts built higher than the general level of the land?
4. What did the ancient Romans build the first viaducts for?
5. What are the longest viaducts?
6. What is the use of aqueducts?
7. What were channels made of in the past?
8. Why is in some cases a new aqueduct built alongside the old one?

IV. Match these terms with their definitions

Aqueduct, viaduct.

1. Type of long bridge or series of bridges, usually supported by a series of arches or on spans between tall towers.
2. Man-made conduit for carrying water

LANGUAGE FOCUS

V. Translate the missing words

The (путепровод) is both functionall and etimologically (относился) to the aqueduct, which (переносят) water; both were developed by Roman engineers. In the early of 20-th century the spread of (железо-бетонных) (конструкций) led to the building of concrete (арочных) structures such as Colorado Street viaduct over the Pasadena Freeway in California. A recent method used on long viaducts is (сегментная конструкция).

The (водоснабжение) in New-York City comes from Thee main (система акведуков) that can (поставлять) from 1 800 000 000 gal. of water a day from (источников) up to 120 miles away. (Система акведуков) in the State of California is by far the largest in the world.

VI. Insert the words

Construction, arches, steel, system, span, distribution point, amount, surpass

1. The long spans of Roman viaducts were supported by semicircular …, resting on piers of stone or masonry.

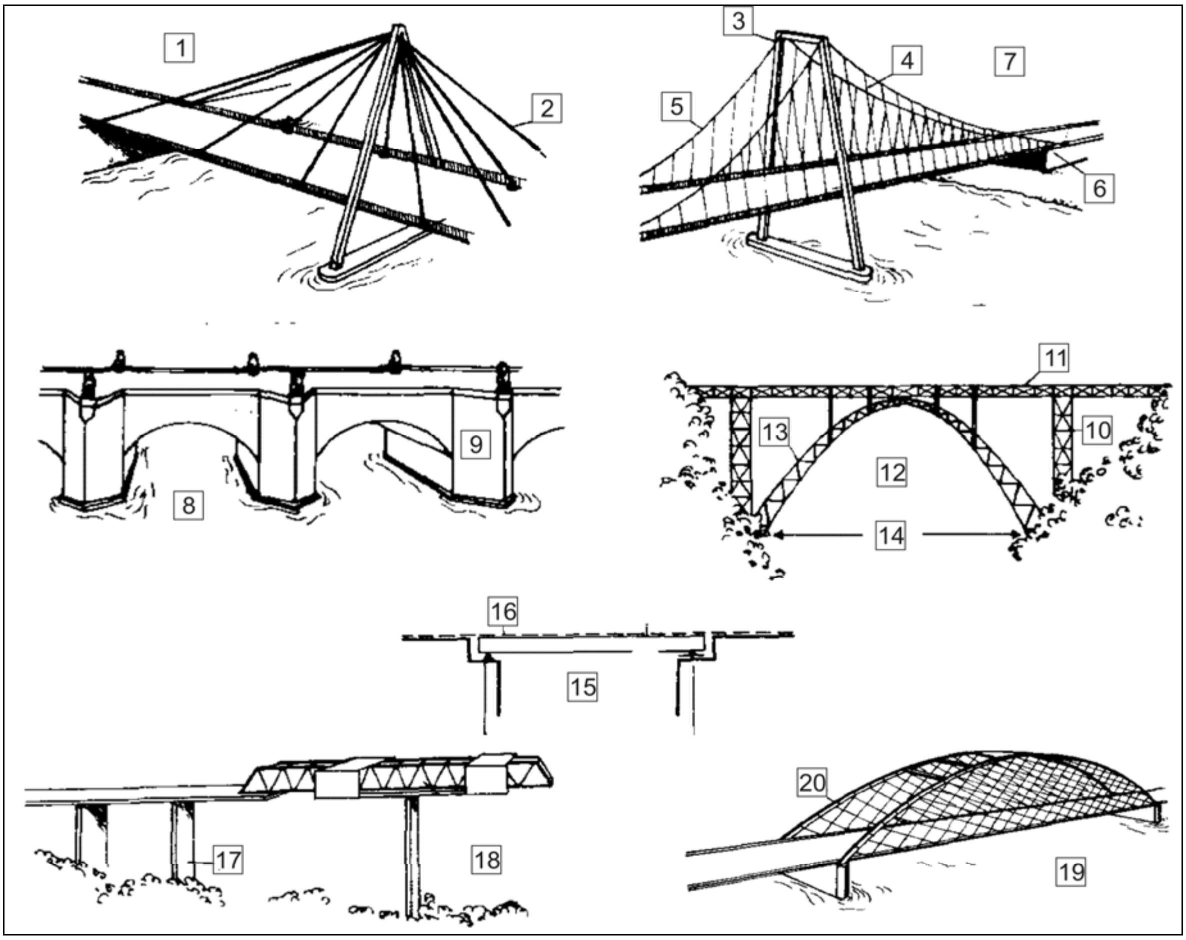
2. A well-preserved example is the … over the Tapus River. At Alcantara, Spain.

3. The next advance in viaduct … did not occur until the late 18-th century development of iron bridges and the 19-th century introduction of … .

4. In modern engineering aqueduct refers to a … of pipes, ditches, canals, tunnels and supporting structures used to convey water from its source to its main … .

5. Modern aqueducts, although lacking the arched grandeur of those built by the Romans, greatly … the earlier ones in length and in the … of water they can carry.

IV. Match the word with the corresponding number:



A. Cable-stayed bridge
B. Suspension cable
C. Tower
D. Pier
E. Suspender (hanger)
F. Trussed arch bridge
G. Trussed arch
H. Suspension bridge
J. Abutment (end pier)
K. Reinforced concrete bridge
L. Reinforced concrete pier
M. Viaduct
N. Stone arch bridge, a solid bridge arch
O. Abutment
P. Solid-web girder bridge (beam bridge)
Q. Arch span
R. Inclined tension cable
S. Reinforced concrete arch
T. Truss element
U. Road surface

FOLLOW UP ACTIVITIES

Speak on: 1. Kinds of bridges. 2. Kinds of bridges in Belarus.

Unit 3: BRIDGE CONSTRUCTION

Lead-in:

What materials are used in bridge construction?

Find the following terms and memorize their meaning.

caisson	cutting edge	falsework
reinforced concrete	tensile strength	web
chamber	shaft	eyebar
prestressed concrete	high-strength steel	dead load
concrete	air lock	live load
wrought iron	slab	

TEXT 1.

It is one thing to design a bridge. It is another thing to build it. Planning and executing the construction of a bridge is often very complicated, and in fact may be the most ingenious parts of the entire enterprise. An incomplete structure is often subjected to stresses and oscillations that would not arise after completion. The construction work is potentially a grave hindrance to existing traffic and to normal life in the area, especially when large local fabrication works have to be installed.

Even before any actual construction is done, substantial work may be needed in the form of tests. Boreholes will be made to check the condition of the ground, in conjunction with any available geological maps. Records of wind speed and direction will be consulted, and new measurements made if necessary. In the case of a river or sea crossing, records of water levels and velocities will be needed. Models of the bridge or of parts may be tested aerodynamically and hydrodynamically, and of course mechanical tests will be made. Computer simulations will supplement these tests, enabling a great variety of applied forces to be investigated. There may also be investigations into the effects on people and on the natural environment. It may even be necessary to overcome opposition to the construction, from a variety of objectors. There was much opposition, for example, to the construction of the Skye bridge. In older times, ferry operators could be extremely vociferous about a bridge proposal.

The bridge builder has to nurse the structure through difficult stages. Very often, the stresses differ considerably from those of the complete structure, and can be more concentrated. The collapse of several box girder bridges in the 1960s damaged the reputation of this type for a period, until the stresses were better understood. Note the paradox that an apparently simple structure, a set of boxes, can be hard to understand, while a complicated looking truss can be solved, at least in principle, using a set of equations. The variation in stresses during construction may be so severe that jacking must be provided.

Excavation for foundations may have to be taken to great depths, through unsuitable ground, often below water level, before solid rock is reached. Keeping out water and preventing diggings from collapsing can require major feats of engineering in themselves.

The pillars of the towers of big suspension bridges may have to be stabilized by temporary cables until they are completed and joined at the top.

Arches generally need to be supported on falsework until they are complete. Perhaps this is the origin of the word "keystone", the last block without which the structure cannot hold up, though in the finished arch, the keystone is no more important than any other voussoir. So the value of the word keystone is to remind us that until the structure is complete, we have to keep thinking.

Completeness includes completeness of communication. The chain of command and communication must be designed to cope with every foreseeable situation, and it must include rules for dealing with emergencies and unforeseen problems.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. An incomplete structure may be subjected to tension and compression
2. Serious research is done before any actual construction is done.
3. The construction of bridges is always greeted by the public.
4. The collapse of several girder bridges in the 1960’s helped to understand the stresses better.
5. The variation in stresses during construction demands jacking.
6. Excavation for foundation is always taken through unsuitable ground before solid rock is reached.
7. The pillars of the towers of suspension bridges are stabilized by cables which are removed after the completion.
8. Arches are usually supported by towers.
9. ‘Keystone’ is an important part of a finished arch.

II. Answer the questions

1. What are the most ingenious parts of bridge building?
2. Why is the construction work a grave hindrance to normal life in the area?
3. What is done before any construction work?
4. How can computer simulations supplement the tests?
5. How can the stresses of the structure differ?
6. When must jacking be provided?
7. What are the difficulties in excavation for foundations?
8. How can the pillars of the towers of big suspension bridges be stabilized?
9. What is a keystone?

LANGUAGE FOCUS

III. Match the words with their synonyms.

1. complicated	a) accessible
2. ingenious	b)suggestion
3. available	c) destruction
4. investigation	d) complex
5. proposal	e) inventive
6. collapse	f) research
7. feat	g) connect
8. join	h) exploit

IV. Match the words with their opposites

1. top	a) mild
2. solid	b)above
3. severe	c) proper
4. below	d) to forget
5. unsuitable	e) to disappear
6. temporary	f) bottom
7. to remind	g) constant
8. to arise	h) soft

V. Insert the prepositions.

To subject … sth, … the form of sth, in conjunction … sth, in case … sth, a great variety … sth, an opposition … sth, to differ … sth, a set … sth, to prevent … sth, the origin … sth, the value … sth, to deal … sth.

VI. Insert the words from the list

spans, cantilevers, jack, rams, completion

1. The four legs of the Tour Eiffel were provided with … which were adjusted from time to time as the structure grew. Even after … a concrete structure may be subject to creep and the ground may settle.
2. Above ground, until … are joined wind, can be a great hazard.
3. Before the Pont de Normandie was completed? There was serious discussion about the use of active stabilizers to keep the long thin … in place.
4. Large weight would have been moved by … .

VII. Make the precis of the text

Text 2. Bridge Construction (According to the Types).

There is nothing especially complicated about the lifting process, and the stresses in the beam are more or less as they will be in the final position. Nevertheless, a heavy object suspended in space is potentially dangerous, and accidents do happen. During the lifting of the suspended span of the Quebec bridge, something broke, and the span fell into the river and was destroyed. During the lifting of one span of the Britannia bridge, a jack burst, and the end of the span fell. Fortunately, Stephenson had given strict orders to insert packing after every few inches of lifting. Nevertheless, a slight distortion of the beam did occur. The incident shows the importance, not only of correct instructions, but of good communications. Accidents have happened because instructions were not received, or if received, modified or ignored. An exception of the method of lifting may be adopted in the case of the suspended span of a cantilever bridge, as in the case of the Forth railway bridge. Here, the beams were built out from the ends of the cantilever arms until they could be joined in the middle. Only then were the temporary rigid connections removed. Such an operation has to be done with great care, because large stresses are released and created. The bending moment at the join completely disappears, for example, while the stress in the top chord of the beam changes from tension to compression. Some continuous box girder beams and concrete beams are constructed as cantilevers until they are joined up. New parts may be taken along the existing part of the bridge, or they may be lifted up from below. Sections of a segmented prestressed concrete bridge may be lifted by a crane which rests on previously attached segments, or they may be manipulated by means of a launching girder which is slowly advanced along the already built part of the span. Another method is to use moving formwork which progresses with the construction. Because the cantilevered part span is subject to stresses for which the complete span is not designed, temporary stays are sometimes attached between the segments and a temporary tower, turning the span into a cable-stayed one until closure is complete.

Yet another technique, when the lower surface of the span is horizontal, is to rest the formwork on the steel girder which reaches to the next pier. The casting of each segment is often done using the previous segment as a part of the formwork. This technique, called match-casting, ensures an almost perfect fit at assembly time, and greatly reduces the tendency for misalignments to occur during erection. A film of epoxy may be spread between segments. After each segment is placed, steel pre-stressing wires, or tendons, are fitted to hold it in position. The pre-stressing tension prevents the concrete ever reaching a tensile state with any foreseeable load. This method of pre-stressing is called post-tensioning, because the stress is added after placement. When the wires are tensioned before the concrete is poured, the process is called pre-tensioning. The tendons are equivalent to the ties in the lattice truss, while the concrete is roughly equivalent to the struts. Thus the concrete and the steel are both used in the roles for which they are best suited.

The joints between the concrete segments are subject to vertical shear forces, which can be resisted by the use of matching corrugated surfaces.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1 The lifting process is the most complicated in bridge construction.

2 Care should be taken during the lifting of the suspended span.

3 Accidents may happen in spite of correct instructions.

4 The temporary rigid connections were removed when the cantilever arms were constructed.

5 The stress in the top chord of the beam completely disappears.

6 Cranes are widely used to lift sections of. prestressed concrete bridge.

7 One of the most popular methods in bridge construction is to turn the span into an arch until closure is complete.

8 The casting of each segment is done on the construction site.

9 Each segment is placed after steel prestressing wires are fitted to hold it in position.

10 The post-tensioning method is called so because the stress is added before placement.

II. Answer the questions:

1 Why are heavy objects suspended in space dangerous?

2 What do incidents show?

3 How was the Forth railway bridge constructed?

4 When were temporary rigid connections removed?

5 When does the bending moment at the join completely disappear?

6 How are some continuous box girder beams constructed?

7 What are the methods of lifting sections of a segmented prestressed concrete bridge?

8 How is the casting of each segment done?

LANGUAGE FOCUS

III. Match the words with their synonyms:

1 Beam	A receive
2 Dangerous	B vanish
3 Get	C expose
4 Disappear	D pellicle
5 Section	E provide
6 Subject	F part
7 Film	G girder
8 ensure	H perilous

IV. Match the words with the opposites:

1 Vertical	A unfortunately
2 Complicated	B quickly
3 Final	C remove

4 Fortunately	D horizontal
5 Slowly	E subsequent
6 Previous	F simple
7 Place	G separation
8 Joint	H initial

V. Fill in the prepositions:

To be … the final position, the lifting … sth., the end … sth., an exception … sth., … the case of, … the middle, to do … great care, to change … sth. … sth., to rest … sth., to turn … sth., to add … sth., to be equivalent … sth.

VI. Make the precis of the text

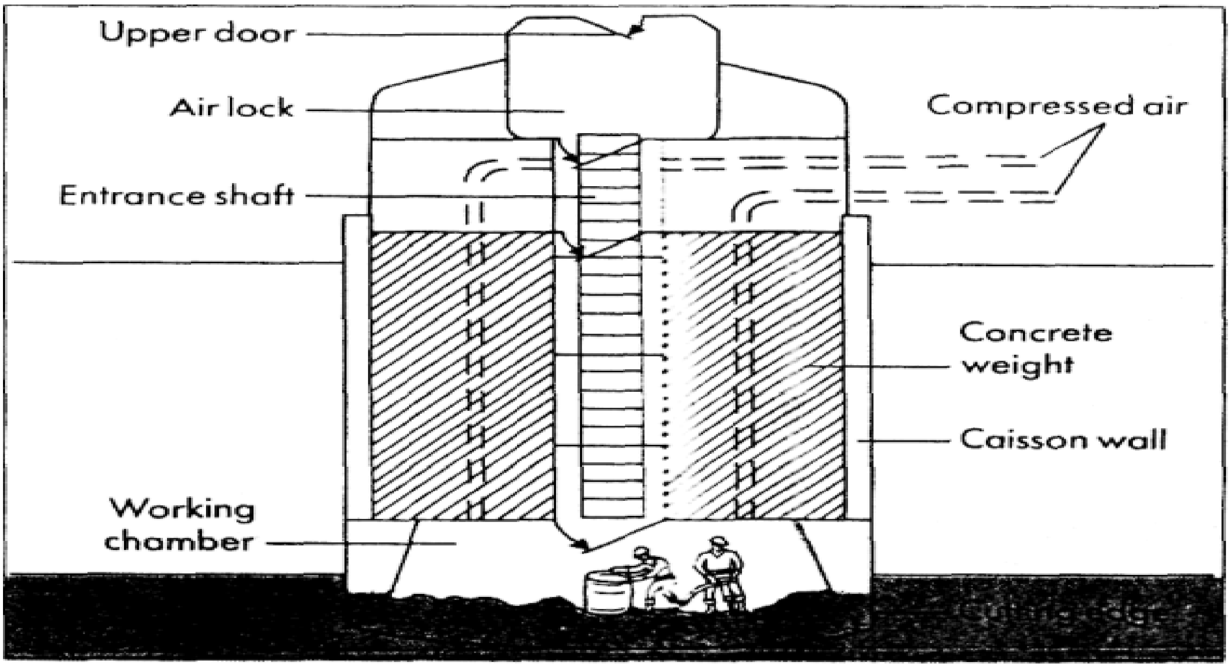
Text 3: CAISSON

Caisson in building, is a watertight chamber used in the construction of building foundations, bridges, tunnels, and other structures. Caissons provide an area in which construction crews can safely work underground or underwater. Caissons also may be filled with concrete and become part of the finished structure.

Most caissons have the shape of a cylinder or a box. The walls may be made of steel, concrete, or timber. All caissons are open at the bottom, where digging takes place. But they may be open or closed on top. The two main types of caissons are open and pneumatic. An open caisson has an open top and bottom. The bottom edges, called cutting edges, are constructed so they can cut into the ground. The caisson sinks deeper into the ground as earth is removed beneath it.

A pneumatic caisson is closed at the top. It uses compressed air to keep water out of the working chamber and to provide oxygen for the workers. This type of caisson consists of two sections. The lower section, where the workers are, has cutting edges like those of open caissons. Concrete is poured into the upper section. Its weight helps drive the caisson deeper into the ground. Workers and materials move in and out of the lower section through a shaft. Pneumatic caissons are usually used to support bridge piers that are located in deep water.

