Министерство науки и высшего образования Российской Федерации

Федеральное государственное бюджетное образовательное учреждение
высшего образования
Санкт-Петербургский горный университет

Кафедра иностранных языков

АНГЛИЙСКИЙ ЯЗЫК

ПРОЕКТИРОВАНИЕ, СТРОИТЕЛЬСТВО И РЕКОНСТРУКЦИЯ ЗДАНИЙ И ПОДЗЕМНЫХ СООРУЖЕНИЙ ПРОМЫШЛЕННОГО И ГРАЖДАНСКОГО НАЗНАЧЕНИЯ

ENGLISH

DESIGN, CONSTRUCTION AND RECONSTRUCTION OF BUILDINGS AND UNDERGROUND STRUCTURES FOR INDUSTRIAL AND CIVIL PURPOSES

Методические указания к практическим работам для студентов магистратуры направления 08.04.01

САНКТ-ПЕТЕРБУРГ
2021

УДК 811.111:69 (073)

АНГЛИЙСКИЙ ЯЗЫК. Проектирование, строительство и реконструкция зданий и подземных сооружений промышленного и гражданского назначения. Design, construction and reconstruction of buildings and underground structures for industrial and civil purposes: Методические указания для практических работ / Санкт-Петербургский Горный Университет. Сост.: *Е.В. Картер*, *В.Н. Ионова*. СПб, 2021. 31 с.

Методические указания ставят своей целью формирование навыков чтения и перевода текстов по специальности, а также извлечения необходимой для речевой практики информации. Тематика текстов, система упражнений и тестовых заданий к ним позволяет научить студентов 1-го курса читать и анализировать прочитанное на иностранном (английском) языке, а также делать устные сообщения и принимать участие в беседе по темам по специальности.

Предназначены для студентов магистратуры направления 08.04.01 «Строительство» и согласованы с программой по иностранному языку для студентов неязыковых вузов.

Научный редактордоц. *И.С.Облова*

Рецензент канд. психол. наук *Н.Э. Горохова* (Санкт-Петербургский экономический университет)

Предисловие

Данные методические указания к практической работе предназначены для студентов 1 курса, обучающихся по направлению подготовки магистратуры 08.04.01 «Строительство».

Изучение предложенного материала направлено на формирование и развитие навыков профессионально-ориентированного чтения и перевода на английском языке.

Методические указания состоят из двух разделов, содержащих разное количество текстов. Предложенные аутентичные тексты содержат информацию по темам, изучаемым в рамках направления подготовки, а также представляющим интерес для студентов профильных направлений. Каждый текст сопровождается заданиями и упражнениями, цель которых – активизация познавательной деятельности учащихся, отработка и закрепление лексического и грамматического материала, формирование активного словарного запаса, развитие навыков аналитического чтения, письма, перевода и поиска информации, контроль понимания и перевода, развитие коммуникативных умений на английском языке, что позволяет мотивировать интерес студентов к будущей специальности.

UNIT I. Tunnels and underground excavations

Text 1. TUNNELS

Task 1: Read the text and speak about tunnels.

Tunnels and underground excavations (horizontal underground passageway) are produced by excavation or occasionally by nature's action in dissolving a soluble rock, such as limestone. A vertical opening is usually called a shaft. 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. True tunnels and chambers are excavated from the inside – with the overlying material left in place – and then lined as necessary to support the adjacent ground. A hillside tunnel entrance is called a portal; tunnels may also be started from the bottom of a vertical shaft or from the end of a horizontal tunnel driven principally for construction access and called an adit. So-called cut-and-cover tunnels (more correctly called conduits) are built by excavating from the surface, constructing the structure, and then covering with backfill. Tunnels underwater are now commonly built by the use of an immersed tube: long, prefabricated tube sections are floated to the site, sunk in a prepared trench, and covered with backfill. For all underground work, difficulties increase with the size of the opening and are greatly dependent upon weaknesses of the natural ground and the extent of the water inflow.

Task 2: Answer the questions.

1. How are tunnels produced?
2. What is usually called a shaft?
3. What uses do tunnels have?
4. What are underground chambers being used for?
5. How are tunnels built?
6. When do difficulties increase?

Task 3: Give the definitions of the following terms: *shaft, adjacent ground, portal, adit, conduit, immersed tube.*

Text 2. HISTORY. ANCIENT TUNNELS

Task 1: Read the text and speak about the ancient tunnels

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. Abu Simbel Temple on the Nile, for instance, was built in sandstone about 1250 BC for Ramses II (in the 1960s it was cut apart and moved to higher ground for preservation before flooding from the Aswān High Dam). 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 limestone with a cross section about 6 feet square. Perhaps the largest tunnel in ancient times was a 4,800-foot-long, 25-foot-wide, 30-foot-high road tunnel (the Pausilippo) between Naples and Pozzuoli, executed in 36 bc. 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. To save the need for a lining, most ancient tunnels were located in reasonably strong rock, which was broken off (spalled) by so-called fire quenching, a method involving heating the rock with fire and suddenly cooling it by dousing with water. 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. In ad 41 the Romans used some 30,000 men for 10 years to push a 3.5-mile (6-kilometre) tunnel to drain Lacus Fucinus. They worked from shafts 120 feet apart and up to 400 feet deep. Far more attention was paid to ventilation and safety measures when workers were freemen, as shown by archaeological diggings at Hallstatt, Austria, where salt-mine tunnels have been worked since 2500 BC.