Before workers enter a pneumatic caisson, they must step into a large airtight chamber called an air lock. The outer door is closed, and the air pressure in the air lock is gradually increased until it is the same as the pressure in the working chamber. When workers prepare to leave the caisson, they again pass through the air lock and the pressure is gradually reduced. If workers go through a change of pressure too quickly, they may develop bends, a painful condition also known as caisson disease. Bends can be fatal in some cases.



COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Construction crews can safely work underwater using a watertight chamber.
2. Most caissons have the shape of a triangle.
3. The walls are usually made of cardboard.
4. Caissons are filled with water after the construction is over.
5. The three main types of caissons are open, pneumatic and closed.
6. An open caisson has an open top and bottom.
7. The top edges are called cutting edges.
8. A pneumatic caisson is closed at the bottom.
9. It uses compressed air to keep water out of the working chamber.
10. This type of caisson consists of two sections.
11. Concrete is poured into the lower section.
12. Workers and materials move in and out of the lower section through bottom edges.
13. When workers enter or leave a pneumatic caisson they must pass through an airtight chamber.
14. If workers stay in a caisson for a long time they may develop bends.

II. Answer the questions

1. What is caisson in building?
2. What is the shape of caissons?
3. What are the kinds of caissons?
4. What is the difference between an open and pneumatic caisson?
5. What are the sections of a pneumatic caisson?
6. Why is concrete poured into the upper section?
7. What is an air lock?
8. How does an air lock operate?
9. Why is the pressure changed in an air lock?
10. What can happen if workers go through a change of pressure too quickly?
11. Are caissons used nowadays?

LANGUAGE FOCUS

III. Complete the sentence with the best answer (a, b or c) according to the information in the text

1. Caisson in building is a watertight chamber used
a) in the construction of roofs
b) in the construction of buildings
c) in the construction of bridges and tunnels
2. All caissons are open … where digging takes place
a) at the bottom
b) on the top
c) at the cutting edges
3. As earth is removed the caisson sinks
a) under the weight of concrete in its working chamber
b) under the weight of an entrance shaft
c) under the weight of concrete in its upper section
4. Workers and materials move in and out of the lower section
a) through a shaft
b) through a working chamber
c) through a top section

IV. Put the words in the right order

1. If, may, of with, caissons, are filled, they, become, concrete, part, structure, the, finished.
2. What, made, are, the, of, walls, of caisson?
3. The, sink, caisson, under, can, the, concrete, of, weight.
4. Is, to, keep, air, water, compressed, used, out, of, chamber, the working.
5. Caissons, piers, pneumatic, bridge, support, deep, in, water, located.
6. An, is, to change, air lock, used, the air pressure.
7. Quick, may, change, cause, of, disease, pressure, caisson.

V. Fill in the correct prepositions

to be filled … sth. to be open … sth. to move … and … of sth. to cut … sth. to pass … sth. to beep sth … sth. to be known … sth. to consist … sth. to be located … sth. to provide sth … smb.

VI. Translate the passage and answer the question: What was done to facilitate the setting of a foundation.

The Romans surmounted the problem of building bridge foundation in water by using cofferdams, which were temporary enclosures made of timber that were driven into the river bottom, made watertight with clay and then pumped dry to facilitate the setting of a foundation. This method was long used and only significantly improved with the development of the pneumatic caisson in the 19-th and 20-th centuries. In the early days of caisson use there were many casualties among workers who made a rapid transition from the compressed chamber to normal atmospheric pressure and developed caisson disease.

VII. Make the precis of the text

Text 4: BRIDGE CONSTRUCTION

Beam bridges. All bridges need to be secure at the foundations and abutments. In the case of a typical overpass beam bridge with one support in the middle, construction begins with the casting of concrete footings for the pier and abutments. Where the soil is especially weak, wooden or steel piles are driven to support the footings. After the concrete piers and abutments have hardened sufficiently, the erection of a concrete or steel superstructure begins. Steel beams are generally made in a factory, shipped to the site, and set in place by cranes. For short spans, steel beams are usually formed as a single unit. At the site, they are placed parallel to each other, with temporary forms between them so that a concrete deck can be cast on top. The beams usually have metal pieces welded on their top flanges, around which the concrete is poured. These pieces provide a connection between beam and slab, thus producing a composite structure.

For longer spans, steel beams are made in the form of plate girders. A plate girder is an I beam consisting of separate top and bottom flanges welded or bolted to a vertical web. While beams for short spans are usually of a constant depth.

Arch bridges. Arches are normally fabricated on-site. After the building of abutments (and piers, if the bridge is multiarch), a falsework is constructed. For a concrete arch, metal or wooden falsework and forms hold the cast concrete and are later removed. For steel arches, a cantilevering method is standard. Each side of an arch is built out toward the other, supported by temporary cables above or by falsework below until the ends meet. At this point the arch becomes self-supporting, and the cables or falsework are removed.

Suspension bridges. When bridges requiring piers are built over a body of water, foundations are made by sinking caissons into the riverbed and filling them with concrete. Cassions are large boxes or cylinders that have been made from wood, metal, or concrete. In the case of suspension bridges, towers are built atop the caissons. The first suspension-bridge towers were stone, but now they are either steel or concrete. Next, the anchorages are built on both ends, usually of reinforced concrete with embedded steel eyebars to which the cables will be fastened. An eyebar is a length of metal with a hole (or "eye") at the ends. Cables for the first suspension bridges were made of linked wrought-iron eyebars; now, however, cables are generally made of thousands of steel wires spun together at the construction site. Spinning is done by rope pulleys that carry each wire across the top of the towers to the opposite anchorage and back. The wires are then bundled and covered to prevent corrosion. When the cables are complete, suspenders are hung, and finally the deck is erected—usually by floating deck sections out on ships, hoisting them with cranes, and securing them to the suspenders.

Cantilever bridges. Like suspension bridges, steel cantilever bridges generally carry heavy loads over water, so their construction begins with the sinking of caissons and the erection of towers and anchorages. For steel cantilever bridges, the steel frame is built out from the towers toward the centre and the abutments. When a shorter central span is required, it is usually floated out and raised into place. The deck is added last.

The cantilever method for erecting prestressed concrete bridges consists of building a concrete cantilever in short segments, prestressing each succeeding segment onto the earlier ones. Each new segment is supported by the previous segment while it is being cast, thus avoiding the need for falsework.

Cable-stayed bridges. Construction of cable-stayed bridges usually follows the cantilever method (see Figure 3). After the tower is built, one cable and a section of the deck are constructed in each direction. Each section of the deck is prestressed before continuing. The process is repeated until the deck sections meet in the middle, where they are connected. The ends are anchored at the abutments.

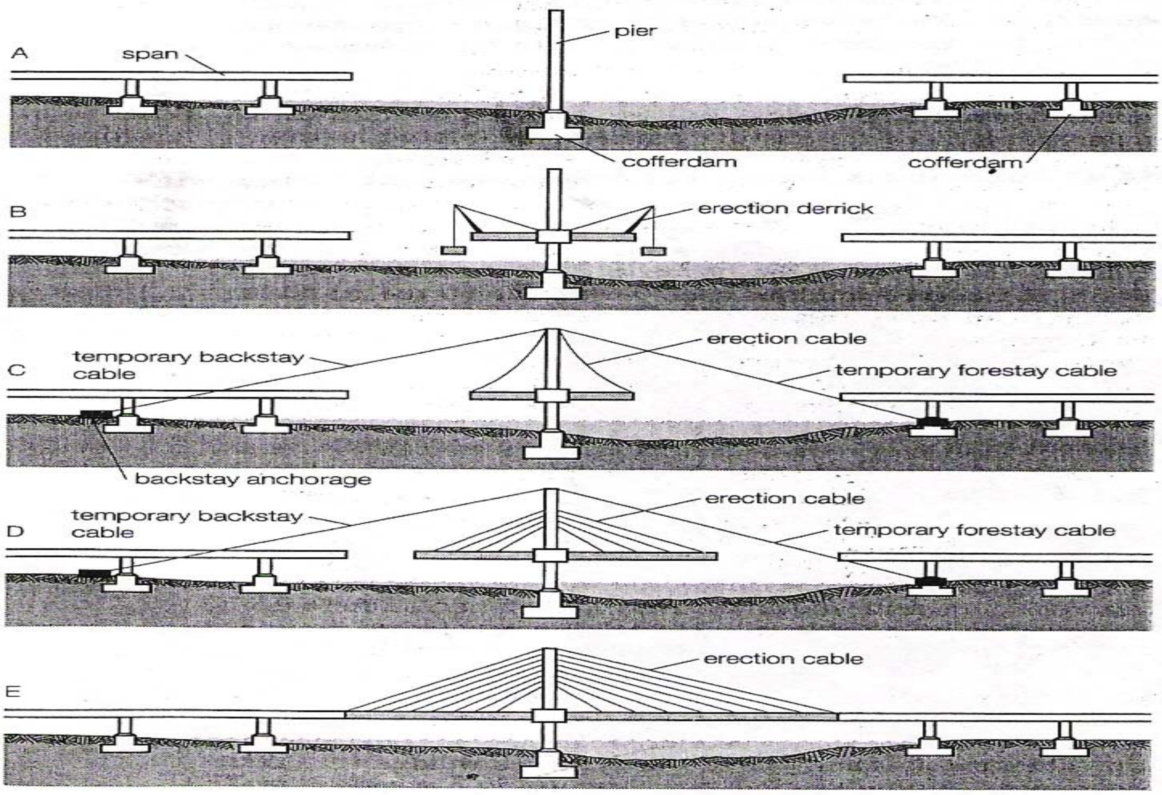


Figure 3: *Five steps in the cantilever-method construction of a cable-stayed bridge.*
(A) Erection of piers and support spans; (B) construction of work station on central pier and beginning of central span; (C) installation of temporary fore- and backstay cables, along with first suspension cables; (D) extension of central span; (E) completion of central span and removal of temporary cables.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The construction of an overpass beam bridge with one support begins with excavation.
2. Wooden beams are usually made on-site.
3. Metal pieces provide a connection between beam and slab.
4. A plate girder consists of separate top and bottom flanges.
5. Beams for short and long spans are usually of a constant depth.
6. Arches are made in a factory, shipped to the site and set in place by cranes.
7. When the ends at an arch meet, the cables or falsework are removed.
8. Foundations of suspension bridges are made by sinking caissons.
9. Suspension bridge towers have always been made of steel.
10. An anchorage is a length of metal with a hole at the ends.
11. Spinning is done by cables that carry each wire across the top of the towers to the opposite anchorage and back.
12. For steel cantilever bridges the steel frame is built out from the abutments toward the towers.
13. Falsework is not used in the construction of cantilever bridges.
14. Cable-stayed and cantilever bridges are built in the same way.

II. Answer the questions:

1. What does the construction of beam bridges begin with?
2. Where are steel beams made ?
3. What are metal pieces used for?
4. What is the difference between beams for short and long spans?
5. When are the cables or falsework removed?
6. How are foundations for bridges requiring piers made?
7. What is an eyebar?
8. What is done to prevent corrosion of the wires?
9. How is the steel frame built for cantilever bridges?
10. What does the cantilever method consists of?
11. What is done to avoid the need for falsework?

FOCUS

III. Insert the words from the list

substantial, continuous, material, away, complete,
multi-arch, falsework, size, rigidly,
to maintain, beam bridges, hindrance

1. The construction of an arch requires…. The type of falsework depends on the… of which the bridge is made and the… of the bridge. Massonry arches need… support and this type of falsework is called centring. For large bridges, the centring will be a … structure in its own right and will be expensive. For a … bridge it is desirable to re-use the centring for each span. In the case of a bridge across a river the centring will be in the form of a tied arch … it integrity.

2. … are generally in the form of plate girders, box girders or trusses. In all cases, a common construction method is to build the beam … from the final position and slide or lift it into place as a … unit.

3. A great advantage of cantilever is that it can be built out from a support without a … to traffic or navigation below. The technique depends on whether the cantilever is attached … to a free standing tower.

IV. Translate the words in brackets.

A major improvement over the single (балка) was the circular (арка), the basic design which was perfected by the ancient Romans. Because the (силы) on an arch bridge extend outward as well as (вниз) a condition called (сжатие) they could be build with longer (пролёты) and with (каменные блоки) rather than with single (брёвна) or slabs of stone. A variant type of a (подвесной мост) is the cable stayed span in which the supporting (тросы) run directly from tall vertical (башни) to the horizontal deck. Besides design, the other great challenge in building (прочные) bridges has been in the methods and materials used in their construction.

Text 5: MATERIALS

The four primary materials used for bridges have been wood, stone, iron, and concrete. Of these, iron has had the greatest influence on modern bridges. From iron, steel is made, and steel is used to make reinforced and prestressed concrete. Modern bridges are almost exclusively built with steel, reinforced concrete, and prestressed concrete.

Wood and stone. Wood is relatively weak in both compression and tension, but it has almost always been widely available and inexpensive. Wood has been used effectively for small bridges that carry light loads, such as footbridges. Engineers now incorporate laminated wooden beams and arches into some modern bridges.

Stone is strong in compression but weak in tension. Its primary application has been in arches, piers, and abutments.

Iron and steel. The first iron used during the Industrial Revolution was cast iron, which is strong in compression but weak in tension. Wrought iron, on the other hand, is as strong in compression as cast iron, but it also has much greater tensile strength. Steel is an even further refinement of iron and is yet stronger, superior to any iron in both tension and compression. Steel can be made to varying strengths, some alloys being five times stronger than others. The engineer refers to these as high-strength steels.

Concrete. Concrete is an artificial stone made from a mixture of water, sand, gravel, and a binder such as cement. Like stone, it is strong in compression and weak in tension. Concrete with steel bars embedded in it is called reinforced concrete. Reinforcement allows for less concrete to be used because the steel carries all the tension; also, the concrete protects the steel from corrosion and fire. Prestressed concrete is an important variation of reinforced concrete. A typical process, called post-tensioned prestressing, involves casting concrete beams with longitudinal holes for steel tendons—cables or bars—like reinforced concrete, but the holes for the tendons are curved upward from end to end, and the tendons, once fitted inside, are stretched and then anchored at the ends. The tendons, now under high tension, pull the two anchored ends together, putting the beam into compression. In addition, the curved tendons exert an upward force, and the designer can make this upward force counteract much of the downward load expected to be carried by the beam. Prestressed concrete reduces the amount of steel and concrete needed in a structure, leading to lighter designs that are often less expensive than designs of reinforced concrete.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The primary materials used for bridges have been iron and concrete.
2. Prestressed concrete is made of sand, gravel and cement.
3. Though wood is weak in compression and tension it has been widely used because it is cheap.
4. As stone is strong in tension and weak in compression it has been used in arches and piers.
5. Cast iron was first used during the industrial revolution.
6. Steel is stronger, superior to any iron in both tension and compression.
7. Concrete is strong in tension and weak in compression.
8. As steel carries all the tension, reinforcement allows to use less concrete.
9. The holes for tendons are curved inside.

II. Answer the questions

1. What materials are used for bridges?
2. What are modern bridges built with?
3. Why was wood widely used in the construction of bridges?
4. When was iron first used?
5. What is the difference between cast iron and wrought iron?
6. What is concrete?
7. What is reinforced concrete?
8. What does post-tensioned prestressing involve?
9 What puts the beams into tension?
10 What makes bridges lighter and less expensive?

LANGUAGE FOCUS

III. Match the meaning of the terms with their definition.

Wood, concrete, stone, iron, steel

1 The hard, compact mineral material of which rocks are made up.
2 The hard, fibrous substance beneath the bark of trees and shrubs.
3 An alloy of iron and carbon.
4 A mixture of cement, sand, gravel and water that hardens as it dries.
5 The commonest and most useful metal, from which tools and machinery are made.

IV. Insert the words and translate the sentences.

Ductility, strength, steel, dactile, form, yield, cast iron, difference, tension, spans

Amongst bridge materials … has the highest and most favourable strength. It is therefore suitable for the most daring bridges with the longest … A special merit of steel is its … due to which it deforms considerably before it breaks, because it begins to … above a certain stress level. For bridges high … steel is often preferred. The higher the strength the smaller the proportional … between the yield strength and the tensile strength. This means that high strength steels are not as … as those with normal strength. For building purposes, steel is fabricated in the … of plates by means of rolling when red hot for bearings and some other items … is used for members under … only, like ropes or cables there are special steels

V. Fill the gaps with the suitable derivatives of the word given on the right.

One of the man's … building materials is finding its way into a lot of new places these days. Concrete first discovered by the Romans, is now	Old
more … used in construction than all other materials together. Concrete is a synthetic stone which can be	Wide
formed while soft into … any shape the builder	Practical
wants. Portland cement … with water is the paste	Mix
that binds sand, gravel, clinker into an … rock that	Art
becomes … as the years pass. It was called Portland	Hard
because Joseph Aspolin, the English … who	Build
invented the first … scientifically made cement thought it resembled the rock excavated on the isle of Portland on the Dorset Coast.	Depend

VI. Read the passage and answer the question: *Why does prestressing significantly reduce the amount of structural materials?*

Often concrete is the main construction material in modern bridges. Reinforced concrete to which emplanted steel bars add strength, was introduced in 19th century; its first significant application was in an arched bridge built in

France in 1898. Engineers later learned to apply tension to the bars before pouring the concrete. This process called prestressing significantly reduces the amount of structural materials needed for a bridge. Prestressed concrete bridges often have a graceful look which cannot be achieved by iron and steel bridges with their geometric configurations.

Text 6: PERFORMANCE IN SERVICE

Bridges are designed, first, to carry their own permanent weight, or dead load; second, to carry traffic, or live loads; and, finally, to resist natural forces such as winds or earthquakes.