Task 2: Answer the questions.

1. What was the first tunneling done by prehistoric people for?
2. What were tunnels used in Babylonia for?
3. What techniques did the Egyptians develop?
4. Did the Greek and Romans both make extensive use of tunnels?
5. Was much attention paid to ventilation and safety measures?

Task 3: Find a phrase match.

1. ...by prehistoric people seeking...	A. ... to connect the royal palace with the temple.
2. ... under the Euphrates River...	B. ... quarrying stone blocks…
3. ... accomplished by diverting the river ...	C. ... at the mouth of the shaft…
4. ... moved to higher ground for...	D. ... during the dry season.
5. ... a technique probably used first for...	E. ... to enlarge their caves.
6. ... often limited to waving a canvas...	F. ... preservation before flooding...

Text 3. FROM THE MIDDLE AGES TO THE PRESENT CANAL AND RAILROAD TUNNELS

Task 1: Read the text and speak about the present canal and railroad tunnels.

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. With a length of 515 feet and a cross section of 22 by 27 feet, it involved what was probably the first major use of explosives in public-works tunneling, gunpowder placed in holes drilled by handheld iron drills. 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. In the United States, the first railroad tunnel was a 701-foot construction on the Allegheny Portage Railroad. Built in 1831–33, it was a combination of canal and railroad systems, carrying canal barges over a summit. Though plans for a transport link from Boston to the Hudson River had first called for a canal tunnel to pass under the Berkshire Mountains, by 1855, when the Hoosac Tunnel was started, railroads had already established their worth, and the plans were changed to a double-track railroad bore 24 by 22 feet and 4.5 miles long. Initial estimates contemplated completion in 3 years; 21 were actually required, partly because the rock proved too hard for either hand drilling or a primitive power saw. When the state of Massachusetts finally took over the project, it completed it in 1876 at five times the originally estimated cost. Despite frustrations, the Hoosac Tunnel contributed notable advances in tunneling, including one of the first uses of dynamite, the first use of electric firing of explosives, and the introduction of power drills, initially steam and later air, from which there ultimately developed a compressed-air industry.

Simultaneously, more spectacular railroad tunnels were being started through the Alps. The first of these, the Mont Cenis Tunnel (also known as Fréjus), required 14 years (1857–71) to complete its 8.5-mile length. Its engineer, Germain Sommeiller, introduced many pioneering techniques, including rail-mounted drill carriages, hydraulic ram air compressors, and construction camps for workers complete with dormitories, family housing, schools, hospitals, a recreation building, and repair shops. Sommeiller also designed an air drill that eventually made it possible to move the tunnel ahead at the rate of 15 feet per day and was used in several later European tunnels until replaced by more durable drills developed in the United States by Simon Ingersoll and others on the Hoosac Tunnel. As this long tunnel was driven from two headings separated by 7.5 miles of mountainous terrain, surveying techniques had to be refined. Ventilation became a major problem, which was solved by the use of forced air from water-powered fans and a horizontal diaphragm at mid-height, forming an exhaust duct at top of the tunnel. Mont Cenis was soon followed by other notable Alpine railroad tunnels: the 9-mile St. Gotthard (1872–82), which introduced compressed-air locomotives and suffered major problems with water inflow, weak rock, and bankrupt contractors; the 12-mile Simplon (1898–1906); and the 9-mile Lötschberg (1906–11), on a northern continuation of the Simplon railroad line.

Nearly 7,000 feet below the mountain crest, Simplon encountered major problems from highly stressed rock flying off the walls in rock bursts; high pressure in weak schists and gypsum, requiring 10-foot-thick masonry lining to resist swelling tendencies in local areas; and from high-temperature water (130° F [54° C]), which was partly treated by spraying from cold springs. Driving Simplon as two parallel tunnels with frequent crosscut connections considerably aided ventilation and drainage.

Lötschberg was the site of a major disaster in 1908. When one heading was passing under the Kander River valley, a sudden inflow of water, gravel, and broken rock filled the tunnel for a length of 4,300 feet, burying the entire crew of 25 men. Though a geologic panel had predicted that the tunnel here would be in solid bedrock far below the bottom of the valley fill, subsequent investigation showed that bedrock lay at a depth of 940 feet, so that at 590 feet the tunnel tapped the Kander River, allowing it and soil of the valley fill to pour into the tunnel, creating a huge depression, or sink, at the surface. After this lesson in the need for improved geologic investigation, the tunnel was rerouted about one mile (1.6 kilometres) upstream, where it successfully crossed the Kander Valley in sound rock.

Most long-distance rock tunnels have encountered problems with water inflows. One of the most notorious was the first Japanese Tanna Tunnel, driven through the Takiji Peak in the 1920s. The engineers and crews had to cope with a long succession of extremely large inflows, the first of which killed 16 men and buried 17 others, who were rescued after seven days of tunneling through the debris. Three years later another major inflow drowned several workers. In the end, Japanese engineers hit on the expedient of digging a parallel drainage 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 mountain tunneling.

Task 2: Mark the sentences as TRUE or FALSE

1. The limited tunneling in the Middle Ages was principally for mining and military engineering.

2. The second of many major canal tunnels was the Canal du Midi (also known as Languedoc) tunnel in France.

3. Many more canal tunnels were dug in Europe and North America in the 18th and late 19th centuries.

4. The Hoosac Tunnel contributed notably advances in tunneling, including one of the first uses of dynamite.

5. Lötschberg was the site of a major disaster in 1922.

6. Most long-distance rock tunnels have encountered problems with water inflows.

Task 3: Fill in the appropriate prepositions.