Live load and dead load. The primary function of a bridge is to carry traffic loads: heavy trucks, cars, and trains. Engineers must estimate the traffic loading. On short spans, it is possible that the maximum conceivable load will be achieved—that is to say, on spans of less than 100 feet (30 metres), four heavy trucks may cross at the same time, two in each direction. On longer spans of several thousand feet, the maximum conceivable load is such a remote possibility (imagine the Golden Gate Bridge with only heavy trucks crossing bumper-to-bumper in each direction at the same time) that the cost of designing for it is unreasonable. Therefore, engineers use probable loads a basis for design. In order to carry traffic, the structure must have some weight, and on short spans this dead load weight is usually less than the live loads. On longer spans, however, the dead load is greater than live loads, and, as spans get longer, it becomes more important to design forms that minimize dead load. In general, shorter spans are built with beams, hollow boxes, trusses, arches, and continuous versions of the same, while longer spans use cantilever, cable-stay, and suspension forms. As spans get longer, questions of shape, materials, and form become increasingly important. New forms have evolved to provide longer spans with more strength from less material. **Forces of nature.** Dead and live weight are essentially vertical loads, whereas forces from nature may be either vertical or horizontal. Wind causes two important loads, one called static and the other dynamic. Static wind load is the horizontal pressure that tries to push a bridge sideways. Dynamic wind load gives rise to vertical motion, creating oscillations in any direction. Like the breaking of an overused violin string, oscillations are vibrations that can cause a bridge to fail. If a deck is thin and not properly shaped and supported, it may experience dangerous vertical or torsional (twisting) movements.

The expansion and contraction of bridge materials by heat and cold have been minimized by the use of expansion joints in the deck along with bearings at the abutments and at the tops of piers. Bearings allow the bridge to react to varying temperatures without causing detrimental stress to the material. In arches, engineers sometimes design hinges to reduce stresses caused by temperature movement.

Modern bridges must also withstand natural disasters such as hurricanes and earthquakes. In general, earthquakes are best withstood by structures that carry as light a dead weight as possible, because the horizontal forces that arise from ground accelerations are proportional to the weight of the structure. (This phenomenon is explained by the fundamental Newtonian law of force equals mass times acceleration.) For hurricanes, it is generally best that the bridge be aerodynamically designed to have little solid material facing the winds, so that they may pass through or around the bridge without setting up dangerous oscillations.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Bridges must carry dead loads, live loads and resist natural forces.
2. The traffic loading is the same for all kinds of bridges.
3. Maximum conceivable load may be achieved on short and long spans.
4. If engineers estimate maximum load for spans over several thousand feet, the cost of a bridge will be very high.
5. Usually engineers use probable loads as basic for design.
6. On short spans the dead load weight is greater than the live loads.
7. Long spans must be designed to minimize dead loads.
8. Longer spans are built with arches, trusses, hollow boxes.
9. Forces from nature are essentially vertical loads.
10. Dynamic and static wind loads push a bridge sideways.
11. Vibrations can cause a bridge to fail.
12. The use of expansion joints in the deck along with bearings at the abutments increase the expansion and contraction of a bridge materials.
13. Bearings and hinges reduce stresses caused by temperature movement.

II. Answer the questions.

1. What are dead and live loads?
2. What must be taken into consideration designing a bridge?
3. Why is the maximum conceivable load different for short and long spans?
4. How do the loads differ on short and long spans?
5. What are shorter spans built with?
6. What questions arise as spans get longer?
7. What loads does the wind load?
8. What static wind load?
9. What is does dynamic wind load cause?
10. What can happen if a deck is thin and not properly shaped?
11. What is done to reduce stresses caused by temperature movement?
12. Why do structures with light dead weight withstand earthquakes better?

LANGUAGE FOCUS

III. Match the meaning of the terms with their definitions.

Live load, dead load, load

1. The weight or force supported by a structure or any part of it.
2. The load that a bridge must support in addition to its own weight.
3. A permanent and fixed load, such as the weight of a bridge or building.

IV. Match the words with their synonyms.

1. carry	a. evaluate
2. resist	b. perilous
3. estimate	c. withstand
4. conceivable	d. project
5. unreasonable	e. thinkable
6. evolve	f. develop
7. dangerous	g. bear
8. design	h. imprudent

V. Match the words with their opposites.

1. permanent	a. minimum
2. finally	b. unessential
3. heavy	c. thick

4. maximum d. temporary
5. important e. loop
6. vertical f. light
7. thin g. at first
8. hinge. h. horizontal

VI. Fill in correct prepositions.

1) … the same time; 2) … each directions; 3) to give rise … sth; 4) to react … sth; 5) … general; 6) to arise… sth; 7) to be proportional … sth; 8) to set … sth; 9) to pass … sth.

Follow up Activities.
Speak on:

1. Materials used in bridge construction.
2. Construction of bridges.

Unit 4: FAMOUS BRIDGES

Lead-in

1. What famous bridges do you know?
2. Which of them are your favourite? Why?

Find the following terms and memorize their meaning.

angled supports	lightpoles
anchorage	lightweight
anchored	magnitude
appearance	mandatory
artificial island	maintain
beam spanning	modeled after
blast	peninsula
bridge trestles	rivet
bridge-tunnel complex	snap
caisson's disease	shipping traffic
causeway	solid ground
clearance	supplemental columns
complex network	sway
counterbalance	swing spans
counteract	tetanus
cut off	total
dip	triangular braces
dismantle	tuned mass dampers
dolphin	withstand
explosive	wreck
feat	resistant
lane	rigid

Famous Cantilever and Cable-Stayed Bridges

Text 1: Firth of Forth Bridge

Lead-in

Look at the picture and answer the following questions:

1. What type is the Firth of Forth Bridge?
2. What can it be used for?

Brief information:

Location:
South Queensferry and North Queensferry, Scotland
Completion Date: 1890
Cost: $15 million
Length: 8,276 feet
Type: Cantilever
Purpose: Railway
Materials: Steel
Longest Single Span: 350 feet (center span)
Engineer(s): Benjamin Baker, John Fowler

Despite its unusual appearance, the bridge that spans Scotland's Firth of Forth has a lot in common with the simplest and oldest bridge type: the post and beam bridge. In a post and beam bridge, solid ground or columns, called piers, on opposite banks of a river or gap support long horizontal beams, often with support from supplemental columns at regular intervals along the way. Similarly, the Forth Railway Bridge spans the waterway called the Firth of Forth. In one important and innovative way, however, the Forth Bridge, designed in the late 1800's by structural engineers Benjamin Baker and Sir John Fowler, is very different from a simple beam bridge. Whereas a beam bridge relies on the strength of the beam spanning the distance between columns to carry its own weight, as well as the loads generated by cars and trains that travel over it, the Forth Bridge uses a cantilever system to counteract the downward force generated between columns.

The two main beams that make up a cantilever bridge rest almost perfectly balanced on piers located part of the way across the span. One end of each beam is also anchored to the nearest bank, while the other end stretches toward the center of the span, like a diving board over a pool. These suspended ends are joined by a relatively lightweight connecting span.

The Forth Bridge's shape -- tall and busy with many angled supports in some areas, almost dainty in others -- results from the need to be both as strong as necessary and as light as possible.

The midsection of each beam that attaches to the piers and carries most of the beam's weight and its load must be very strong, so engineers increased the depth (or height) of the bridge in this location, making it resistant to bending even under extreme loads. In contrast, the connecting spans, which are supported entirely by the main beams they connect, are built minimally to be as light as possible. Such a design allows the Forth Bridge to span a much greater distance with many fewer vertical piers than a typical post and beam bridge would require.

Fast Facts:

- The Firth of Forth Bridge may not have been a bridge at all -- engineers considered building a tunnel, but abandoned the idea because it seemed too risky.
- The Firth of Forth was the first bridge built primarily of steel.
- It took 54,000 tons of steel; 194,000 cubic yards of granite, stone, and concrete; 21,000 tons of cement; and almost seven million rivets to build the Firth of Forth Bridge.
- The midsection of each beam that attaches to the piers and carries most of the beam's weight.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The Firth of Forth Bridge has nothing in common with the oldest bridge types.
2. The Forth Bridge relies on the strength of the beam spanning the distance between columns to carry its own weight.
3. The Forth Bridge was designed by structural engineers Benjamin Baker and Sir John Fowler.
4. The Bridge uses a cantilever system.
5. Suspended ends of the bridge’s beams are joined by a heavy and strong connecting span.
6. The Forth Bridge's shape results from the need to be light as possible.
7. The connecting spans of the bridge are built to be as strong and heavy as possible.
8. The Firth of Forth was the first bridge built primarily of steel (54,000 tons).
9. Such a design allows the Forth Bridge to span a much greater distance.
10. The purpose of the bridge is a roadway.

II. Answer the following questions:

1. It's said that the Firth of Forth has much in common with the simplest and oldest bridge type. Do you agree? How can you prove the statement?
2. The bridge's engineers Benjamin Baker and Sir John Fowler made the Firth of Forth different from a simple beam bridge. In what way?
3. What was a canteliver system used for?
4. What did the shape of the bridge result from?
5. In what way was the midsection of each beam made strong?
6. Why were the connecting spans built lightweight?
7. What materials were used to build the bridge?
8. What was the reason of building a canteliver bridge at that location?

The Firth of Forth Bridge was said to be similar to the beam bridge and at the same time it differs much from this oldest bridge type. Complete the following table to illustrate the statement:

The Firth of Forth Bridge

Similarities with a beam bridge	Differences from a beam bridge
•	•
•	•
•	•

Text 2: Sunshine Skyway Bridge

Brief information:

Location: St. Petersburg and Bradenton, Florida, USA

Completion Date: 1987

Cost: $244 million

Length: 29,040 feet

Type: Cable-Stayed

Purpose: Roadway

Materials: Steel, concrete

Longest Single Span: 1,200 feet

Engineer(s): Figg & Muller Engineering Group

Completed in 1987, the Sunshine Skyway is the world's longest cable-stayed concrete bridge. It is probably the best known of the several dozen cable-stayed bridges that have been built in the United States since the late 1970s. Its popularity may be due to its unique color -- its cables are painted a bright taxicab yellow -- but the bridge also boasts an interesting history. The need for a lower Tampa Bay crossing can be traced back to the 1920's when a suspension bridge was proposed. However, it met opposition from shipping interests in Tampa, who wanted a tunnel instead. All ideas of a bridge or tunnel had to be put on the shelf when World War II broke out. After World War II the idea of a bridge was resurfaced. The need for a bridge was justified due to the traffic using the Bee Line Ferry as it was the only way to get to Bradenton and points south without having to make the long drive through Tampa.

Construction began on the original Sunshine Skyway Bridge in 1950 and it was completed in 1954. The original bridge was a cantilever through-truss with a vertical clearance of 150 feet and a shipping channel clearance of 800 feet, which was adequate for ships of that era. One could admire the architecture of the major support piers on either side of the shipping channel as well as the three other support piers on the deck truss section of the bridge.

During a violent thunderstorm on the morning of May 9, 1980, the freighter Summit Venture plowed into the cantilever bridge. More than 1,000 feet of the bridge fell into the bay, killing 35 motorists and bus passengers instantly. After the Skyway disaster there was a choice that had to be made:

Repair or replace? One side wanted the bridge repaired while the other side wanted a whole new bridge. After all, two way traffic was once again being maintained on the 1954 span. A decision was made to replace the Sunshine Skyway Bridge with a cable-stayed bridge modeled after a bridge in France. The Florida Department of Transportation began construction on a safer Sunshine Skyway Bridge only days later. More than 300 precast concrete segments were linked together with high-strength steel cables to form the roadway. Protecting the new bridge from ships was a big priority, so they installed large concrete islands, called dolphins, around each of the bridge's six piers to absorb unwanted impact.

Since it opened to traffic in 1987, the sleek, new Sunshine Skyway has won dozens of engineering and design awards.

In November 2005 the Sunshine Skyway was renamed the Bob Graham Sunshine Skyway Bridge in honor of the former Florida governor who made the right decision to replace the 1954 and 1971 cantilever spans with a new cable stayed bridge.

Fast Facts:

- The dolphins around each pier were designed to withstand the impact of an 87,000-ton ship.
- Twenty-one steel cables support the roadway. The cables are sheathed in steel pipes, nine inches in diameter. The pipes were painted a brilliant yellow to reflect its location: the Sunshine State.
- Forty-foot-wide roadways run on either side of the cables. This design allows drivers to have unobstructed views of the water.
- Tampa is a busy shipping port. To ensure that navigation would not be blocked, engineers designed the bridge to soar 190 feet above the water.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The Sunshine Skyway is probably the best known of the several world's longest cable-stayed concrete bridges.
2. The bridge is famous because of its colour.
3. More than 300 precast steel segments were linked together with high-strength steel cables to form the roadway.
4. Large concrete islands, called dolphins, were installed to protect the new bridge from ships.
5. The pipes were painted a brilliant yellow to reflect the colour of taxicabs in the Sunshine State.
6. Forty-foot-wide roadways run on either side of the cables and the design enables drivers to have a safe moving.
7. A violent thunderstorm destroyed a four-mile steel cantilever bridge.
8. The bridge was named after Bob Graham Sunshine Skyway.
9. Engineers designed the bridge to lift apr. 200 feet above the water.

II. Answer the following questions:

1. Why is the Sunshine Skyway so popular and famous?
2. Why did building the bridge meet an opposition?
3. What was the main purpose to build the bridge after the war?
4. What can you say about the disaster in 1980?

5. What decision was made after the disaster? What would you have done if you had been a chief engineer?

6. What was the reason to use dolphins? What are they?

7. The Sunshine Skyway was renamed. After whom was it renamed? Why?

LANGUAGE FOCUS

III. Match the meanings of these terms with their definition:

concrete, precast, deck, load, canteliver, pier, tunnel, bay, suspended, disaster, counteract, harbour, channel, balance

1. a vertical structure which supports the ends of a multi-span superstructure at a location between abutments.
2. mixture of gravel, sand, cement, and water
3. underground passage dug through a hill or under a road, river, esp. for a railway or road
4. great or sudden misfortune; catastrophe
5. a structural member which projects beyond a supporting column or wall and is counterbalanced and/or supported at only one end
6. the top surface of a bridge which carries the traffic

a. navigable part of a waterway
b. broad curving inlet of the sea
c. cast in its final stage before positioning
d. amount usu. or actually carried
e. hinder or neutralize by contrary action
f. a harbour
g. hanging, pendant
h. to be in equilibrium

IV. Complete the table with the missing words:

Noun	**verb**	**adjective / participle**
		suspended
	to span	
	to replace	
Decision		
		supplemental
Support		
		structural
	to construct	

Choose any 6 words and make sentences with them.

V. Say in other words (use synonyms or terms instead of words and word-combinations in italics):

The Forth Railway Bridge *bridges* the *navigable channel* called the Firth of Forth. The Sunshine Skyway bridge *stretches over* the Tampa Bay. The former is *a bridge made of cantilevers projecting from piers and connected by girders*, the latter is a *variation of suspension bridge in which the tension members extend from one or more towers at varying angles to carry the deck*. The connecting spans of the Firth of Forth bridge, which are *sustained* entirely by the main *horizontal structure members supporting vertical loads by resisting bending* they connect, are built minimally to be as light as *they can be*. To say about the Sunshine Skyway construction, more than 300 concrete segments *ready for use* were *connected* together with high-strength steel *thick strong metal ropes* to form the *part of the road used by vehicles*.

VI. Write down the key-words from the text.

VII. Get ready to speak on the Sunshine Skyway Bridge.

Famous Suspension Bridges

Text 3: Akashi Kaikyo Bridge

Lead-in:

1. What can the Akashi Kaikyo Bridge be famous for?
2. What is the purpose of the bridge?
3. What country does it present?

<u>*Brief information*</u>

Location: Kobe and Awaji-shima, Japan
Completion Date: 1998
Cost: $4.3 billion
Length: 12,828 feet
Type: Suspension
Purpose: Roadway
Materials: Steel
Longest Single Span: 6,527 feet

Engineer(s): Honshu-Shikoku Bridge Authority

In 1998, Japanese engineers stretched the limits of bridge engineering with the completion of the Akashi Kaikyo Bridge. Currently the longest spanning suspension bridge in the world, the Akashi Kaiko Bridge stretches 12,828 feet across the Akashi Strait to link the city of Kobe with Awaji-shima Island. It would take four Brooklyn Bridges to span the same distance! The Akashi Kaikyo Bridge isn't just long -- it's also extremely tall. Its two towers, at 928 feet, soar higher than any other bridge towers in the world. The Akashi Strait is a busy shipping port, so engineers had to design a bridge that would not block shipping traffic. They also had to consider the weather. Japan experiences some of the worst weather on the planet. Gale winds whip through the Strait. Rain pours down at a rate of 57 inches per year. Hurricanes, tsunamis, and earthquakes rattle and thrash the island almost annually. How did the Japanese engineers get around these problems? They supported their bridge with a truss, or complex network of triangular braces, beneath the roadway. The open network of triangles makes the bridge very rigid, but it also allows the wind to blow right through the structure. In addition, engineers placed 20 tuned mass dampers (TMDs) in each tower. The TMDs swing in the opposite direction of the wind sway. So when the wind blows the bridge in one direction, the TMDs sway in the opposite direction, effectively "balancing" the bridge and canceling out the sway. With this design, the Akashi Kaikyo can handle 180-mile-per-hour winds, and it can withstand an earthquake with a magnitude of up to 8.5 on the Richter scale!

Fast Facts:

1. The bridge is so long, it would take eight Sears Towers laid end to end to span the same distance.

2. The length of the cables used in the bridge totals 300,000 kilometers. That's enough to circle the earth 7.5 times!

3. The bridge was originally designed to be 12,825 feet. But on January 17, 1995, the Great Hanshin Earthquake stretched the bridge an additional three feet.

4. The bridge holds three records: it is the longest, tallest, and most expensive suspension bridge ever built.

COMPREHENSION CHECK:

I. Decide whether the following statements are true or false according to the text:

1. The Akashi Kaiko Bridge is the longest spanning cable-stayed bridge in the world.
2. The Akashi Kaiko Bridge being the longest blocks shipping traffic sometimes.
3. A complex network of triangular braces doesn't let the wind to blow through the structure.
4. The bridge is supported with a truss.
5. The TMDs help balancing the bridge.
6. Being the longest and the highest the Akashi Kaiko Bridge can't resist an earthquake

II. Answer the following questions:

1. What records does the Akashi Kaiko Bridge hold? Prove it with numbers.
2. What did engineers have to consider building the bridge?
3. How did engineers cope with problems they encountered?
4. What are tuned mass dampers? How do they work?
5. How strong is the bridge?