1. Because the limited tunneling ___ the Middle Ages was principally ___ mining and military engineering, the next major advance was to meet Europe's growing transportation needs ___ the 17th century.

2. A notable canal tunnel ___ England was the Bridgewater Canal Tunnel, built ___ 1761 ___ James Brindley to carry coal ___ Manchester ___ the Worsley mine.

3. Though the canals fell ___ disuse ___ the introduction ___ railroads ___ 1830, the new form ___ transport produced a huge increase ___ tunneling, which continued ___ nearly 100 years as railroads expanded ___ the world.

4. Though plans ___ a transport link ___ Boston ___ the Hudson River had first called ___ a canal tunnel to pass ___ the Berkshire Mountains, ___ 1855, when the Hoosac Tunnel was started, railroads had already established their worth, and the plans were changed ___ a double-track railroad bore 24 ___ 22 feet and 4.5 miles long.

5. Ventilation became a major problem, which was solved ___ the use ___ forced air ___ water-powered fans and a horizontal diaphragm ___ mid-height, forming an exhaust duct ___ top ___ the tunnel.

6. Nearly 7,000 feet ___ the mountain crest, Simplon encountered major problems ___ highly stressed rock flying ___ the walls ___ rock

bursts; high pressure ___ weak schists and gypsum, requiring 10-foot-thick masonry lining to resist swelling tendencies ___ local areas.

7. Though a geologic panel had predicted that the tunnel here would be ___ solid bedrock far ___ the bottom ___ the valley fill, subsequent investigation showed that bedrock lay ___ a depth ___ 940 feet.

8. The engineers and crews had to cope ___ a long succession ___ extremely large inflows, the first ___ which killed 16 men and buried 17 others, who were rescued ___ seven days ___ tunneling ___ the debris.

Text 4. SUBAQUEOUS TUNNELS

Task 1: Read the text and speak about the subaqueous tunnels.

Tunneling under rivers was considered impossible until the protective shield was developed in England by Marc Brunel, a French émigré engineer. The first use of the shield, by Brunel 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 $^1/_4$ by 37 $^1/_2$ 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. In 1869 by reducing to a small size (8 feet) and by changing to a circular shield plus a lining of cast-iron segments, Peter W. Barlow and his field engineer, James Henry Greathead, were able to complete a second Thames tunnel in only one year as a pedestrian walkway from Tower Hill. In 1874, Greathead made the subaqueous technique really practical by refinements and mechanization of the Brunel-Barlow shield and by adding compressed air pressure inside the tunnel to hold back the outside water pressure. Compressed air alone was used to hold back the water in 1880 in a first attempt to tunnel under New York's Hudson River; major difficulties and the loss of 20 lives forced abandonment after only 1,600 feet had been excavated. The first major application of the shield-plus-compressed-air technique occurred in 1886 on the London subway with an 11-foot bore, where it accomplished the unheard-of record of seven miles of tunneling without a single fatality. So thoroughly did Greathead develop his procedure that it was used successfully for the next 75 years with no significant change. A modern Greathead shield illustrates his original developments: miners working under a hood in individual small pockets that can be quickly closed against inflow; shield propelled forward by jacks; permanent lining segments erected under protection of the shield tail; and the whole tunnel pressurized to resist water inflow.

Once subaqueous tunneling became practical, many railroad and subway crossings were constructed with the Greathead shield, and the technique later proved adaptable for the much larger tunnels required for automobiles. A new problem, noxious gases from internal-combustion engines, was successfully solved by Clifford Holland for the world's first vehicular tunnel, completed in 1927 under the Hudson River and now bearing his name. Holland and his chief engineer, Ole Singstad, solved the ventilation problem with huge-capacity fans in ventilating buildings at each end, forcing air through a supply duct below the roadway, with an exhaust duct above the ceiling. Such ventilation provisions significantly increased the tunnel size, requiring about a 30-foot diameter for a two-lane vehicular tunnel.

Many similar vehicular tunnels were built by shield-and-compressed-air methods—including Lincoln and Queens tunnels in New York City, Sumner and Callahan in Boston, and Mersey in Liverpool. Since 1950, however, most subaqueous tunnelers preferred the immersed-tube method, in which long tube sections are prefabricated, towed to the site, sunk in a previously dredged trench, connected to sections already in place, and then covered with backfill. This basic procedure was first used in its present form on the Detroit River Railroad Tunnel between Detroit and Windsor, Ontario (1906–10). A prime advantage is the avoidance of high costs and the risks of operating a shield under high air pressure, since work inside the sunken tube is at atmospheric pressure (free air).

Task 2: Mark the sentences as TRUE or FALSE

1. The first use of the shield, by Brunel and his son Isambard, was in 1820 on the Wapping-Rotherhithe Tunnel through clay under the Thames River.

2. After several floodings from hitting sand pockets and a five-year shutdown for refinancing and building a second shield, the Brunels succeeded in completing the world's first true subaqueous tunnel in 1841.

3. In 1874, Greathead made the subaqueous technique really practical by refinements and mechanization of the Brunel-Barlow shield.

4. The first major application of the shield-plus-compressed-air technique occurred in 1886 on the Paris subway.

5. Once subaqueous tunneling became practical, many railroad and subway crossings were constructed with the Greathead shield.

6. A few similar vehicular tunnels were built by shield-and-compressed-air methods.

Task 3: Find a phrase match.

1. ... considered impossible until...	A. ... huge-capacity fans in ventilating buildings at each end...
2. ... by reducing to a small size and…	B. ... the protective shield was developed in England by Marc Brunel …
3. ... by adding compressed air pressure inside the tunnel...	C. ... under New York's Hudson River…
4. ... used successfully for the next 75 years with...	D. ... to hold back the outside water pressure...
5. ... in a first attempt to tunnel...	E. ... no significant change.
6. ... the ventilation problem with...	F. ... by changing to a circular shield plus a lining of cast-iron segments ...

Text 5. MACHINE-MINED TUNNELS

Task: Fill in the appropriate prepositions: *of, in, from, as, to, for*.

Sporadic attempts to realize the tunnel engineer's dream 1. ___ a mechanical rotary excavator culminated in 1954 at Oahe Dam on the Missouri River near Pierre, 2. ___ South Dakota. With ground conditions being favourable (a readily cuttable clay-shale), success resulted 3. ___ a team effort: Jerome O. Ackerman 4. ___ chief engineer, F.K. Mittry as initial contractor, and James S. Robbins as builder of the first machine—the "Mittry Mole." Later contracts developed three other Oahe-type moles, so that all the various tunnels here were machine-mined—totaling eight miles of 25- to 30-foot diameter. These were the first of the modern moles that since 1960 have been rapidly adopted for many of the world's tunnels … a means of increasing speeds from the previous range of 25 5. ___ 50 feet per day to a range of several hundred feet per day. The Oahe mole was partly inspired by work on a pilot tunnel in chalk started under the English Channel 6. ___ which an air-powered rotary cutting arm, the Beaumont borer, had been invented. A 1947 coal-mining version followed, and in 1949 a coal saw was used to cut a circumferential slot in chalk for 33-foot-diameter tunnels at Fort Randall Dam in South Dakota. 7. ___ 1962 a comparable breakthrough for the more difficult excavation of vertical shafts was achieved in the American development of the mechanical raise borer, profiting from earlier trials 8. ___ Germany.

Unit II. TUNNELINGTECHNIQUES

Text 1. BASIC TUNNELING SYSTEM

Task: Read the text and fill in the gaps with the following words: *soft, projects, basic, doubled, contrast, instances, grouped, planned, cost, condition, role*.

Tunnels are generally _____ in four broad categories, depending on the material through which they pass: soft ground, consisting of soil and very weak rock; hard rock; _____ rock, such as shale, chalk, and friable sandstone; and subaqueous. While these four broad types of ground _____ require very different methods of excavation and ground support, nearly all tunneling operations nevertheless involve certain _____ procedures: investigation, excavation and materials transport, ground support, and environmental control. Similarly, tunnels for mining and for civil-engineering _____ share the basic procedures but differ greatly in the design approach toward permanence, owing to their differing purposes. Many mining tunnels have been _____ 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 _____, 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 _____ in governing the acceptability of construction methods and the practicality of different designs. Indeed, tunneling history is filled with _____ in which a sudden encounter with unanticipated conditions caused long stoppages for changes in construction methods, in design, or in both, with resulting great increases in _____ and time. At the Awali Tunnel in Lebanon in

1960, for example, a huge flow of water and sand filled over 2 miles of the bore and more than _____ construction time to eight years for its 10-mile length.

Text 2. GEOLOGIC INVESTIGATION

Task: Fill in the gaps with the appropriate tense-aspect forms of the verbs.

Thorough geologic analysis _____ *(to be)* 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 _____ *(to 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 _____ *(to limit)* their number; but much can _____ *(to learn)* from thorough aerial and surface surveys, plus well-logging and geophysical techniques developed in the oil industry. Often the problem _____ *(to approach)* with flexibility toward changes in design and in construction methods and with continuous exploration ahead of the tunnel face, done in older tunnels by mining a pilot bore ahead and now by drilling. Japanese engineers _____ *(to pioneer)* methods for prelocating troublesome rock and water conditions.

For large rock chambers and also particularly large tunnels, the problems _____ *(to increase)* so rapidly with increasing opening size that adverse geology can make the project impractical or at least tremendously costly. Hence, the concentrated opening areas of these projects invariably _____ *(to investigate)* during the design stage by a series of small exploratory tunnels called drifts, which also provide for in-place field tests to investigate engineering properties of the rock mass and can often _____ *(to locate)* so their later enlargement affords access for construction.

Since shallow tunnels are more often in soft ground, borings _____ *(to become)* more practical. Hence, most subways _____ *(to involve)* borings at intervals of 100–500 feet to observe the water table and _____ *(to obtain)* undisturbed samples for testing strength, permeability, and other engineering properties of the soil. Portals of rock tunnels _____ *(to be)* often in soil or in rock weakened by weathering. Being shallow, they readily _____ *(to investigate)* by borings, but, unfortunately, portal problems have frequently been treated lightly. Often, they only marginally _____ *(to explore)* or the design is left to the contractor, with the result that a high percentage of tunnels, especially in the United States, have experienced portal failures. Failure to locate buried valleys also _____ (*to cause)* a number of costly surprises.