Text 4: Brooklyn Bridge

Brief information

Location: Manhattan and Brooklyn, New York, USA
Completion Date: 1883
Cost: $18 million
Length: 3,460 feet
Type: Suspension
Purpose: Roadway
Materials: Steel, granite
Longest Single Span: 1,595 feet
Engineer(s): John A. Roebling, Washington A. Roebling

Considered a brilliant feat of 19th-century engineering, the Brooklyn Bridge was a bridge of many firsts. It was the first suspension bridge to use steel for its cable wire. It was the first bridge to use explosives in a dangerous underwater device called a caisson. At the time it was built, the 3,460-foot Brooklyn Bridge was also crowned the longest suspension bridge in the world. But the Brooklyn Bridge was plagued with its share of problems. Before construction even began, the bridge's chief engineer, John A. Roebling, died from tetanus. The project was taken over and seen to its completion by his son, Washington Roebling. Three years later, Roebling developed a crippling illness called caisson's disease, known today as "the bends." Bedridden but determined to stay in charge, Roebling used a telescope to keep watch over the bridge's progress. He dictated instructions to his wife, Emily, who passed on his orders to the workers. During this time, an unexpected blast wrecked one caisson, a fire damaged another, and a cable snapped from its anchorage and crashed into the river.

Despite these problems, construction continued at a feverish pace. By 1883, 14 years after it began, Roebling successfully guided the completion of one of the most famous bridges in the world -- without ever leaving his apartment.

Fast Facts:

1. Although he was physically able to leave his apartment, Washington Roebling refused to attend the opening celebration honoring his remarkable achievement.

2. The bridge opened to the public on May 24, 1883, at 2:00 p.m. A total of 150,300 people crossed the bridge on opening day. Each person was charged one cent to cross.

3. The bridge opened to vehicles on May 24, 1883, at 5:00 p.m. A total of 1,800 vehicles crossed on the first day. Vehicles were charged five cents to cross. Today, the Brooklyn Bridge is the second busiest bridge in New York City. One hundred forty-four thousand vehicles cross the bridge every day.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The Brooklyn Bridge is considered a brilliant deed of 20th-century engineering.
2. The Brooklyn Bridge is said to be the longest in the world.

3. The bridge's chief engineer was John A. Roebling.
4. It was the first bridge to use a caisson.
5. The bridge is quite busy today.

II. Answer the following questions:

1. The Brooklyn Bridge is named as a bridge of many firsts. What firsts can you recollect?
2. Look at the *Brief Information* section—two engineers are mentioned to have built the bridge. How can you explain the fact?
3. What is a caisson? What problems did it present to the engineers?
4. How much did the bridge "earn" on the opening day?
5. By how many times has a total of vehicles risen since the first day?
6. Do you agree that The Brooklyn Bridge is considered a brilliant deed of 20th-century engineering?
7. Why were vehicles charged some money to cross the bridge? Do you think it's correct?

III. You've read about two most famous suspension bridges in the world. Can you compare them? Complete the following table:

	Akashi Kaikyo Bridge	Brooklyn Bridge
Type		
Date of completion		
Purpose		
Materials		
Building method		
Problems encountered		
Innovations		
Singularity		
Engineers		
Cost		

LANGUAGE FOCUS

IV. Match the meanings of these terms with their definition:

1. caisson 2. to span 3. cable 4. anchorage 5. to block 6. explosive 7. TDM 8. a tower 9. a suspension bridge 10. to snap	a. thick rope of wire or hemp b. located at the outermost ends, the part of a suspension bridge to which the cables are attached. Similar in location to an abutment of a beam bridge. c. a bridge which carries its deck with many tension members attached to cables draped over tower piers. d. to obstruct e. a tall pier or frame supporting the cable of a suspension bridge. f. to break suddenly g. to stretch from side to side of; extend across h. a device that is an effective and practical means for reducing resonant vibration in structures. i. watertight chamber for underwater construction work j. a substance likely to cause a violent outburst

V. Put the words in the right order to make a statement:

1. The, both, Bridge, long, tall, Akashi, is, and, Kaikyo, extremely.
2. Building, had to, Japanese, the weather, also, consider, the bridge, engineers.
2. The TMDs, the direction, the bridge, of the wind, sway, balancing, against.
3. is, triangular, with, of, complex, the bridge, network, braces, supported.
4. the, suspension, cable, Bridge, steel, bridge, was, the first, to, Brooklyn, use, its, wire, for.
5. underwater, an, American, a caisson, device, for, engineers, the, first, time, used, called, explosives, in.
6. Before, even, engineer, construction, the bridge's, died, began, chief.

VI. Read the text below and decide which answer A, B, C, or D best fits each space. Circle your answer.

Today, some call it the "most (1) _____ bridge in the world." But a century ago, (2) ______ the Golden Gate Bridge seemed like an impossible task.

Any bridge in this location would have to (3) ______ brutal winds, tide, and fog. It would also (4) _____ less than eight miles from the epicenter of the most catastrophic earthquake in history. Only one engineer was (5) ____ to gamble that his bridge could withstand such (6) ____ power. His name was Joseph Strauss. Strauss used more than one million tons of concrete to build the (7)_____ -- the massive blocks that grip the bridge's supporting cables. The north (8) ____ , which supports the tower, was built easily on a (9) _____ ledge 20 feet below the water. But on the southern San Francisco side, Strauss had to build his pier in the open ocean, 100 feet below the surface. He built a huge water-tight (10) ____ -- big enough to enclose a football field -- and pumped in hundreds of tons of concrete. By 1935, the towers were (11) ____ , and cable-spinning began. Two years later, the bridge was finished. Strauss completed the $27 million bridge only five months after the promised date and $1.3 million under budget. For his (12) ____ , Strauss received $1 million and a lifetime bridge pass.

1. A spectacle	B spectacular	C spectacled	D spectator
2. A building	B being built	C built	D to have built
3. A support	B stand	C oppose	D withstand
4. A sit	B sat	C sitting	D stands
5. A in wills	B will	C desired	D willing
6. A destruct	B destructive	C destruction	D destructed
7. A anchorages	B anchorage	C anchor	D piers
8. A span	B tower	C pier	D anchorage
9. A bedpost	B bedrench	C bedrop	D bedrock
10. A TDM	B cofferdam	C tube	D tunnel
11. A completed	B ended	C being built	D complete
12. A effort	B efforts	C skills	D skill

Famous Moveable Bridges

Text 5: Tower Bridge

Lead-in

1. Work with a partner to discuss the following questions and choose answers.

1. Everybody who has ever been to Great Britain can recollect its famous Tower Bridge. Where is it situated?

a) Cardiff b) London c) Edinburgh d) Oxford e) Cambridge

2. Why is this bridge called Tower Bridge? What do you think?

a) it has towers b) it is located close to the Tower c) Tower was the constructor of the bridge d) it looks like a tower

3. How old is the bridge?

a) about 100 years old b) about 200 years old c) about 150 years old

4. Look at the picture of Tower Bridge. What type is it?

a) cantilever b) arch c) bascule d) truss e) beam
f) suspension

5. Tower Bridge has two leaves that weigh more than 1, 000 tones. What time does it take to raise them?

a) 10 minutes b) 5 minutes c) 3 minutes d) 2 minutes
e) 1 minute

6. What materials were chiefly used to construct Tower Bridge?

a) bricks and concrete b) concrete and steel c) glass and steel
d) granite

2. Now read the text about Tower Bridge to see whether you are right.

Tower Bridge is a bridge in London, England, over the River Thames. It is close to the Tower of London, which gives it its name. It is occasionally incorrectly referred to as London Bridge, which is in fact the next bridge upstream.

In the second half of the 19th century increased commercial development in the East End of London led to a requirement of a new river crossing downstream of London Bridge. However, a traditional bridge could not be built because it would cut off access to the port facilities situated at that time in the Pool of London, between London Bridge and the Tower of London. A tunnel beneath the Thames, the Tower Subway was opened in 1870, but it could only accommodate pedestrian traffic.

A Special Bridge or Subway Committee was formed in 1876 to find a solution to the river crossing problem. It opened the design of the new crossing to public competition. Over 50 designs were submitted including one from civil engineer Sir Joseph Bazalgette. However, the evaluation of the designs was surrounded by controversy, and it was not until 1844 that a design submitted by Horace Jones, the City Architect, was finally approved. Jones' design was for a bascule bridge 800 feet (244 m) in length with two towers each 213 feet (65 m) high, built on piers.

The central span of 200 feet (61m) between the towers is split into two equal bascules, or leaves, which can be raised to an angle of 86 degrees to allow river traffic to pass through. Although each bascule weighs over 1, 000 tons, they are counterbalanced to minimize the force and time required to raise them, and they can be raised in under one minute. The original hydraulic raising mechanism was powered by pressurized water stored in six accumulators. Water was pumped into the accumulators by steam engines. Although the bridge is raised today electrically, the original steam engines are preserved as a visitor attraction.

Construction of the bridge started in 1886 and took 8 years, employing 5 major contractors and 432 construction workers. Two massive piers containing over 70, 000 tons of concrete were sunk into the river bed to support the construction. Over 11, 000 tons of steel provided the framework for the towers and walkways. This was then clad in Cornish granite and Portland Stone, both to protect the underlying steelwork and to give the bridge a more pleasant appearance. Jones died in 1887, and his chief engineer, Sir John Wolfe-Barry, took over the project.

Wolfe-Barry replaced Jones' original medieval style of façade with more ornate Victorian gothic style that makes the bridge such a distinctive landmark. The bridge was opened in 1894. The official opening ceremony was conducted by the Prince of Wales, the future King Edward VII of the United Kingdom and his wife Alexandra of Denmark.

The high-level walkways between the towers were never much used and were closed in 1910, but have now been reopened. The towers and walkways contain an exhibition about the Bridge's history, including the original steam engines that once powered the Bridge bascules. A "Behind the Scene" tour can be booked in advance where it is possible to see the bridge's command center (where the raising of the bridge is controlled when a vessel passes underneath). The bascules of the bridge are raised round five hundred times a year. The bridge sits almost directly above the Tower Subway, the world's first underground tube railway (1870), which, until the Bridge was opened, was the shortest way to cross the river from Tower Hill to Tooley Sreet.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Tower Bridge is a bridge in London, or London Bridge.
2. A traditional bridge could not be built in the second half of the 19th century because it would cut off access to the port facilities.
3. The Tower Subway could only accommodate pedestrian traffic.
4. The evaluation of the designs didn't provoke any controversy.
5. The central span of 200 feet (61m) between the towers is split into four equal bascules which can be raised to an angle of 36 degrees to allow river traffic to pass through.
6. Water was pumped into the accumulators by water turbines.
7. About 11, 000 tons of steel provided the framework for the towers and walkways.
8. The high-level walkways between the towers were never much used and were closed in 1910, having never been reopened.

II. Answer the following questions:

1. What was the reason of building Tower Bridge?
2. Why could not a traditional bridge be built between London Bridge and the Tower of London?
3. Who was in charge of finding a solution to the problem?
4. Was the construction of the Bridge an easy task?
5. What did Wolfe-Barry make for the bridge's beauty?
6. The official opening ceremony was conducted by the Prince of Wales, the future King Edward VII. TO your mind, why was the opening so grand?
7. What is the purpose of the bridge's command center?
8. How many times a year are the bascules of the bridge raised?

Text 6: George P. Coleman Bridge

Brief information:

Location: Yorktown, Virginia, USA
Completion Date: 1952 (original), 1995 (reconstruction)
Cost: $9 million (original), $76.8 million (reconstruction)
Length: 3,750 feet
Type: Movable (double swing span)
Purpose: Highway
Materials: Steel, concrete
Longest Single Span: 500 feet
Engineer(s): Parsons Brinckerhoff, Inc.

In the spring of 1995, the largest double-swing-span bridge in the United States was dismantled and replaced in only nine days. The George P. Coleman Bridge in Virginia was originally constructed in 1952 as a two-lane highway designed to carry no more than 15,000 vehicles a day. By 1995, the population around the bridge had increased so much that the structure was carrying in excess of 27,000 vehicles a day.

To make matters worse, the machinery that rotated the massive swing spans often experienced mechanical problems. In short, the bridge was a major headache. Engineers considered several designs to ease congestion -- from building a tunnel to constructing a new bridge upstream -- but the least expensive option proved to be reconstruction of the existing bridge. So between May 4 and May 13, 1995, about 2,500 feet of truss and swing spans -- complete with pavement, lightpoles, and barrier walls -- were floated in six sections over 40 miles from Norfolk, Virginia, to the bridge site. It marked the first time in engineering history that such an enormous bridge was assembled off site and floated into place.

The new four-lane bridge is three times wider than the original bridge and can now carry up to 50,000 vehicles daily.

Fast Facts:

- The George P. Coleman Bridge is the largest double-swing-span bridge in the United States and the second largest in the world.
- The new bridge weighs only 25 percent more than the original because the new spans are made of lightweight, high-strength steel.

- The two main river piers contain mechanisms that lift the swing spans to different elevations so they don't hit each other when they rotate.

COMPREHENSION CHECK

I. Answer the following questions:

1. How can you prove that the George P. Coleman Bridge is the second largest double-swing-span bridge in the world?
2. Do you agree that before the reconstruction the bridge was a major headache?
3. What is peculiar about the George P. Coleman Bridge?
4. How many vehicles can it carry nowadays?
5. How is it possible that swing spans don't hit each other while rotating?

LANGUAGE FOCUS

II. Match the meanings of these terms with their definition:

1. downstream 2.design 3. counterbalance 4. tunnel 5. framework 6. upstream 7. to rotate 8. lane 9. tunnel 10 swing bridge 11. congestion	a. in the direction contrary to the flow of a stream b. in the direction in which a stream etc. flows. c. an underground passage dug through a hill or under a road, river. d. a preliminary plan or sketch for making something e. weight or influence balancing another f. essential supporting structure g. abnormal accumulation or obstruction of traffic h. to move round an axis or centre, revolve i. A movable deck bridge which opens by rotating horizontally on an axis j. division of a road for a stream of traffic k. An underground passage for vehicles or pedestrians, especially one which is created by digging into earth. Occasionally, tunnel structures are built in an excavated area then covered over.

III. Fill in the correct prepositions:

Of (3), in (2), into, to (2), off, between, with, for

to find a solution … the river crossing problem, to be assembled … site and floated … place , the central span … 200 feet … the towers, the structure carries … excess … 27,000 vehicles … a day, to propose a design … a bascule bridge 244 m … length … two towers each 65 m … high, to be raised … an angle …86 degrees

IV. Say in other words:

Tower Bridge was built because of *the demand for* access across the Thames. A tunnel *under* the Thames could only *carry* pedestrian traffic. Although each *leave* of the bridge weighs quite much, they are counterbalanced to *limit* the force and time *necessary* to raise them. Two *heavy* piers were *put* into the river bed to support the *structure*. Victorian gothic style makes the bridge a *distinguishing* landmark.

V. Reconstruct the following texts and title them:

1. London … (noun) is a bridge …(adverb) the River … (proper noun) in London, connecting the …(adjective) centre of the city to the district of Southwark. … (preposition) 1750 it was the only bridge … (participle 1) the Thames in London. The present bridge , … (participle 11) in 1973, replaced one that was sold to a US businessman and rebuilt in Arizona.

2. … (noun) bridge is a bridge across the … (noun) Thames and is one of the most … (adjective) structures in London. It was … (participle 11) between 1886 and 1894 and is close to London … (noun) and the Tower of London. Its towers are in … (adjective) style and the part of the bridge with the road on … (pronoun) can be … (participle 11) to allow ships to pass through.

VI. Have you ever seen the bridges described in the photos?

VII. How are the following names and things connected to Tower Bridge? Say some words about each of them.

- A Special Bridge or Subway Committee
- the Tower of London
- Horace Jones
- Wolfe-Barry

- the Prince of Wales
- Cornish granite and Portland Stone
- A "Behind the Scene" tour

Imagine you are Horace Jones, the City Architect. You have to convince A Special Bridge or Subway Committee to approve your design. Describe the design you've submitted keeping in mind the following points:

Location of the Bridge	Time of construction
Type of the Bridge	Materials to be used
Characteristics of the Bridge	Costs (including labour force)
Style of the Bridge	Its being necessary to the city

VI. Make the plan of the text Tower Bridge.

VII. Write down the key-words to expand the plan.

VII. Make an abstract of the same text.

Text 7: Chesapeake Bay Bridge-Tunnel

Lead-in

Look at the picture and answer the following questions

1. Why is the bridge-tunnel considered unique?
2. What do you think about the length of the complex?
3. What is the main purpose of the bridge-tunnel complex?

Brief information:

Location: Cape Charles and Virginia Beach, Virginia, USA
Completion Date: 1964
Cost: $200 million
Length: 89,760 feet (total length); 79,200 feet (bridge length)
Type: Beam, tunnel
Purpose: Roadway
Materials: Steel, concrete
Longest Single Span: 100 feet
Engineer(s): Sverdrup & Parcel

Distinguished as an "Outstanding Civil Engineering Achievement" by the American Society of Civil Engineers in 1965, the Chesapeake Bay Bridge-Tunnel is nothing short of a modern engineering wonder. Dipping over and under open waters with a complex chain of artificial islands, tunnels, and bridges, the Chesapeake Bay Bridge provides a direct link between Southeastern Virginia and the Delmarva Peninsula.

The bridge-tunnel complex is 17.6 miles long from shore to shore, and it cuts 95 miles off the journey between Virginia Beach and points north of Wilmington, Delaware. The majority of the bridge-tunnel complex is above the water, supported by more than 5,000 piers. But due to the importance of shipping in the bay, the crossing was sunk deep beneath the bay in two mile-long tunnels to allow the passage of ships. Four artificial islands, each with approximately 10 acres of surface, provide the portals by which the road enters the tunnels. The original Chesapeake Bay Bridge-Tunnel 2-lane crossing consists of 12.5 miles of low level concrete bridge trestles, two tunnels each about one mile long, two high-level steel bridges, four man-made portal islands each 1,500 feet long, 1.5 miles of earthfill causeway across Fisherman Island, and about 5.5 miles of land approach highway. The roadway on the bridge portions is 28 feet wide.

The individual components of the Bridge-Tunnel are not the longest or the largest ever built; however, the total project is unique in the number of different types of major structures included in one crossing and the fact that construction was accomplished under the severe conditions imposed by northeasters, hurricanes, and the unpredictable Atlantic Ocean. It's quite an eerie experience to be driving along and see the road you're on disappear into the bay. Since it opened (1965), more than 67 million vehicles have crossed the Chesapeake Bay Bridge-Tunnel. It's possible that many just crossed it for the thrill of it! It is mandatory that the bridge be checked and serviced every five years. Since servicing the bridge takes about five years, the work never stops.

Fast Facts:

- Following its opening in 1964, the Bridge-Tunnel was selected as "One of the Seven Engineering Wonders of the Modern World" in a worldwide competition that included more than 100 major projects.
- Since it opened in 1965, more than 67 million vehicles have crossed the Chesapeake Bay Bridge-Tunnel.
- One artificial island actually has a gift shop, restrooms, and a parking lot to allow drivers to stretch, relax, and enjoy the scenic view.
- Four artificial islands, each with approximately 10 acres of surface, provide the portals by which the road enters the tunnels.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The Chesapeake Bay Bridge-Tunnel has nothing to do with a modern engineering wonder.
2. The Bridge-Tunnel is both the longest and the largest ever built.
3. The bridge-tunnel complex is about 32.6 km long from shore to shore.
4. The bridge-tunnel complex is mostly under the water.
5. On the way of the bridge-tunnel complex there are five artificial islands, each with approximately 10 acres of surface.
6. The roadway on the bridge portions is about 890 m wide.
7. The Bridge is not serviced less than once in 5 years period.
8. Artificial island are big enough to house shops, parking lots, restaurants etc.
9. The Bridge-Tunnel was selected as "The second of the Seven Engineering Wonders of the Modern World" in a worldwide competition that included more than 1000 major projects.

II. Answer the following questions:

1. Why was the bridge-tunnel complex distinguished as "Outstanding Civil Engineering Achievement"?
2. How long is the complex?
3. What components does the bridge-tunnel have?
4. Is the complex mostly above or under the water?

5. Why was the crossing sunk deep beneath the bay in two mile-long tunnels?
6. What conditions hindered constructing the bridge-tunnel complex?
7. How many times a decade is the Chesapeake serviced?
8. The Bridge-Tunnel was selected as "One of the Seven Engineering Wonders of the Modern World". Was the competition fierce?
9. What are artificial islands provide?

III. Complete the sentences:

1. The Chesapeake Bay Bridge provides …
2. The bridge-tunnel complex is …
3. The majority of the bridge-tunnel complex is above …
4. Four artificial islands provide …
5. The total project is unique in …

LANGUAGE FOCUS

IV. Make the collocations and make up the sentences with them:

complex chain of	deep beneath the bay
to provide	earthfill causeway
to be accomplished	a direct link
to be sunk	under the severe conditions
concrete	artificial islands
1.5 miles of	bridge trestles

V. Fill in the correct prepositions:

Society … Civil Engineers; to dip … and … waters; a link … smth and smth; some miles long … shore … shore; to be done … conditions; to be unique … the number … different types; to cross … the thrill … it.

VI. Say in other words (if very complicated, use the words after the text):

The Chesapeake Bay Bridge-Tunnel is a 23-mile, open-water drive across the *influx* of Chesapeake Bay. This highway *system* traverses *a series of shorter spans in which most of the spans are of similar length*, *raised roads or path across wet ground or through water*, bridges, *artificial* islands, and tunnels to *link* the southern tip of the Delmarva Peninsula with the Norfolk-Virginia Beach area. The at-sea a *particular place or position* also makes this the best place in Virginia to watch sea birds. The *road* over the water is broken up by two *underwater passages*. A stop at the restaurant and fishing *vertical structure which supports the ends of a multi-span superstructure at a location between abutments* 4 miles out at sea on one of the manmade *pieces of land completely surrounded by water* gives you the *possibility* to walk out over the water to look at birds, ocean-going *ships*, and views of the distant *land along the edge of a large area of water*.

(island, opportunity, complex, connect, location, drive, trestles, tunnels, pier, vessels, mouth, causeways, manmade, shore)

VII. Complete the text with suitable letters or words:

A bridge-tunnel is a water c…sing that uses a combina…. of bridge and tunnel structures. For water crossings, a …nel is generally more costly to c….ruct than a brid... . Ho..ver, navigational considerations at some l….ions may limit the use of high …dges or drawbridge spa.. when crossing shipping ch….ls, necessitating the use of a tu..el. In other instances, when lon..r ..stances are involv.., a combination of … and …nels may be less c….y and easi.. to ventilate than a single very long tunnel. This situation may oc..r when more eco….cal d..wbri..es are not allowed for one reason or ……. . Examples include the Hampton Roads Bridge-Tunnel and the Chesapeake …Bridge-Tunnel, a 37 km long …ucture (including ap…ach highways) that …sses the mouth of the Chesapeake Bay with a com…….. of bridges and tunnels across two widely separ…d shipping channels, using four a……..l islands built in the bay as …tals. Tunnels had to be used instead of ..awbrid... because the waterw… they cross are critical to mil…ry naval operations and could not a..ord to be blocked off by a bridge co…pse in the event of the ….ster or war.

FOLLOW UP ACTIVITIES:

Speak on:

1. Famous bridges.
2. Famous bridges in Belarus.

Unit 5: THE HISTORY OF TUNNELING

Find the following terms and memorize their meaning.

Drain	quarrying
drainage	surveying
obstacle	shaft
sewer system	fine quenching
divert	shield
inflow	lining

Text 1. TUNNEL

Tunnel is an underground passageway. The definition of what constitutes a tunnel is not universally agreed upon. However, in general tunnels have a ratio of the length of the passage to the width of at least 2 to 1. In addition, they should be completely enclosed on all sides (save the openings) for the length of the covered area. Tunnels were known in ancient times. They were, for instance, driven into the rock under the Pyramids of Egypt, and the Romans built one in Rome for their chief drain, parts of which still remain. One of the earliest tunnels known was made in Babylon. It passed under the Euphrates river and was built of arched brickwork being 12 feet high and 15 feet wide. Other ancient tunnels were built for water supply and for drainage. Tunnels are dug through hills and mountains, and under cities and waterways. They provide highways, subways, and railroads with convenient routes past natural and artificial obstacles. Miners use tunnels to reach valuable minerals deep within the earth. Tunnels also carry large volumes of water for hydroelectric power plants. Some tunnels provide fresh water for irrigation or drinking, and others transport wastes in sewer systems. In addition, tunnels provide underground space for cold storage. A tunnel may be for pedestrians and for cyclists, for general road traffic, for motor vehicles only, for rail traffic, or for a canal. while others carry other services such as telecommunications cables. There are even tunnels designed as wildlife crossings for European badgers and other endangered species. Some secret tunnels have also been made as a method of entrance or escape from an area. In the UK a pedestrian tunnel or other underpass beneath a road is called a subway. This term was also used in the past in the US, but is now used to refer to underground rapid transit systems. The central part of a rapid transit network is usually built in tunnels. To allow non-level crossings, some lines are in deeper tunnels than others. At metro stations there are usually also pedestrian tunnels from one platform to another. Often, ground-level railway stations also have one or more pedestrian tunnels under the railway to enable passengers to reach the platforms without having to walk across the tracks.

For water crossings, a tunnel is generally more costly to construct than a bridge. However, navigational considerations may limit the use of high bridges or drawbridge spans when intersecting with shipping channels at some locations, necessitating use of a tunnel. Additionally, bridges usually require a larger footprint on each shore than tunnels; in areas with particularly expensive real estate, such as Manhattan and urban Hong Kong, this is a strong factor in tunnels' favor. Examples of water-crossing tunnels built instead of bridges include the Holland Tunnel and Lincoln Tunnel between New Jersey and Manhattan in New York City, and the Elizabeth River tunnels between Norfolk and Portsmouth, Virginia and the Westerscheldetunnel, Zeeland, Netherlands. Some water crossings are a mixture of bridges and tunnels, such as the Denmark to Sweden link.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. A ratio of the length of the passage to the width is 3 to 1.
2. Tunnels built in ancient times didn’t preserve.
3. The first tunnel was driven into the rock under the Pyramids of Egypt.
4. Ancient tunnels were built for water supply and for drainage.
5. Miners use tunnels to carry large volumes of water for hydroelectric power plant.
6. Except transporting fresh water for irrigation or drinking, tunnels provide underground space for cold storage.
7. In the UK a pedestrian tunnel or other underpass beneath a road is called an underground.
8. The central part of a rapid transit network is usually built in tunnels.
9. Ground level railway stations have only one pedestrian tunnel.
10. For water crossing a bridge is cheaper to construct than a bridge.

II. Answer the questions.

1. What is tunnel?
2. Where were the earliest tunnels built?

3. What do tunnels provide?
4. How is an underpass beneath a road called in the UK?
5. What does the term subway refer to in the US?
6. Why are some lines located in deeper tunnels than others?
7. What is done to allow passengers to reach the platforms with safety?
8. Where may the use of high bridges or draw bridges be limited?
9. Why are tunnels more preferable in such areas as Manhattan and Hong Kong?
10. What examples of water crossing tunnels built instead of bridge do you know?

LANGUAGE FOCUS

III. Match the words with their synonyms

1. ancient	a) hindrance
2. brickwork	b) foot-passenger
3. obstacle	c) intersection
4. pedestrian	d) antique
5. real estate	e) flight
6. crossing	f) estimate
7. escape	g) masonry
8. value	h) immovables

IV. Match the words with their opposites

1. length	a) exit
2. natural	b) slow
3. entrance	c) bank
4. rapid	d) disagree
5. costly	e) width
6. shore	f) appearance
7. agree	g) cheap
8. escape	h) artificial

V. Insert the prepositions

1) … addition 2) to pass … something 3) to agree … 4) to provide something … something 5) to be designed … something 6) a method … something 7) to refer … something 8) to walk … something 9) to limit the use

… something 10) … favour 11) instead … something 12) a mixture … something

VI. Insert the words from the list

transportation, vertical, construction, excavating, underground, tube, inside, portal, bottom, backfill

A tunnel is essentially horizontal … passageway produced by excavating or occasionally … by nature's action in dissolving a soluble rock. A … opening is usually called a shaft. Tunnels have many uses: for mining ores, for … and for conducting water and sewage. True tunnels and chambers are excavated from the … and then lined as necessary to support the adjacent ground. A hillside tunnel entrance is called a … . Tunnels may also be started from the … of a vertical shaft or from the end of a horizontal tunnel driven principally for … access and called an adit. So-called cut-and-cover tunnels (more correctly called conduits) are built by … from the surface, constructing the structure, and then covering with … . Tunnels underwater are now commonly built by the use of an immersed … .

VII. Make the precis of the text.

Text 2. THE HISTORY OF TUNNELING

Part 1

It is probable that the first tunneling was done by prehistoric people seeking to enlarge their caves. All major ancient civilizations developed tunneling methods. In Babylonia, tunnels were used extensively for irrigation; and a brick-lined pedestrian passage some 3,000 feet (900 metres) long was built about 2180 to 2160 BC under the Euphrates River to connect the royal palace with the temple. Construction was accomplished by diverting the river during the dry season. The Egyptians developed techniques for cutting soft rocks with copper saws and hollow reed drills, both surrounded by an abrasive, a technique probably used first for quarrying stone blocks and later in excavating temple rooms inside rock cliffs. Even more elaborate temples were later excavated within solid rock in Ethiopia and India.

The Greeks and Romans both made extensive use of tunnels: to reclaim marshes by drainage and for water aqueducts, such as the 6th-century-BC Greek water tunnel on the isle of Samos driven some 3,400 feet through lime-largest stone with a cross section about 6 feet square. By that time surveying methods (commonly by string line and plumb bobs) had been introduced, and tunnels were advanced from a succession of closely spaced shafts to provide ventilation. Ventilation methods were primitive, often limited to waving a canvas at the mouth of the shaft, and most tunnels claimed the lives of hundreds or even thousands of the slaves used as workers.

Because the limited tunneling in the Middle Ages was principally for mining and military engineering, the next major advance was to meet Europe's growing transportation needs in the 17th century. The first of many major canal tunnels was the Canal du Midi (also known as Languedoc) tunnel in France, built in 1666-81 by Pierre Riquet as part of the first canal linking the Atlantic and the Mediterranean.

A notable canal tunnel in England was the Bridgewater Canal Tunnel, built in 1761 by James Brindley to carry coal to Manchester from the Worsley mine. Many more canal tunnels were dug in Europe and North America in the 18th and early 19th centuries. Though the canals fell into disuse with the introduction of railroads about 1830, the new form of transport produced a huge increase in tunneling, which continued for nearly 100 years as railroads expanded over the world.

Much pioneer railroad tunneling developed in England. A 3.5-mile tunnel (the Woodhead) of the Manchester-Sheffield Railroad (1839-45) was driven from five shafts up to 600 feet deep.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The first tunnels were built by Romans.
2. In the Middle Ages tunnels were built to connect castles with churches
3. The Egyptians used advanced technologies for cutting soft rocks.
4. The Greeks and Romans widely used tunnels.
5. Ventilation methods were limited to waving a canvas at the mouth of the shaft.
6. Transportation needs greatly increased in the 17-th century in Europe.
7. The first canal tunnel was built in France to connect The Indian and the Mediterranean.
8. James Brindley built the Bridgewater Canal Tunnel to carry coal.
9. The introduction of railroads slowed the building of canal tunnels.
10. Railroad tunneling was developed mainly in England.

II. Answer the questions

1. Why did prehistoric people do the first tunneling?
2. Who developed tunneling methods?
3. How were tunnels used in ancient times?
4. What method had been introduced by the 6-th century B.C.?
5. What were ventilation methods like?
6. What were tunnels built for in Middle Ages?
7. Why were canal tunnels built in the 17-th century?
8. What canal tunnels do you know?
9. Why did the canal tunnels fall into disuse about 1830?
10. When was railroad tunneling developed?

LANGUAGE FOCUS

III. Match the words with their synonyms.

1. to look for	a) extensively
2. to expand	b) to connect
3. widely	c) to divert
4. to link	d) advance
5. to complete	e) to seek
6. to draw aside	f) primitive
7. approach	g) to accomplish
8. simple	h) to enlarge

IV. Match the words with their opposites

1. modern	a) irrigation
2. drainage	b) expand
3. fill up	c) prehistoric
4. plain	d) notable
5. source	e) mouth
6. civil	f) elaborate
7. obscure	g) military
8. narrow	h) excavate

V. Fill in the prepositions.

1) To be used … sth, 2) to connect sth … sth, 3) to make use … sth, 4) to limit … sth, 5) … the mouth, 6) to carry sth … sth, 7) with the introduction … sth, 8) to expand … the world, 9) increase … sth, 10) to fall … disuse.

VI. Insert the words from the list

preservation, dangerous, heating, sandstone, road, lining, cooling, safety, to drain, salt mine

1. Tunneling is difficult, expensive and … engineering work.

2. Temple on the Nile was built in … about 1250 B.C. for Ramses II. In the 1960's it was cut apart and moved to higher ground for … before flooding from the Aswan High Dam.
3. Perhaps the largest tunnel in ancient times was a 4800 foot-long, 25 foot-wide, 30 foot-high … tunnel between Naples and Pozzuoli, executed in 36 B.C.
4. To save the need for a … , most ancient tunnels were located in reasonably strong rock. It was broken off by so called fire quenching, a method involving … the rock with fire and suddenly … in by dousing with water.
5. In A.D. 41 the Romans used some 30 000 men for 10 years to push a 3.5 mile (6 kilometers) tunnel … Lacus Fucinus.
6. Far more attention was paid to ventilation and … measures when workers were freemen, as shown by archaeological diggings at Hallstall, Austria, where … tunnels have been worked since 2500 B.C.

VII. Make the precis of the text

Text 2. THE HISTORY OF TUNNELING

Part 2

The great civil engineers of the nineteenth century were drawn into really grand tunneling. Two new kinds of transport created a need for tunnels. Railways had to lie on almost flat ground, and so did England's huge canal system. By the early 1800s those canals had become England's primary commercial trade network. Canals and railways, like the Roman aqueducts before them, spawned heroic tunneling through obstacles. Tunneling under rivers was considered impossible until the protective shield was developed in England by Marc Brunei, a French emigre engineer. The first use of the shield, by Brunei and his son Isambard, was in 1825 on the Wapping-Rotherhithe Tunnel through clay under the Thames River. The tunnel was of horseshoe section 22'/4 by 37'/2 feet and brick-lined. After several floodings from hitting sand pockets and a seven-year shutdown for refinancing and building a second shield, the Brunels succeeded in completing the world's first true subaqueous tunnel in 1841, essentially nine years' work for a 1,200-foot-long tunnel. During the 19th and 20th centuries, the development of railroad and motor vehicle transportation led to bigger, better, and longer tunnels. With the latest tunnel construction technology, engineers can bore through mountains, under rivers, and beneath bustling cities. Before carving a tunnel, engineers investigate ground conditions by analyzing soil and rock samples and drilling test holes. Today, engineers know that there are three basic steps to building a stable tunnel. The first step is excavation: engineers dig through the earth with a reliable tool or technique. The second step is support: engineers must support any unstable ground around them while they dig. The final step is lining: engineers add the final touches, like the roadway and lights, when the tunnel is structurally sound. Worldwide efforts are under way to accelerate improvements in the technology of underground construction and are likely to be stimulated as a result of the 1970 OECD International Conference recommending improvement as government policy. The endeavour involves specialists such as geologists, soil- and rock-mechanics engineers, public-works designers, mining engineers, contractors, equipment and materials manufacturers, planners, and also lawyers, who aid in the search for more equitable contractual methods to share the risks of unknown geology and resulting extra costs.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The great military engineers of the 19-th century were drawn into grand tunneling.
2. The development of new kinds of transport created a need for tunnels.
3. By the early 1800s railways had become England’s primary commercial trade network.
4. The development of the protective shield made possible the construction of tunnels under rivers.
5. The first use of the shield was done by Isambard in 1825 under the Thames River.

6. The world's first true subaqueous tunnel was completed in 1841.
7. The development of railroad and motor vehicle transportation accelerated the construction of tunnels.
8. Engineers must investigate ground conditions after the completion of the tunnel.
9. There are four basic steps in building a stable tunnel.
10. The endeav our involves a wide range of specialists.

II. Answer the questions.

1. Why were the engineers of the 19-th century drawn into grand tunneling?
2. What had become England's primary commercial trade network by the early 1800s?
3. Who developed the protective shield?
4. When and where was the first use of the shield?
5. How much time did it take to build the world's first true subaqueous tunnel?
6. What can engineers do using the latest tunnel construction technology?
7. How are ground conditions investigated?
8. What are the steps of tunneling?
9. When is excavation done?
10. Who is involved in tunneling?

LANGUAGE FOCUS

III. Match the words with their synonyms.

1. necessity	a. grand
2. come to an end	b. protect
3. pattern	c. complete
4. plane	d. basic
5. main	e. need
6. fussy	f. sample
7. great	g. bustling
8. defend	h. flat

IV. Match the words with their opposites.

1. mountainous	a. add
2. deterioration	b. create
3. first	c. accelerate
4. unsteady	d. flat
5. delay	e. final
6. diminish	f. improvement
7. ruin	g. reliable
8. insecure	h. stable

V. Fill in the prepositions.

1) to be drawn … sth; 2) a need … sth; 3) to succeed … sth; 4) to lead … sth; 5) to dig … sth; 6) … the search …; 7) to share the risk … sth.