Text 3. EXCAVATION AND MATERIALS HANDLING

Task 1: Read the text and speak about the 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. For underground use these require diesel engines with scrubbers to eliminate dangerous gases from the exhaust. While existing truck and rail systems are adequate for tunnels progressing in the range of 40–60 feet (12–18 metres) per day, their capacity is inadequate to keep up with fast-moving moles progressing at the rate of several hundred feet per day. Hence, considerable attention is being devoted to developing high-capacity transport systems—continuous-belt conveyors, pipelines, and innovative rail systems (high-capacity cars on high-speed trains). Muck disposal and its transport on the surface can also be a problem in congested urban areas. One solution successfully applied in Japan is to convey it by pipeline to sites where it can be used for reclamation by landfill. For survey control, high-accuracy transit-level work (from base lines established by mountaintop triangulation) has generally been adequate; long tunnels from opposite sides of the mountain commonly meet with an error of one foot or less. Further improvements are likely from the recent introduction of the laser, the pencil-size light beam of which supplies a reference line readily interpreted by workers. Most moles in the United States now use a laser beam to guide steering, and some experimental machines employ electronic steering actuated by the laser beam.

Task 2: Mark the sentences as TRUE or FALSE

1. Excavation of the ground within the tunnel bore may be only semicontinuous, as by handheld power tools or mining machine.

2. 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.

3. For bigger diameters and longer tunnels, a narrow-gauge railroad is commonly employed to take out the muck and bring in workers and construction material.

4. For underground use these require diesel engines with scrubbers to eliminate dangerous gases from the exhaust.

5. Muck disposal and its transport on the surface cannot be a problem in congested urban areas.

6. Further improvements are likely from the recent introduction of the laser, the pencil-size light beam of which supplies a reference line readily interpreted by workers.

Task 3: Match parts of the sentence.

1. Here each cycle involves drilling, loading explosive,	A. ... that moves the broken rock onto a belt conveyor that dumps it into a hauling system of cars or trucks.
2. The mucker is a type of front-end loader	B. ... trucks are generally preferred.
3. Since progress depends on the rate of heading advance,	C. ... to convey it by pipeline to sites where it can be used for reclama-

	tion by landfill.
4. For larger-size bores of short to moderate length,	D. ... blasting, ventilating fumes, and excavation of the blasted rock.
5. Hence, considerable attention is being devoted to developing high-capacity transport systems—continuous-belt conveyors,	E. ... it is often facilitated by mining several headings simultaneously.
6. One solution successfully applied in Japan is …	F. ... pipelines, and innovative rail systems (high-capacity cars on high-speed trains).

Text 4. ENVIRONMENTAL CONTROL

Task 1: Read the text and speak about the 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. In smaller tunnels, the fans are frequently reversible, exhausting fumes immediately after blasting, then reversing to supply fresh air to the heading where the work is now concentrated.

High-level noise generated at the heading by drilling equipment and throughout the tunnel by high-velocity air in the vent lines frequently requires the use of earplugs with sign language for communication. In the future, equipment operators may work in sealed cabs, but communication is an unsolved problem. Electronic equipment in tunnels is prohibited, since stray currents may activate blasting circuits. Thunderstorms may also produce stray currents and require special precautions.

Dust is controlled by water sprays, wet drilling, and the use of respirator masks. Since prolonged exposure to dust from rocks containing a high percentage of silica may cause a respiratory ailment known as silicosis, severe conditions require special precautions, such as a vacuumexhaust hood for each drill. While excess heat is more common in deep tunnels, it occasionally occurs in fairly shallow tunnels. In 1953, workers in the 6.4-mile Telecote Tunnel near Santa Barbara, California, were transported immersed in water-filled mine cars through the hot area (117° F [47° C]). In 1970 a complete refrigeration plant was required to progress through a huge inflow of hot water at 150° F (66° C) in the 7-mile Graton Tunnel, driven under the Andes to drain a copper mine in Peru.

Task 2: Answer the questions.

1. Why is control of the environment essential in all but the shortest tunnels?
2. How are explosive gases removed?
3. Why is the use of earplugs frequently required?
4. Why is electronic equipment prohibited in tunnels?
5. How is the level of dust controlled?
6. What is silicosis?
7. Where is excess heat more common?

Text 5. MODERN SOFT-GROUND TUNNELING

Task: Read the text and fill in the gaps with the following words: *bedrock, avoid, time, urban, circular, method, usually, shallow, structure*.

Soft-ground tunnels most commonly are used for _____ services (subways, sewers, and other utilities) for which the need for quick access by passengers or maintenance staff favours a shallow depth. In many cities this means that the tunnels are above _____, making tunneling easier but requiring continuous support. The tunnel _____ in such cases is generally designed to support the entire load of the ground above it, in part because the ground arch in soil deteriorates with _____ and in part as an allowance for load changes resulting from future construction of buildings or tunnels. Soft-ground tunnels are typically _____ in shape because of this shape's inherently greater strength and ability to readjust to future load changes. In locations within street rights-of-way, the dominant concern in urban tunneling is the need to _____ intolerable settlement damage to adjoining buildings. While this is rarely a problem in the case of modern skyscrapers, which _____ have foundations extending to rock and deep basements often extending below the tunnel, it can be a decisive consideration in the presence of moderate-height buildings, whose foundations are usually _____. In this case the tunnel engineer must choose between underpinning or employing a tunneling _____ method that is sufficiently foolproof that it will prevent settlement damage.

Text 6. HAND-MINED TUNNELS

Task 1: Read the text and answer the question "Why is the ancient practice of hand mining still economical?