VI. Insert the words from the list.

Techniques, combination, forced, mountain, notorious, railroad, long-distance, spectacular, succession, drainage, inflow

In the United States the first … tunnel was a 701-foot construction on the Allegheny Portage Railroad. Built in 1831-33 it was a … of canal and railroad systems carrying canal barges over a summit. Simultaneously more … railroad tunnels were being started through the Alps. Its engineer, A. Sommeiller, introduced many pioneering … . Ventilation became a major problem which was solved by the use of … air from water powered fans and a horizontal diaphragm at mid height. Most … rock tunnels have encountered problems with water inflows. One of the most … was the first Japanese Tanna Tunnel driven through the Takiji Peak in 1920. The engineers and crews had to cope with a long … of extremely large inflows the first of which killed 16 men and buried 17 others. Three years later another major … drowned several workers. In the end Japanese engineers hit on the expedient of digging a parallel … tunnel the entire length of the main tunnel. In addition, they resorted to compressed - air tunneling with shield and air lock a technique almost unheard - of in … tunneling.

FOLLOW UP ACTIVITIES:
Speak on:
1. The history of tunneling.
2. The history of tunneling in Belarus.

Unit 6: KINDS OF TUNNELS

Lead in

What are tunnels used for?

Find the following terms and memorize their meaning.

to bore	to withstand
steep grades	blasting
to haul	open cut
exhaust fumes	cut and cover
fan	shield
jam	interference
to line	savings

Text 1. KINDS OF TUNNELS

Tunnels have many uses: for mining ores, for transportation—including road vehicles, trains, subways, and canals—and for conducting water and sewage. Underground chambers, often associated with a complex of connecting tunnels and shafts, increasingly are being used for such things as underground hydroelectric-power plants, ore-processing plants, pumping stations, vehicle parking, storage of oil and water, water-treatment plants, warehouses, and light manufacturing; also command centres and other special military needs.

There are four main types of tunnels. They are: (1) rail road tunnels, (2) motor-traffic tunnels, (3) water tunnels and (4) mine tunnels.

Railroad tunnels. Among the world's greatest engineering feats was the boring of long railroad tunnels through the rocks of the Alps and the Rocky Mountains. Railroad tunnels reduce traveling time and increase the efficiency of trains. The steeper a locomotive must climb, the less weight it can pull. Tunnels through mountains reduce steep grades, allowing trains to haul more goods and people.

Motor-traffic tunnels. These tunnels provide routes for automobiles, trucks, and other motor vehicles. Such tunnels have special equipment to remove exhaust fumes. For example, the Holland Tunnel, which is situated under the Hudson River and which links New York City and New Jersey, uses electric fans for ventilation. These fans are capable of completely changing the air in the tunnel every 90 seconds. Many motor-traffic tunnels also have signal lights and special monitoring systems to help prevent traffic jams.

Water tunnels. Many tunnels provide water to city waterworks, to hydroelectric power plants, or to farms for irrigation. Others carry storm drainage or sewage. Most water tunnels measure 10 to 20 feet (3 to 6 meters) or more in diameter, and they have smooth linings that help the water flow. Many tunnels carrying water to hydroelectric power plants are lined with steel to withstand extremely high water pressures.

Mine tunnels. These are made by blasting or by tunneling machines. Mine shafts are not usually lined, but they may have supports.

COMPREHENSION CHECK

1. Decide whether the following statements are true or false according to the text:

1. Tunnels are mainly used for transportation including road vehicles, trains, subways and canals.
2. Underground chambers serve different purposes.
3. There are 5 main types of tunnels.
4. The boring of long railroad tunnels through the rocks of the Alps and the Rocky Mountains was an outstanding feat.
5. Though railroad tunnels increase the efficiency of trains they don’t reduce travelling time.
6. The steeper a locomotive must climb, the heavier weight it can pull.
7. It is necessary for motor-traffic tunnels to be equipped with special equipment to remove exhaust fumes.
8. Electric fans for ventilation in the Holland Tunnel can completely change the air in the tunnel every hour.
9. Water tunnels provide water to city waterworks.
10. Mine tunnels are made by tunneling machines.

2. Answer the questions:

1. What are tunnels used for?
2. Why are underground chambers so widely used?
3. How many types of tunnels do you know?
4. What is one of the world’s greatest engineering feats?
5. Why do railroad tunnels increase the efficiency of trains?
6. What do motor-traffic tunnels provide?

7. How are exhaust fumes removed?
8. Why do motor-traffic tunnels have special signals and monitoring systems?
9. Where do tunnels carry water?
10. How are mine tunnels made?

LANGUAGE FOCUS

III. Insert the words from the list

bottom, shaft, rock, adjacent, underwater, trench, tunnel, chambers, horizontal, entrance

A tunnel is an essentially … underground passageway produced by excavation or occasionally by nature’s action in dissolving a soluble … . A vertical opening is usually called a … . True tunnels and … are excavated from inside. Then, they are lined to support the … ground. A hillside tunnel … is called a portal. Tunnels may also be started from the … of a vertical shaft or from the end of a horizontal …, driven principally for construction access and called an adit. Tunnels … are now commonly built by the use of an immersed tube. Long prefabricated tube sections are floated to the site, sunk in a prepared … and covered with backfill.

IV. Fill in the prepositions:

1. the efficiency … sth; 2) to provide sth … sth; 3) to be associated … sth; 4) to be situated … sth; 5) to be capable … sth; 6) … diameter; 7) to be lined … sth.

V. Complete the sentences using appropriate derivates of the words given on the right.

Tunnel is an underground passageway. Tunnels provide	convenience
highways, subways and railroad with … routs past … and	nature
artificial obstacles. … use tunnels to reach … minerals	mine
	value
deep within the earth. Some tunnels provide fresh water	
for … or …, and others transport wastes in sewer systems.	irrigate
	drink
In addition, tunnels provide underground space for cold … .	store

VII. Make the precis of the text

Text 2. SUBWAY

Subway, also called underground, tube, or metro, underground railway system used to transport large numbers of passengers within urban and suburban areas. Subways are usually built under city streets for ease of construction, but they may take shortcuts and sometimes must pass under rivers. Outlying sections of the system usually emerge above-ground, becoming conventional railways or elevated transit lines. Subway trains are usually made up of a number of cars operated on the multiple-unit system.

There are three types of subways. One is called the open cut. The construction crew tears out the streets and builds the subways in deep ditches. If two lines are going to cross, the crew digs one roadbed deeper than the other. If the crew lays a pavement or other type of cover over the cut in the ground, the subway is called a cut and cover subway. The third form of subway, which is called a tube, is constructed by boring through the earth at the desired depth without disturbing the surface. This type of construction is for one or two tracks. The tunnels of an open-cut subway have a rectangular shape. The tunnels of a tube subway are usually circular or semicircular. New York City's subway is mainly rectangular. Much of the London subway is semicircular.

London's underground. The first subway system was proposed for London by Charles Pearson, a city solicitor, as part of a city-improvement plan shortly after the opening of the Thames Tunnel in 1843.

After 10 years of discussion, Parliament authorized the construction of 3.75 miles (6km) of underground railway between Farringdon Street and Bishop's Road, Paddington. Work on the Metropolitan Railway began in 1860 by cut-and-cover methods—that is, by making trenches along the streets, giving them brick sides, providing girders or a brick arch for the roof, and then restoring the roadway on top. On Jan. 10, 1863, the line was opened using steam locomotives that burned coke and, later, coal; despite sulfurous fumes, the line was a success from its opening, carrying 9,500,000 passengers in the first year of its existence. In 1866 the City of London and Southwark Subway Company (later the City and South London Railway) began work on their "tube" line, using a tunneling shield developed by J.I I. Greathead. The tunnels were driven at a depth sufficient to avoid interference with building foundations or public-utility works, and there was no disruption of street traffic. The original plan called for cable operation, but electric traction was substituted before the line was opened. Operation began on this first electric underground railway in 1890 with a uniform fare of two pence for any journey on the 3-mile (5-kilometre) line. In

1900 Charles Tyson Yerkes, an American railway magnate, arrived in London, and he was subsequently responsible for the construction of more tube railways arid for the electrification of the cut-and-cover lines. During World Wars I and II the tube stations performed the unplanned function of air-raid shelters. Today, London has 10 lines that provide quick, cheap transportation to all parts of the city and suburbs. This subway system is often called the tube or the underground. Some of its subway lines are so far underground that passengers go down on elevators. There are numerous escalators which help to keep the traffic moving. The first was installed in 1911. One of them at Leicester Square is over 80 feet in length. On long escalators the speed is changeable. The "up" escalator runs at full speed when carrying passengers, but when empty it runs at half speed. Many of the new escalators have automatic control making a more frequent service throughout the day possible.

Automatic trains, designed, built, and operated using aerospace and computer technology, have been developed in a few metropolitan areas, including a section of the London subway system, the Victoria Line (completed 1971). The first rapid-transit system to be designed for completely automatic operation is BART (Bay Area Rapid Transit). Air-conditioned trains with lightweight aluminum cars, smoother and faster rides due to refinements in track construction and car-support systems, and attention to the architectural appearance of and passenger safety in underground stations are other features of modern subway construction.

COMPREHENSION CHECK

1. Decide whether the following statements are true or false according to the text:

1. Subway is used to transport passengers from one city to another.
2. Subways are usually built under city streets and sometimes under rivers.
3. There are four types of subways.
4. The construction crew digs one roadbed deeper than the other if two lines are going to cross.
5. The subway is called a cut and cover subway if the crew lays a pavement under the cut.
6. The tunnels of a tube subway have a rectangular shape.
7. New York City's subway is mainly semicircular.
8. In 1863 the City of London and Southwark Subway Company began work on their "tube".

9. A uniform fare for any journey on the 3-mile line was two pence.
10. Some of the subway lines are rather far underground and passengers go down on elevators.

II. Answer the questions:

1. What is a subway?
2. How many types of subways are there?
3. When does the crew dig one roadbed deeper than the other?
4. What is the shape of an open-cut subway and a tube subway?
5. Who proposed the first subway system for London?
6. Why was the first line a success despite sulfurous fumes?
7. How were the tube stations used during world wars I and II?
8. When was the first escalator installed?
9. Why is the speed on long escalators changeable?

LANGUAGE FOCUS

III. Insert the words from the list

subway, cars, trench, lead, street traffic, overhead, masonry, cut-and-cover method, shafts

1. Many other cities followed London's … . In Budapest, a 2.5 mile electric subway was opened in 1896, using single … with trolley poles; it was the first subway on the European continent. Considerable savings were achieved in its construction over earlier … using a flat roof with steel beams instead of a brick arch, and therefore a shallower … . In Paris the rapid progress was attributed to the wide streets … and the modification of the cut-and-cover method devised by the French engineer F.Bienvenue. Vertical … were sunk at intervals along the route; and from there side trenches were dug and … foundations to support wooden shuttering were placed immediately under the road surfaces. Construction of the roof arch then proceeded with relatively little disturbance to … . This method, while it is still used in Paris, has not been widely copied in … construction elsewhere.

IV. Fill in the gaps with suitable derivatives of the words given on the right:

In the United States the first … subway line was constructed in Boston between 1895 and 1897. It was 1.5	practice length

miles … and at first used trolley streetcars or tramcars. Later Boston acquired … subway trains. New York City opened the first section of what was to become the … system in the world on October 27, 1904. In Canada, Toronto opened a subway in 1954, a second system was constructed in Montreal during the 1960s … Paris-type rubber-tires cars. In Mexico City the first stage of a … underground and surface metro system was opened in 1969.	convention large use combine

FOLLOW UP ACTIVITIES

Speak on: 1. Kinds of tunnels. 2. Minsk underground.

Unit 7: TUNNELING TECHNIQUES

Find the following terms and memorize their meanings

Submerged tunnel	Jack
Jumbo	Shale
Rock tunnel	Sandstone
Muck	Friable
Shield	Access
Mucker	Bed
Reversible	

Text 1: BASIC TUNNELING SYSTEM

Tunnels are generally grouped in four broad categories, depending on the material through which they pass: soft ground, consisting of soil and very weak rock; hard rock; soft rock, such as shale, chalk, and friable sandstone; and subaqueous. While these four broad types of ground condition require very different methods of excavation and ground support, nevertheless, nearly all tunneling operations involve certain basic procedures: investigation, excavation and materials transport, ground support, and environmental control. Similarly, tunnels for mining and for civil-engineering projects share the basic procedures but differ greatly in the design approach toward permanence, owing to their differing purposes. Many mining tunnels have been planned only for minimum-cost temporary use during ore extraction, although the growing desire of surface owners for legal protection against subsequent tunnel collapse may cause this to change. By contrast, most civil-engineering or public-works tunnels involve continued human occupancy plus full protection of adjacent owners and are much more conservatively designed for permanent safety. In all tunnels, geologic conditions play the dominant role in governing the acceptability of construction methods and the practicality of different designs.

Geologic investigation. Thorough geologic analysis is essential in order to assess the relative risks of different locations and to reduce the uncertainties of ground and water conditions at the location chosen. In addition to soil and rock types, key factors include the initial defects controlling behaviour of the rock mass; size of rock block between joints; weak beds and zones, including faults, shear zones, and altered areas weakened by weathering or thermal action; groundwater, including flow pattern and pressure; plus several special hazards, such as heat, gas, and earthquake risk. For mountain regions the large cost and long time required for deep borings generally limit their number; but much can be learned from thorough aerial and surface surveys, plus well-logging and geophysical techniques developed in the oil industry.

Excavation and materials handling. Excavation of the ground within the tunnel bore may be either semicontinuous, as by handheld power tools or mining machine, or cyclic, as by drilling and blasting methods for harder rock. Here each cycle involves drilling, loading explosive, blasting, ventilating fumes, and excavation of the blasted rock (called mucking). Commonly, the mucker is a type of front-end loader that moves the broken rock onto a belt conveyor that dumps it into a hauling system of cars or trucks. As all operations are concentrated at the heading, congestion is chronic, and much ingenuity has gone into designing equipment able to work in a small space. Since progress depends on the rate of heading advance, it is often facilitated by mining several headings simultaneously, as opening up intermediate headings from shafts or from adits driven to provide extra points of access for longer tunnels.

For smaller diameters and longer tunnels, a narrow-gauge railroad is commonly employed to take out the muck and bring in workers and construction material. For larger-size bores of short to moderate length, trucks are generally preferred.

Ground support. The dominant factor in all phases of the tunneling system is the extent of support needed to hold the surrounding ground safely. Engineers must consider the type of support, its strength, and how soon it must be installed after excavation. The key factor in timing support installation is so-called stand-up time— *i.e.,* how long the ground will safely stand by itself at the heading, thus providing a period for installing supports. In soft ground, stand-up time can vary from seconds in such soils as loose stand up-to hours in such ground as cohesive clay and even drops to zero in flowing ground below the water table, where inward seepage moves loose sand into the tunnel. Stand-up time in rock may vary from minutes in raveling ground (closely fractured rock where pieces gradually loosen and fall) up to days in moderately jointed rock (joint spacing in feet) and may even be measured in centuries in nearly intact rock, where the rock-block size (between joints) equals or exceeds size of the tunnel opening, thus requiring no support.

In early tunnels, timber was used for the initial or temporary support, followed by a permanent lining of brick or stone masonry. Since steel became available, it has been widely used as the first temporary stage or primary support. For protection against corrosion, it is nearly always encased in concrete as a second stage or final lining. Steel-rib support with timber blocking outside has been widely employed in rock tunnels.

Environmental control. In all but the shortest tunnels, control of the environment is essential to provide safe working conditions. Ventilation is vital, both to provide fresh air and to remove explosive gases such as methane and noxious gases, including blast fumes. While the problem is reduced by using diesel engines with exhaust scrubbers and by selecting only low-fume explosives for underground use, long tunnels involve a major ventilating plant that employs a forced draft through lightweight pipes up to three feet in diameter and with booster fans at intervals.

Electronic equipment in tunnels is prohibited, since stray currents may activate blasting circuits. Thunderstorms may also produce stray currents and require special precautions.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. Tunnels are divided into four groups depending on the ground through which they pass.
2. All kinds of tunnels require the same methods of excavation and ground support.
3. Thorough geologic analysis is one of the main tunneling operations.
4. Excavation of the ground is either cyclic or continuous.
5. Each cycle involves drilling, loading explosive, blasting, ventilating fumes and excavation of the blasted rock.
6. The dominant factor in all phases of the tunneling system is ground support.
7. In soft ground stand-up time can vary from minutes up to hours.
8. In rock stand-up time may vary from seconds up to days.
9. Ventilation provides fresh air and removes explosive gases.
10. Electronic equipment is widely used in tunnels.

II. Answer the questions

1. How are tunnels generally grouped?
2. What do tunneling operations involve?
3. Why is thorough geologic analysis very important?

4. What does each cycle involve?
5. How long will soft ground safely stand by itself at the heading?
6. Stand-up time in rock varies from minutes up to days, doesn't it?
7. Where is control of environment essential?
8. How does ventilation work?
9. What tunnels involve a major ventilating plant?
10. Why is electronic equipment prohibited in tunnels?

LANGUAGE FOCUS

III. Fill in the prepositions.

1. To be grouped … 2. Depend … 3. Consist … 4. … order to 5. … addition to.
6. Excavation … smth. 7. Vary … up to 8. To be used …

IV. Fill in the words.

Dominant, soft, timber, sides, safe, ore extraction, meet, deep, inflow, corrosion.

1. Many mining tunnels have been planned only for minimum-cost temporary use during … .
2. In all tunnels, geologic conditions play the … role.
3. Since shallow tunnels are more often in … ground, borings become more practical.
4. Long tunnels from opposite sides of the mountain commonly … with an error of one foot or less.
5. Under most conditions, tunneling causes a transfer of the ground load by arching to … of the opening.
6. In early tunnels, … was used for the initial or temporary support.
7. For protection against … it is nearly encased in concrete as final lining.
8. Environment control is essential to provide … working conditions.
9. While excess heat is more common in … tunnels, it occasionally occurs in fairly shallow tunnels.
10. In 1970 a complete refrigeration plant was required to progress through a huge … of hot water.

V. Give the missing forms of the words below.

Verb	**Noun**	**Adjective**
Differ		
	Operator	

Additional

Protect

Acceptability

Locative

Alter

Variability

Selective

Text 2: HOW TUNNELS ARE BUILT

People dig some tunnels through rock or soft earth. Other tunnels, known as *submerged tunnels,* lie in trenches dug into the bottoms of rivers or other bodies of water.

Rock tunnels. The construction of most rock tunnels involves blasting. To blast rock, workers first move a scaffold called *a jumbo* next to the tunnel *face* (front). Mounted on the jumbo are several drills, which bore holes into the rock. The holes are usually about 10 feet (3 meters) long, but may be longer or shorter depending on the rock. The holes measure only a few inches or centimeters in diameter. Workers pack explosives into the holes. After these charges are exploded and the fumes sucked out, carts carry away the pieces of rock, called *muck.*

If the tunnel is strong, solid rock, it may not require extra support for its roof and walls. But most rock tunnels are built through rock that is naturally broken into large blocks or contains pockets of fractured rock. To prevent this fragmented rock from falling, workers usually insert long bolts through the rock or spray it with concrete. Sometimes they apply a steel mesh first to help hold broken rock. Workers using an older method erect rings of steel beams or timbers. In most cases, they add a permanent lining of concrete later.

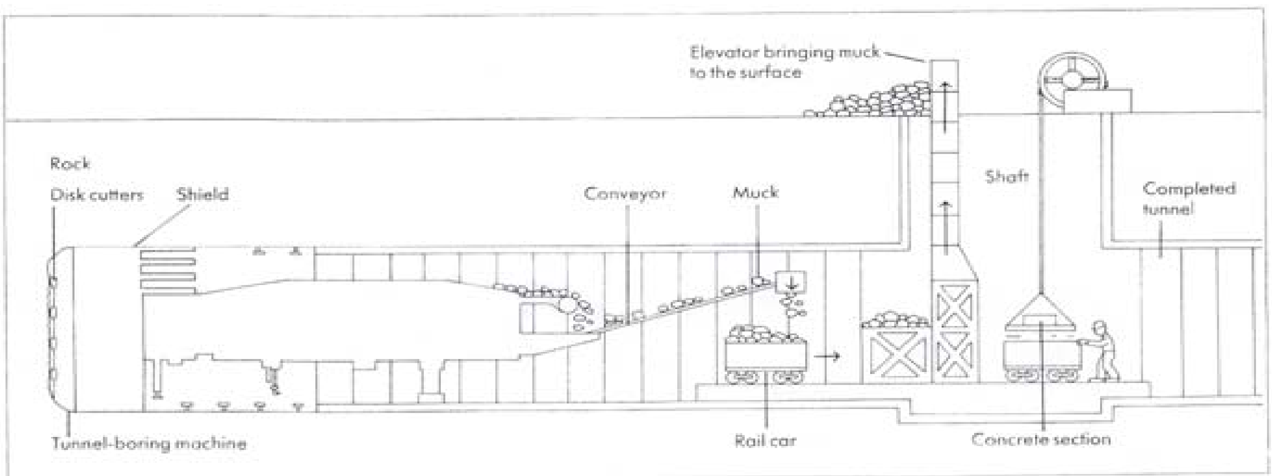
Tunnel-boring machines dig tunnels in soft, but firm rock such as limestone or shale and in hard rock such as granite. A circular plate covered with *disk cutters* is attached to the front of these machines. As the plate rotates slowly, the disk cutters slice into the rock. Scoops on the machine carry the muck to a conveyor that removes it to the rear. To cut weaker rock such as sandstone, workers use road header's and other machinery.

Earth tunnels include tunnels that are dug through clay, silt, sand, or gravel, or in muddy riverbeds. Tunneling through such soft earth is especially dangerous because of the threat of cave-ins. In most cases, the roof and walls of a section of tunnel dug through these materials are held up by a steel cylinder called a shield. Workers leave the shield in place while they remove the earth inside it and install a permanent lining of cast iron or precast concrete. After this work is completed, jacks push the shield into the earth ahead of the tunnel, and the process is repeated. Some tunnel-boring machines have a shield attached to them and are able to position sections of concrete tunnel lining into place as they dig. Such a machine dug part of the London subway system

If the soil is strong enough to stand by itself for at least a few hours, workers may not use concrete sections. Instead, they would hold the soil in place with bolts, steel ribs, and sprayed concrete.

Tunneling through the earth beneath bodies of water adds the danger of flooding to that of cave-ins. Engineers generally prevent water from entering a tunnel during construction by compressing the air in the end of the tunnel where the work is going on. When the air pressure inside the tunnel exceeds the pressure of the water outside, the water is kept out. This method was used to build the subway tunnels under the East River in New York City and the River Thames in London.

Submerged tunnels are built across the bottoms of rivers, bays, and other bodies of water. Submerged tunnels are generally less expensive to build than those dug by the shield or compressed-air methods. Construction begins by dredging a trench for the tunnel. Closed-ended steel or concrete tunnel sections are then floated over the trench and sunk into place. Next, divers connect the sections and remove the ends, and any water in the tunnel is pumped out. In most cases, the tunnels are then covered with earth. Submerged tunnels include the railroad tunnel under the Detroit River and the rapid transit tunnel under San Francisco Bay.



How a tunnel is constructed

A tunnel-boring machine digs into rock with attachments called *disk cutters.*

The broken rock, called *muck* then is removed by conveyor and rail car and brought to the surface in an elevator. Meanwhile, concrete sections of the tunnel lining are lowered through a shaft. A shield on the tunnel-boring machine holds up the roof until workers can erect a new section of tunnel lining.

COMPREHENSION CHECK.

I. Decide whether the following statements are true or false according to the text.

1. Submerged tunnels lie in the trenches dug through rock.
2. Blasting is one of the main methods used in the construction of rock tunnels.
3. The length of the holes varies from 2 to 5 meters.
4. After the explosion it is always necessary to construct a support.
5. Rings of steel beams or timber can prevent large fragments of rock from falling.
6. Tunnel-boring machines dig tunnels in sandstone.
7. Tunneling through soft earth is more dangerous than through rock.
8. Concrete sections are always used in earth tunnels.
9. When the air pressure inside the tunnel is equal to the pressure of the water outside, the water is kept out.
10. Submerged tunnels are the cheapest.

II. Answer the following questions.

1. What is done first to blast the rock?
2. How are holes bored?
3. Where do workers pack explosives?
4. When doesn't the tunnel require extra support?
5. Why do workers insert long bolts through the rock?
6. How does a tunnel-boring machine work?
7. When do worker hold the soil in place with bolts, steel ribs and sprayed concrete?
8. Tunneling beneath bodies of water is more dangerous, isn't it?
9. What tunnels are cheaper?
10. Do you know any submerged tunnels?

LANGUAGE FOCUS

I. Match the words with their synonyms.

1. Drill	a) trench
2. Excavate	b) mesh
3. Need	c) permanent
4. Perilous	d) require
5. Ditch	e) bore
6. Net	f) dangerous
7. Constant	g) muck
8. Girder	h) remote
9. Blasted rock	i) beam

II. Match the words with their opposites.

1. Solid	a) pack
2. Extract	b) remote
3. Add	c) cheap
4. Long	d) behind
5. Complete	e) separate
6. Expensive	f) permanent
7. Connect	g) start
8. Ahead	h) short
9. Temporary	i) soft

III. Fill in the words: feet, shallow, circular, mining, steel, conditions, waterproofed, cost, dangerous, downward.

The … industry has been the primary constructor of shafts. Depth of several thousand … are common. In public works projects, such as sewer tunnels, shafts are usually only a few hundred feet deep and because of their high … are avoided in the design stage whenever practical … shafts find many uses. Being essentially vertical tunnels, shafts involve the same problems of different types of ground and water … . Inflowing water is far more … during construction and generally intolerable during operation. Hence, most shafts are concrete-lined and … , and the lining installation usually follows only a short distance behind excavation. The shape is usually … , although, before current mechanized excavation methods, mining shafts were frequently rectangular. Mining … is called shaft sinking. In soil, shallow shafts are frequently supported with interlocking … sheet piling held by ring beams.

FOLLOW UP ACTIVITIES

Speak on:

1. Basic procedures in tunneling operations.
2. The construction of tunnels.

Unit 8: FAMOUS TUNNELS

Lead in:

1. What famous tunnels do you know?
2. Why are they called famous?

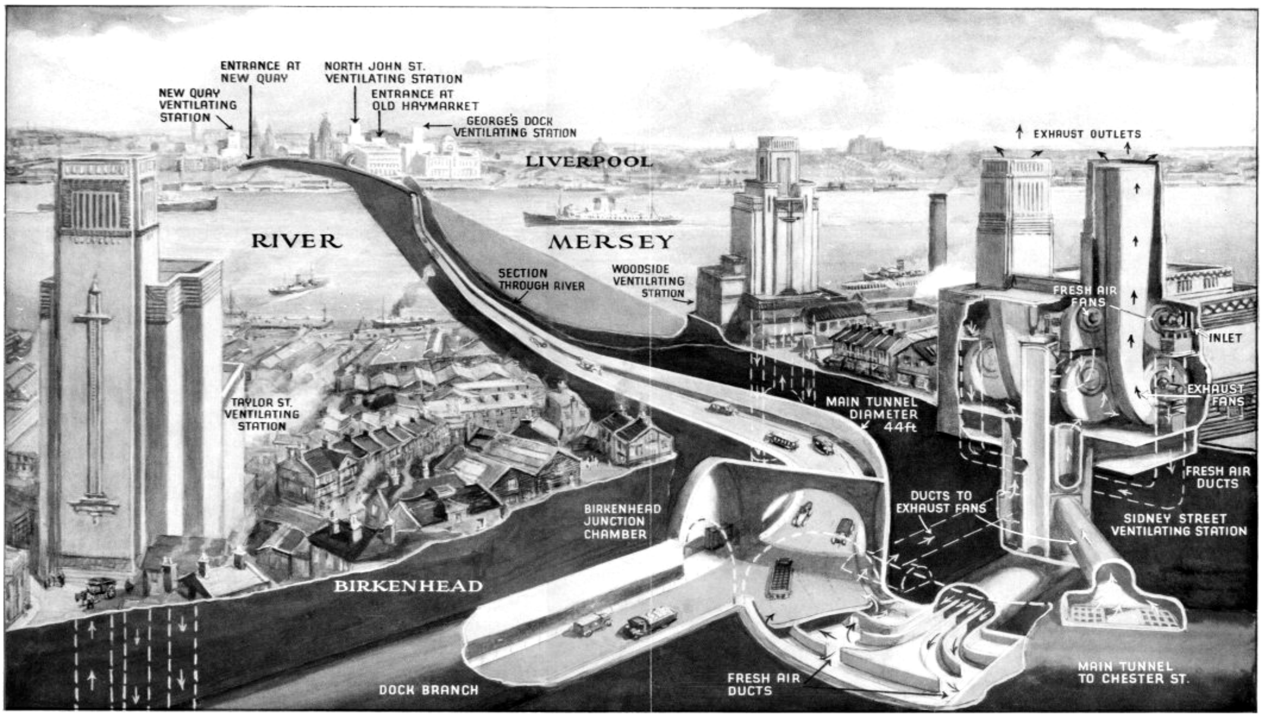
Find the following terms and memorize their meaning.

bank	flooding
blow into	frames
determination	impede
divergence	impel
draw off	inch
duct	leaks
banquet	prop
brick cylinder	propel
bricklayer	purposes
chamber	survey
compressed air	technique
controversy	temporary
drainage	underwater tunnel
enlarge	screw
exhausts	sealing
engineering failure	shaft
fraction	shield
heading	shotcreting
internal combustion	sinking
lining	surface
motor traffic	approach

Text 1: The Mersey Tunnel

1. The Mersey tunnel is one of the biggest underwater tunnel of the world. What other underwater tunnels do you know?
2. What are the construction techniques of underwater tunnels?

3. What are the purposes of underwater tunnels?



The cities of Liverpool and Birkenhead are joined by a tunnel which goes under the river Mersey. It is the famous Mersey Tunnel, one of the biggest underwater tunnels in the world. Its total length is over two and a half miles. During the year 1956 more than 10 million vehicles used the tunnel. Its construction has been a great engineering achievement. The work started in December 1925 on the Liverpool side and a few months later on the Birkenhead side. It had been decided to approach the work by driving from each bank of the river two pilot headings, an upper and a lower one, which would meet under the middle part of the river. Vertical shafts were sunk on both sides of the river and the excavation work began. At first the working face of the heading was broken up by compressed air drills, later explosives were used. The headings met on the 3rd of April, 1928, twenty-seven months after the work had begun. The divergences in line and level were found to be a fraction of an inch, showing how accurately and correctly the survey work and the determination of working levels had been done. The next stage of the work was the enlarging of the pilot headings into the full-sized tunnel. Steel, cast iron and concrete were used in lining the tunnel. From the very start it was realised that the ventilation of a tunnel of such length, which was to be used by vehicles propelled by internal combustion, would be a very difficult problem. Finally, a system of ventilation was adopted in which air is blown into the tunnel through ducts at roadway level and drawn off along the roof through exhausts. The Mersey Tunnel was completed in 1934. It was opened on the 18th of July, 1934. At the time it seemed a complete solution of the communication difficulties that had existed between Liverpool and Birkenhead. Today it is obvious that the solution has been only temporary. The ever-increasing exports from the port of Liverpool and the rapid development of Merseyside as an industrial centre have resulted in a great increase in motor traffic through the tunnel. Plans are now being made for the use of the space between the walls supporting the reinforced concrete roadway at the lower level of the tunnel (1840).

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The Mersey Tunnel is one of the most famous underwater tunnels in the world.
2. Two pilot headings , an upper and a left one, were decided to be driven from each bank of the river.
3. The working face of the heading was broken by latest explosives.
4. The divergences in line and level were found to be a fraction of an inch, showing that engineers and designers were a bit inaccurate in their calculations.
5. Ventilation wasn’t considered to be a very big problem.
6. The air was exhausted at the roof level.
7. The tunnel proves to be a solution of the communication difficulties.
8. Plans are now being made for constructing a parallel tunnel along the main one.
9. Now the tunnel carries 10 million vehicles a year.
10. Its total length is over 4 kilometers.

II. Answer the following questions:

1. Prove that the tunnel was quite popular after it had been completed.
2. What was new about the construction of the tunnel?
3. What was used to break up the working face?
4. What did the divergences in line and level show?
5. Why was the ventilation in the tunnel realized a problem?
6. How was the ventilation system arranged?

7. What are the plans to solve communication difficulties between Liverpool and Birkenhead?

LANGUAGE FOCUS

III. Match the meanings of these terms with their definition:

1. heading	a. a difference between two or more things
2. communication	b. examine the condition of anything
3. explosive	c. form a layer over the inner surface of something
4. fraction	d. pipe or system by which waste gases are expelled
5. survey	e. connection or means of access
6. exhausts	f. horizontal passage made in preparation for building a tunnel, or in a mine.
7. line	g. small part, piece, or amount
8. divergence	h. a substance that can cause an outburst

IV. Complete the following table:

noun	**verb**	**adjective**
divergence		
	to explode	
		accurate
determination		
		long
	to adopt	
solution		
	to ventilate	
communication		
		strong

V. Using the words from the table above complete the following sentences:

1. They have to _____ the problem with the ventilation.
2. To avoid divergences in line and level, the engineers had to be very _____ with their survey.
3. To _____ the road is not an easy task.
4. Your calculation _____ considerably from mine.

5. The _____ of this system of ventilation resulted in imroving indoor comfort.
6. Breaking up the working face of the heading is done with the help of _____.

VI. Make up the sentences from the words below:

The Holland Tunnel

1. has, providing, with, more than, from Canal Street, link, two traffic, to Jersey City, direct, a, two tubes, 8,000 feet long, lanes, in each for automobiles, trucks, and buses. 2. was, to traffic, and New Jersey, the Port Authority, which, of New York, tunnel, is operated, The, by, opened, in 1927. 3. used, and construction, of the tunnel, still, vehicular, The, throughout, method, building tunnels, the world, the basis for, and principles, form, in the design

VI. Complete the text with the words below:

westbound, authority, tubes, vehicles, motor, conditions, vehicular, lanes

The Lincoln Tunnel, also used by motor__(1)__, provides a link between 38th Street in midtown Manhattan and Weehawken, N.J. The tunnel, operated by the Port __(2)__ of New York and New Jersey, is the only three-tube underwater __(3)__ tunnel in the world. Two of its __(4)__ are over 8,000 feet (2,400 meters) long, and the third is about 7,500 feet (2,290 meters) long. Each tube has two __(5)__ for vehicular traffic. The center tube, used for eastbound, __(6)__ , or two-way traffic as __(7)__ require, opened in 1937. The north tube, for westbound traffic, opened in 1945. The south tube, used for eastbound traffic, opened in 1957.

VII. What plan of the text The Mersey Tunnel is better? Why?

1. the Mersey Tunnel 2.engineering achievement 3. headings 4. ventilation 5.communication difficulties	1. basic information 2. the construction of the tunnel 3. the system of ventilation 4. the solution of communication difficulties	1. the famous Tunnel 2. the process and stages of construction 3. the problem of ventilation 4. the completion of the tunnel

Text 2: Central Artery/Tunnel Project (Big Dig)

The tunnel is called Big Dig. Why? Give your ideas

Some call the Central Artery/Tunnel Project in Boston, Massachusetts, the "largest, most complex and technologically challenging highway project in American history." Others consider it one of the most expensive engineering projects of all time. Locals simply call it the "Big Dig." The tunnel is eight lanes wide, 3.5 miles long, and completely buried beneath a major highway and dozens of glass-and-steel skyscrapers in Boston’s bustling financial district. What does it take to dig a tunnel like this? A lot of hard work and a handful of engineering tricks.

Today, engineers use special excavating equipment, called "clamshell excavators," that work well in confined spaces like downtown Boston. These special machines carve narrow trenches -- about three feet wide and up to 120 feet deep -- down to bedrock. In Boston, engineers are pumping liquid slurry (clay mixed with water) into the trenches to keep the surrounding dirt from caving in.

Huge reinforcing steel beams are lowered into the soupy trenches, and concrete is pumped into the mix. Concrete is heavier than slurry, so it displaces the clay-water mix. The side-by-side concrete-and-steel panels form the walls of the tunnel, which will allow workers to remove more than three miles of dirt beneath the city. As if tunneling beneath a city isn’t hard enough, the soil beneath Boston is actually landfill -- it’s very loose and soggy. Engineers had to devise a few tricks to keep the soggy soil from collapsing. Their solution: freezing the soil!