The ancient practice of hand mining is still economical for some conditions (shorter and smaller tunnels) and may illustrate particular techniques better than its mechanized counterpart. Examples are forepoling and breasting techniques as developed for the hazardous case of running (unstable) ground. With careful work the method permits advance with very little lost ground. The top breastboard may be removed, a small advance excavated, this breastboard replaced, and progress continued by working down one board at a time. While solid wall forepoling is nearly a lost art, an adaptation of it is termed spiling. In spiling the forepoles are intermittent with gaps between. Crown spiling is still resorted to for passing bad ground; in this case spiles may consist of rails driven ahead, or even steel bars set in holes drilled into crushed rock.

In ground providing a reasonable stand-up time, a modern support system uses steel liner-plate sections placed against the soil and bolted into a solid sheeted complete circle and, in larger tunnels, strengthened inside by circular steel ribs. Individual liner plates are light in weight and are easily erected by hand. By employing small drifts (horizontal passageways), braced to a central core, liner-plate technique has been successful in larger tunnels. The top heading is carried ahead, preceded slightly by a "monkey drift" in which the wall plate is set and serves as a footing for the arch ribs, also to span over as the wall plate is underpinned by erecting posts in small notches at each side of the lower bench. As the ribs and liner plate provide only a light support, they are stiffened by installation of a concrete lining about one day behind the mining. While liner-plate tunnels are more economical than shield tunnels, the risks of lost ground are somewhat greater and require not only very careful workmanship but also thorough soil-mechanics investigation in advance, pioneered in Chicago by Karl V. Terzaghi.

Task 2: Mark the sentences as TRUE or FALSE

1. Examples are forepoling and breasting techniques as developed for the hazardous case of running (unstable) ground.

2. The top breastboard may not be removed, a small advance excavated, this breastboard replaced, and progress continued by working down one board at a time.

3. Crown spiling is no more resorted to for passing bad ground.

4. By employing small drifts (horizontal passageways), braced to a central core, liner-plate technique has been successful in larger tunnels.

5. As the ribs and liner plate provide only a light support, they are stiffened by installation of a concrete lining about two days behind the mining.

6. Liner-plate tunnels are more economical than shield tunnels.

Task 3: Match parts of the sentence.

1. The ancient practice of hand mining is still economical…	A. ... an adaptation of it is termed spiling.
2. With careful work the method permits …	B. ... light in weight and are easily erected by hand.
3. While solid wall forepoling is nearly a lost art,	C. ... rails driven ahead, or even steel bars set in holes drilled into crushed rock.
4. Individual liner plates are…	D. ... preceded slightly by a "monkey drift".
5. In this case spiles may consist of …	E. ... advance with very little lost ground.
6. The top heading is carried ahead,	F. ... for some conditions (shorter and smaller tunnels) and may illustrate particular techniques better than its mechanized counterpart.

Text 7. SHIELD TUNNELS

Task: Fill in the appropriate prepositions: *of, in, from, with, by, for, through, on*.

The risk of lost ground can also be reduced 1. ___ using a shield with individual pockets 2. ___ which workers can mine ahead; these can quickly be closed to stop a run-in. In extremely soft ground the shield may be simply shoved ahead 3. ___ all its pockets closed, completely displacing the soil ahead of it; or it may be shoved with some of the pockets open, 4. ___ which the soft soil extrudes like a sausage, cut into chunks for removal by a belt conveyor. The first of these methods was used 5. ___ the Lincoln Tunnel in Hudson River silt.

Support erected inside the tail of the shield consists 6. ___ large segments, so heavy that they require a power erector arm for positioning while being bolted together. Because 7. ___ its high resistance to corrosion, cast iron has been the most commonly used material for segments, thus eliminating the need for a secondary lining of concrete. Today, lighter segments are employed. In 1968, for example, the San Francisco subway used welded steel-plate segments, protected outside 8. ___ a bituminous coating and galvanized inside. British engineers have developed precast concrete segments that are proving popular 9. ___ Europe.

An inherent problem 10. ___ the shield method is the existence of a 2- to 5-inch (5- to 13-centimetre) ring-shaped void left outside the segments as the result of the thickness of the skin plate and the clearance needed for segment erection. Movement of soil into this void could result 11. ___ up to 5 percent lost ground, an amount intolerable in urban work. Lost ground is held to reasonable levels 12. ___ promptly blowing small-sized gravel into the void, then injecting cement grout (sand-cement-water mixture).

Text 8. WATER CONTROL

Task 1: Read the text and speak about water control.

A soft-ground tunnel below the water table involves a constant risk of a run-in—i.e., soil and water flowing into the tunnel, which often results in complete loss of the heading. One solution is to lower the water table below the tunnel bottom before construction begins. This can be accomplished by pumping from deep wells ahead and from well points within the tunnel. While this benefits the tunneling, dropping the water table increases the loading on deeper soil layers. If these are relatively compressible, the result can be a major settlement of adjacent buildings on shallow foundations, an extreme example being a 15- to 20-foot subsidence in Mexico City due to overpumping.

When soil conditions make it undesirable to drop the water table, compressed air inside the tunnel may offset the outside water pressure. In larger tunnels, air pressure is generally set to balance the water pressure in the lower part of the tunnel, with the result that it then exceeds the smaller water pressure at the crown (upper part). Since air tends to escape through the upper part of the tunnel, constant inspection and repair of leaks with straw and mud are required. Otherwise, a blowout could occur, depressurizing the tunnel and possibly losing the heading as soil enters. Compressed air greatly increases operating costs, partly because a large compressor plant is needed, with standby equipment to insure against loss of pressure and partly because of the slow movement of workers and muck trains through the air locks. The dominant factor, however, is the huge reduction in productive time and lengthy decompression time required for people working under air to prevent the crippling disease known as the bends (or caisson disease), also encountered by divers. Regulations stiffen as pressure increases up to the usual maximum of 45 pounds per square inch (3 atmospheres) where daily time is limited to one hour working and six hours for decompression. This, plus higher hazard pay, makes tunneling under high air pressure very costly. In consequence, many tunneling operations attempt to lower the operating air pressure, either by partially dropping the water table or, especially in Europe, by strengthening the ground through the injection of solidifying chemical grouts. French and British grouting-specialist companies have developed a number of highly engineered chemical grouts, and these are achieving considerable success in advance cementing of weak soil.

Task 2: Answer the questions.

1. What does a run-in often result in?
2. What is the solution to the problem of a run-in?
3. What is usually done when soil conditions make it undesirable to drop the water table?
4. Why does compressed air greatly increase operating costs?
5. What attempts to lower the operating air pressure have been made?

Text 9. MODERN ROCK TUNNELING

Task: Read the text and give definitions to the following terms: *intact rock, quarrying, drilling, joints, faults, shear zones, altered zones, weak seams, geostress, rock mechanics.*

It is important to distinguish between the high strength of a block of solid or intact rock and the much lower strength of the rock mass consisting of strong rock blocks separated by much weaker joints and other rock defects. While the nature of intact rock is significant in quarrying, drilling, and cutting by moles, tunneling and other areas of rock engineering are concerned with the properties of the rock mass. These properties are controlled by the spacing and nature of the defects, including joints (generally fractures caused by tension and sometimes filled with weaker material), faults (shear fractures frequently filled with claylike material called gouge), shear zones (crushed from shear displacement), altered zones (in which heat or chemical action have largely destroyed the original bond cementing the rock crystals), bedding planes, and weak seams (in shale, often altered to clay). Since these geologic details (or hazards) usually can only be generalized in advance predictions, rock-tunneling methods require flexibility for handling conditions as they are encountered. Any of these defects can convert the rock to the more hazardous soft-ground case.

Also important is the geostress—i.e., the state of stress existing in situ prior to tunneling. Though conditions are fairly simple in soil, geostress in rock has a wide range because it is influenced by the stresses remaining from past geologic events: mountain building, crustal movements, or load subsequently removed (melting of glacial ice or erosion of former sediment cover). Evaluation of the geostress effects and the rock mass properties are primary objectives of the relatively new field of rock mechanics and are dealt with below with underground chambers since their significance increases with opening size. This section therefore emphasizes the usual rock tunnel, in the size range of 15 to 25 feet.

Text 10. CONVENTIONAL BLASTING

Task: Fill in the gaps with the appropriate tense-aspect forms of the verbs.

Blasting _____ *(to carry)* on in a cycle of drilling, loading, blasting, ventilating fumes, and removing muck. Since only one of these five operations can _____ *(to conduct)* at a time in the confined space at the heading, concentrated efforts to improve each _____ *(to result)* in raising the rate of advance to a range of 40–60 feet per day, or probably near the limit for such a cyclic system. Drilling, which _____ *(to consume)* a major part of the time cycle, has been intensely mechanized in the United States. High-speed drills with renewable bits of hard tungsten carbide _____ *(to position)* by power-operated jib booms located at each platform level of the drilling jumbo (a mounted platform for carrying drills). Truck-mounted jumbos _____ *(to use)* in larger tunnels. When rail-mounted, the drilling jumbo is arranged to straddle the mucker so that drilling can _____ *(to resume)* during the last phase of the mucking operation. By experimenting with various drill-hole patterns and the sequence of firing explosives in the holes, Swedish engineers _____ *(to be able)* to blast a nearly clean cylinder in each cycle, while minimizing use of explosives. Dynamite, the usual explosive, _____ *(to fire)* by electric blasting caps, energized from a separate firing circuit with locked switches. Cartridges generally _____ *(to load)* individually and seated with a wooden tamping rod; Swedish efforts to expedite loading often employ a pneumatic cartridge loader. American efforts toward reduced loading time _____ *(to tend)* to replace dynamite with a free-running blasting agent, such as a mixture of ammonium nitrate and fuel oil (called AN-FO), which in granular form (prills) can _____ *(to blow)* into the drill hole by compressed air. While AN-FO-type agents are cheaper, their lower power increases the quantity required, and their fumes usually _____ *(to increase)* ventilating requirements. For wet holes, the prills must be changed to a slurry requiring special processing and pumping equipment.

Text 11. ROCK SUPPORT

Task 1: Read the text and translate it in writing.