Engineers pump very cold saltwater through a web of pipes beneath the city streets. The cold pipes draw heat out of the soil little by little. Once frozen, the soil can be excavated without sinking. Engineers also inject glue, or grout, into pores in the ground to make the soil stronger and less spongy during tunnel construction.

Fast Facts:

1. The project will excavate a total of 15 million cubic yards of dirt, enough to fill Foxboro Stadium -- where the New England Patriots football and Revolution soccer teams play -- 15 times.

2. Reinforcing steel used in the project would make a one-inch steel bar long enough to wrap once around the Earth at the equator.

3. Moving all the dirt in the tunnel will take more than 541,000 truckloads. If all those trucks were lined up end to end, they'd stretch 4,612 miles. That's the same distance from Boston, Massachusetts, to Brasilia, the capital of Brazil.

4. The tunnel will emerge next to the FleetCenter, home of the Boston Bruins hockey team, and will cross the Charles River under the widest cable-stayed bridge in the world, the Charles River Bridge.

COMPREHENSION CHECK

I. Using the words in the box complete the following table:

<table>
<tr><td colspan="2">Soft ground, 2004, Bechtel, Parsons Brinckerhoff, Quaide Douglas, Roadway, Boston, Massachusetts, USA, 18,480 feet (3.5 miles), more than $10 billion, Steel, concrete,</td></tr>
<tr><td>Location:
Completion Date:
Cost:
Length:</td><td>Purpose:
Setting:
Materials:
Engineer(s):</td></tr>
</table>

II. Decide whether the following statements are true or false according to the text:

1. The Central Artery/Tunnel Project is called the most complex and the most expensive project in the world.
2. The tunnel is located in Boston’s commercial district.
3. Some skyscrapers are above the tunnel.
4. Though the tunnel is considered the most expensive project, it was quite easy to build.
5. Clamshell excavators are used in closed spaces.
6. These special machines dig rather wide trenches.
7. Liquid slurry is sand mixed with water.
8. Liquid slurry helps to keep dirt away.

9. Huge reinforcing steel beams are lowered into the soupy trenches to remove slurry.
10. The soil beneath Boston is easy to work with.

III. Answer the following questions:

1. What project can you name ***challenging***?
2. What does *'a handful of engineering tricks'* mean concerning the tunnel described?
3. How do clamshell excavators operate?
4. What is liquid slurry pumped into trenches for?
5. What's the aim of side-by-side concrete-and-steel panels?

IV. Arrange the following statements in right order:

1. lowering of steel beams
2. freezing the soil
3. pumping concrete into the mix
4. pumping liquid slurry into trenches
5. removing dirt
6. carving narrow trenches
7. drawing heat out of the soil
8. excavating

V. Choose the right variant:

1. Clamshell excavators are used to

a. to dig dirt out	b. to carve narrow trenches	c. to carve wide trenches

2. Liquid slurry is pumped into trenches

a. to make them stronger	b. to take dirt out	c. to prevent dirt from getting into caving

3. The clay-water mix

a. removes concrete	b. is replaced by concrete	c. is removed

4. Tunneling beneath a city

a. is rather easy	b. is hard enough	c. is very hard

VI. Convert the following units of length into the units accepted in Belarus:

3.5 miles - … *kilometers*
4,612 miles - … *kilometers*
15 million cubic yards - … *cubic meters*
120 feet - … *meters*

VII. Complete the following table and analyze it

World's longest motor-traffic tunnels

Tunnel	Location	Length		Year opened
		in miles	in kilometres	
St.Gotthard Road	Switzerland	10.1	16.3	1980
Arlberg	Austria	8.6	…	1978
Frejus	France- Italy	8.0	12.9	1980
Mt. Blanc	...	...	11.7	1965
Gran Sasso	Italy	6.2	10.0	1976
Seelisberg	Switzerland	5.8	...	1980
Ena	Japan	5.3	8.5	1976

LANGUAGE FOCUS

VIII. Match the meanings of these terms with their definition:

1. trench	a. division of a road for a stream of traffic
2. soggy	b. thin semi-liquid cement, mud, manure, etc.
3. beneath	c. long narrow deep ditch
4. bedrock	d. machine digging and moving earth and soil
5. lane	e. below, under, underneath
6. excavator	f. to force liquid or gas into or out of something
7. pump	g. solid rock underlying alluvial deposits
8. slurry	h. sodden, saturated; too moist

IX. Complete the text using the words below:

a) mountain c) line e) starts g) train
b) ends d) length f) rail h) construction

Apennine Tunnel, *AP uh NYN,* is a 1… tunnel on the Florence-Bologna railroad 2… in north-central Italy. The tunnel runs through the 3… range called the Apennines. Its 11.5-mile (18.5-kilometer) 4… makes it one of the longest train tunnels in the world. The Apennine Tunnel was built between 1920 and 1934. To speed 5…, the tunnel was bored from both 6…, and at the same time two shafts were dropped in to enable workers to dig out from the center.

X. Put correct forms into the gaps in the text:

Simplon Pass and Tunnel, *SIMM plahn,* are $_{1}$…	*importance*
gateways through the $_{2}$… Alps. Napoleon built a military road	*Switzerland*
over the pass in the early 1800's. The road begins at Brig in the	
Rhone Valley. It reaches an $_{3}$… of 6,592 feet (2,009 meters),	*to elevate*
then descends toward the Lake District of $_{4}$… Italy. The	*North*
Simplon Tunnel is one of the $_{5}$… railroad tunnels in the world.	*long*
It is 12.3 miles (19.8 kilometers) long, and has a maximum	
elevation of 2,312 feet (705 meters). It consists of two $_{6}$ …	*parallels*
tunnels. One tunnel was $_{7}$… in 1906, and the other was	*to complete*
completed in 1874, but the work was stopped before it was	
finished. In 1902, a lawyer $_{8}$… William G. McAdoo raised	*name*
money to complete the tunnel and to build a second one so $_{9}$…	*two ways*
traffic could run under the river. McAdoo represented the	
Hudson and Manhattan Railroad Company. The uptown	
tunnels were opened to traffic in 1908. McAdoo also $_{10}$…	*to raise*
money to build the downtown tunnels, which opened in 1909.	

X. Make a précis of the text Central Artery/Tunnel Project (Big Dig)

Test 3: The Thames Tunnel

Lead-in:

1. What type of a tunnel is the Thames tunnel?
2. How would you build such type of a tunnel?
3. What materials and techniques would you need to construct the tunnel?

The Thames Tunnel is a tunnel, 35 feet wide and 1,300 feet long, beneath the River Thames in London, between Rotherhithe and Wapping. Originally constructed for pedestrian use, it is currently used by trains of the London Underground's East London Line. It was built by Marc Isambard Brunei and his son Isambard Kingdom Brunei in the 19th century.

A previous attempt at construction by Richard Trevithick in 1808 failed due to the difficult conditions of the ground. Marc Brunei's approach at the start of the project in January 1825 was to begin by digging a large shaft on the south bank at Rotherhithe. He did this by first building a brick cylinder above ground and then gradually sinking it by removing the earth beneath it. Brunei and Thomas Cochrane devised the tunnelling shield to dig the tunnel. The Illustrated London News of 25 March 1843 described how it worked: *"The mode in which this great excavation was accomplished was by means of a powerful apparatus termed a shield, consisting of twelve great frames, lying close to each other like as many volumes on the shelf of a book-case, and divided into three stages or stories, thus presenting 36 chambers of cells, each for one workman, and open to the rear, but closed in the front with moveable boards. The front was placed against the earth to be removed, and the workman, having removed one board, excavated the earth behind it to the depth directed, and placed the board against the new surface exposed. The board was then in advance of the cell, and was kept in its place by props; and having thus proceeded with all the boards, each cell was advanced by two screws, one at its head and the other at its foot, which, resting against the finished brickwork and turned, impelled it forward into the vacant space. The other set of divisions then advanced. As the miners worked at one end of the cell, so the bricklayers formed at the other the top, sides and bottom. "*

The key innovation of the tunnelling shield was its use of compressed air to keep the working face from flooding. But the dangers of compression and decompression were not understood, and workers soon fell ill from the poor conditions, including Brunei himself; ten men died during the project.

Work was slow, progressing at only 8-12 feet a week. Isambard Kingdom Brunei took over as chief engineer, and when on 18 May 1827 the tunnel flooded, he used a diving bell to repair the hole at the bottom of the river. Following the repairs and the drainage of the tunnel, he held a banquet inside it.

The tunnel was flooded again the following year, 12 January 1828, and the project was abandoned for seven years, until Marc Brunei succeeded in raising sufficient money to continue work. Impeded by further floods and gas leaks (methane and hydrogen sulphide), it was not completed until 1842. It was finally opened to the public on 25 March 1843. The tunnel was not, however, a financial success and soon acquired an unpleasant reputation.

In 1865 the tunnel was bought by the East London Railway Company and was adapted for trains, which ran out of Liverpool Street station.

It was subsequently absorbed into the London Underground. In 1995 it became the focus of considerable controversy when the tunnel was closed for long-term maintenance, with the intention of sealing it against leaks by "shotcreting" it.

This led to a legal conflict with architectural interests wishing to preserve the tunnel's appearance and disputing the need for the treatment. Following an agreement to leave a short section at one end of the tunnel untreated, and more sympathetic treatment of the rest of the tunnel, the work went ahead and the route reopened - much later than originally anticipated - in 1998.

Although the tunnel itself cannot usually be visited (except by train), the engine house on the southern bank, which originally housed the pumps to drain the tunnel, has been restored and converted into a museum.

COMPREHENSION CHECK

I. Decide whether the following statements are true or false according to the text:

1. The tunnel was constructed for pedestrians and now they use it.
2. The first attempt failed because of no possibility to dig the ground.
3. The tunneling shield was invented by Richard Trevithick in 1808.
4. A new thing about tunneling shield was the use of compressed air.
5. The construction of the tunnel was accomplished quickly.
6. No floods happened during construction period.
7. Because of floods the project was abandoned for 7 years.
8. The purpose of the tunnel was changed.
9. There was quite much controversy about construction of the tunnel.
10. Everybody has an advantage to visit the tunnel.
11. The tunnel was restored and converted into a museum.
12. The tunnel was the first to be written about.

II. Using the information given in the text complete the following table:

Location: Completion Date: Cost: Length:	Purpose: Setting: Materials: Engineer(s):

III. Answer the following questions:

1. Why was the tunnel turned from a pedestrian to a train one?
2. Why did a previous attempt to construct the tunnel fail?
3. What was Marc Brunei's approach at the start of the project?
4. What helped the engineers dig the tunnel?
5. Describe the shield used for the excavation.
6. What was new about the tunneling shield?
7. Were the working conditions dangerous?

IV. Fill in the correct prepositions and match the collocations:

1. the use	___	as a chief engineer
2. to take	___	the new surface
3. to be constructed	___	flooding
4. to impel smth	___	the treatment
5. to place the board	___	compressed air
6. to keep	___	gas leaks
7. to divide	___	the tunnel
8. to be advanced	___	three stages
9. the drainage	___	the vacant space
10. to be impeded	___	two screws
11. the need	___	pedestrian use

V. Say in other words:

1. The tunnel cannot usually be *attended*. 2. As a matter of fact, the tunnel was *turned into* museum. 3. The construction work went *forward*. 4. The construction failed *because of* the ground conditions. 5. The workers suffered from *bad* conditions. 6. The project started with *tunneling* a large shaft. 7. Work was slow, *proceeding* at 10 feet a week. 8. It was necessary to repair the hole at *the underside*. 9. To dig, or to tunnel means *to take* the ground *away*. 10. The tunnel was closed for *prolonged* maintenance.

VI. Guess the words in the text:

In March 1853, one of the earliest tunnel **1b_____** machines ground 10 feet into the Hoosac Mountain and died, never to run again. It remained stuck in its hole for many **2y_____** as a grim symbol of engineering **3f_____**. In fact, it would take several failed **4a_____**, 200 lives and 20 years to complete the Hoosac Tunnel.

When **5c_____** began in 1851, workers relied on gunpowder to **6b_____** through the mountain. Progress was slow as each blast produced only a few feet of shattered rock. In 1866, two tunnel blasting tools -- nitroglycerin and the **7c_____** air drill -- were used in the Hoosac for the first time. Workers blasted faster than ever before, but not without risk.

Nitroglycerine is an extremely unstable **8e_____.** Hundreds of workers **9l_____** their lives in unexpected explosions. The Hoosac Tunnel remains a landmark in **10h_____**-rock tunneling. Over the course of its construction, virtually every kind of tunnel **11d_____** device was used to **12b_____** through the Hoosac Mountain -- and virtually every kind of mistake was made. Thanks to these mistakes, engineers today can build longer tunnels in a fraction of the time.

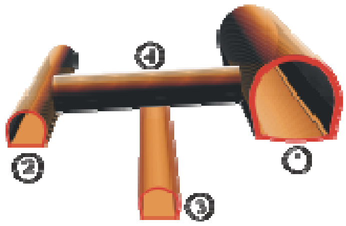
VII. Read the text above once again and choose the sentence summarizing it:

1. Engineering mistakes help build longer tunnels.
2. The Hoosac Tunnel is the landmark in hard-rock tunneling.
3. Nitroglycerin and compressed air drills were used for the first time.
4. The use of different devices and engineering mistakes make tunnel construction go ahead.
5. The construction of the Hoosac Tunnel was rich in engineering failures.

VIII. Arrange the words relating to "construction" from the list below into thematic groups: *Gigantic, brick, completing, canal, basic, steel, railway, large, massive, wooden, complex, bridge, tunnel, starting, project, building, heavy, solid, road, huge, fiberglass, industrial, house, beginning, proceeding with, clay, concrete*

kinds of construction	materials	purposes	stages of construction
basic	*clay*	*bridge*	*finishing*

Text 4: Seikan Tunnel



The **Seikan Tunnel** is a 53.85 km (33.49 mile) railway tunnel in Japan, with a 23.3 km (14.5 mile) portion under the seabed. Although it is the longest railway tunnel in the world, faster and cheaper air travel has left the Seikan Tunnel comparatively underutilized. Typical tunnel cross section. **(1)** Main tunnel, **(2)** service tunnel, **(3)** pilot tunnel, **(4)** connecting gallery

I. Arrange the parts of the text according to the following plan:

1. The history of the construction,
2. Surveying, construction and geology,
3. Maintenance

<table>
<tr>
<td colspan="2">The undersea portion of the tunnel consists of volcanic rock, pyroclastic rock, and sedimentary rock.The area is folded into a nearly vertical anticline, which means that the youngest rock is in the centre of the Strait, and encountered last. Divided roughly into thirds, the Honshū side consists of volcanic rocks (andesite, basalt etc); the Hokkaidō side consists of sedimentary rocks and the centre portion consists of sand-like mudstone. Igneous intrusions and faults caused crushing of the rock and complicated the tunnelling procedures.</td>
<td rowspan="2">In September 1971, the decision was made to commence work on the tunnel. Arduous construction in difficult geological conditions proceeded. 34 workers were killed during construction. On January 27, 1983, Japanese Prime Minister Yasuhiro Nakasone pressed a switch that set off a blast that completed the pilot tunnel. The tunnel was opened on March 13, 1988, at a cost of 538.4 billion yen (US$3.6 billion). Once the tunnel was completed, all railway transport between Honshū and Hokkaidō utilised the tunnel. However, for passenger transport, 90% of people use air due to the speed and cost. For example, to travel between Tokyo and Sapporo by train takes more than 10 hours and 30 minutes, with several</td>
</tr>
<tr>
<td>Beneath the Tsugaru Strait, the use of a tunnel boring machine (TBM) was abandoned after less than 2 km due to the variable nature of the rock and difficulty in accessing the face for advanced grouting. Blasting with dynamite and mechanical picking</td>
<td>A 2002 report by Michitsugu Ikuma described, for the undersea section, that "the tunnel structure appears to remain in a good condition". The amount of inflow has been decreasing with time, although it "increases right after a large earthquake".</td>
</tr>
</table>

<table>
<tr><td>were then used to excavate.</td><td></td><td>transfers. By air, the journey is 3 hours and 30 minutes.</td></tr>
<tr><td colspan="3">Tunnelling occurred simultaneously from both the northern and southern ends. The dry land portions were tackled with traditional mountain tunnelling techniques, with a single main tunnel. However, for the 23.3 km undersea portion, three bores were excavated with increasing diameters respectively: an initial pilot tunnel, a service tunnel, and finally the main tunnel. The service tunnel was periodically connected to the main tunnel with a series of connecting shafts, at 600 to 1,000 m intervals. The pilot tunnel served as the service tunnel for the 5 km centre portion.</td></tr>
<tr><td colspan="3">Surveying started in 1946. In 1971, 25 years later, construction began. In August 1982, less than 700 m remained to be excavated. First contact between the two sides was in 1983. The Tsugaru Strait has eastern and western necks, both approximately 20 km across. Initial surveys undertaken in 1946 indicated that the eastern neck was up to 200 m deep with volcanic geology. The western neck had a maximum depth of 140 m and geology consisting mostly of sedimentary rocks of the Neogene period. The western neck was selected, with its conditions considered favourable for tunnelling.</td></tr>
</table>

COMPREHENSION CHECK

II. Read the next part of the text and choose the title below the text summarizing it:

Two stations are located within the tunnel: Tappi-Kaitei Station and Yoshioka-Kaitei Station. The stations serve as emergency escape points. In the event of a fire or other disaster the stations provide equivalent safety of a much shorter tunnel. The effectiveness of the escape shafts located at the emergency stations is enhanced by exhaust fans to extract smoke, television cameras to route passengers to safety, thermal (infrared) fire alarm systems and water spray nozzles. Previously, both the stations contained museums detailing the history and function of the tunnel, and could be visited on special sightseeing tours. Now only Tappi-Kaitei remains as a museum, Yoshioka-Kaitei was demolished on March 16, 2006 to make way for Hokkaido Shinkansen preparations. The two stations were the first train stations in the world built under the sea.

a. two stations of the tunnel
b. the safety of the tunnel
c. the structure of the tunnel
d. the effectiveness of the tunnel

III. Make the precis of the text Seikan Tunnel

FOLLOW UP ACTIVITIES

Speak on:

1. Famous tunnels in the world
2. Famous tunnels in Belarus.

Contents