Most common loading on the support of a tunnel in hard rock is due to the weight of loosened rock below the ground arch, where designers rely particularly on experience with Alpine tunnels as evaluated by two Austrians, Karl V. Terzaghi, the founder of soil mechanics, and Josef Stini, a pioneer in engineering geology. The support load is greatly increased by factors weakening the rock mass, particularly blasting damage. Furthermore, if a delay in placing support allows the zone of rock loosening to propagate upward (*i.e.,* rock falls from the tunnel roof), the rock-mass strength is reduced, and the ground arch is raised. Obviously, the loosened rock load can be greatly altered by a change in joint inclination (orientation of rock fractures) or by the presence of one or more of the rock defects previously mentioned. Less frequent but more severe is the case of high geostress, which in hard, brittle rock may result in dangerous rock bursts (explosive spalling off from the tunnel side) or in a more plastic rock mass may exhibit a slow squeezing into the tunnel. In extreme cases, squeezing ground has been handled by allowing the rock to yield while keeping the process under control, then remining and resetting initial support several times, plus deferring concrete lining until the ground arch becomes stabilized.

For many years steel rib sets were the usual first-stage support for rock tunnels, with close spacing of the wood blocking against the rock being important to reduce bending stress in the rib. Advantages are increased flexibility in changing rib spacing plus the ability to handle squeezing ground by resetting the ribs after remining. A disadvantage is that in many cases the system yields excessively, thus inviting weakening of the rock mass. Finally, the rib system serves only as a first-stage or temporary support, requiring a second-stage encasement in a concrete lining for corrosion protection.

Text 12. CONCRETE LINING

Task 1: Read the text and speak about concrete lining.

Concrete linings aid fluid flow by providing a smooth surface and insure against rock fragment falling on vehicles using the tunnel. While shallow tunnels are often lined by dropping concrete down holes drilled from the surface, the greater depth of most rock tunnels requires concreting entirely within the tunnel. Operations in such congested space involve special equipment, including agitator cars for transport, pumps or compressed-air devices for placing the concrete, and telescoping arch forms that can be collapsed to move forward inside forms remaining in place. The invert is generally concreted first, followed by the arch where forms must be left in place from 14 to 18 hours for the concrete to gain necessary strength. Voids at the crown are minimized by keeping the discharge pipe buried in fresh concrete. The final operation consists of contact grouting, in which a sand-cement grout is injected to fill any voids and to establish full contact between lining and ground. The method usually produces progress in the range of 40 to 120 feet per day. In the 1960s there was a trend toward an advancing-slope method of continuous concreting, as originally devised for embedding the steel cylinder of a hydropower penstock. In this procedure, several hundred feet of forms are initially set, then collapsed in short sections and moved forward after the concrete has gained necessary strength, thus keeping ahead of the continuously advancing slope of fresh concrete. As a 1968 example, Libby Dam's Flathead Tunnel in Montana attained a concreting rate of 300 feet (90 metres) per day by using the advancing slope method.

Task 2: Answer the questions.

1. How do concrete lining aid fluid flow?
2. What kind of equipment do operations in such congested space involve?
3. What does the final operation consist of?
4. What was an advancing-slope method of continuous concreting originally devised for?
5. What are the advantages of the advancing slope method?

Text 13. ROCK BOLTS

Task: Read the text and speak about rock bolts and their use.

Rock bolts are used to reinforce jointed rock much as reinforcing bars supply tensile resistance in reinforced concrete. After early trials about 1920, they were developed in the 1940s for strengthening laminated roof strata in mines. For public works their use has increased rapidly since 1955, as confidence has developed from two independent pioneering applications, both in the early 1950s. One was the successful change from steel rib sets to cheaper rock bolts on major portions of the 85 miles of tunnels forming New York City's Delaware River Aqueduct. The other was the success of such bolts as the sole rock support in large underground powerhouse chambers of Australia's Snowy Mountains project. Since about 1960, rock bolts have had major success in providing the sole support for large tunnels and rock chambers with spans up to 100 feet. Bolts are commonly sized from 0.75 to 1.5 inches and function to create a compression across rock fissures, both to prevent the joints opening and to create resistance to sliding along the joints. For this they are placed promptly after blasting, anchored at the end, tensioned, and then grouted to resist corrosion and to prevent anchor creep. Rock tendons (prestressed cables or bundled rods, providing higher capacity than rock bolts) up to 250 feet long and prestressed to several hundred tons each have succeeded in stabilizing many sliding rock masses in rock chambers, dam abutments, and high rock slopes. A noted example is their use in reinforcing the abutments of Vaiont Dam in Italy. In 1963 this project experienced disaster when a giant landslide filled the reservoir, causing a huge wave to overtop the dam, with large loss of life. Remarkably, the 875-foot-high arch dam survived this huge overloading; the rock tendons are believed to have supplied a major strengthening.

Text 14. PRESERVING ROCK STRENGTH

Task: Read the text and give definitions to the following terms: *blasting, cutter life, medium-strength rock, hard rock, equipment breakages, milling-type cutters.*

In rock tunnels, the requirements for support can be significantly decreased to the extent that the construction method can preserve the inherent strength of the rock mass. The opinion has been often expressed that a high percentage of support in rock tunnels in the United States (perhaps over half) has been needed to stabilize rock damaged by blasting rather than because of an inherently low strength of the rock. As a remedy, two techniques are currently available. First is the Swedish development of sound-wall blasting (to preserve rock strength), treated below under rock chambers, since its importance increases with size of the opening. The second is the American development of rock moles that cut a smooth surface in the tunnel, thus minimizing rock damage and support needs—here limited to rock bolts connected by steel straps for this sandstone tunnel. In stronger rocks (as the 1970 Chicago sewers in dolomite) mole excavation not only largely eliminated need for support but also produced a surface of adequate smoothness for sewer flow, which permitted a major saving by omitting the concrete lining. Since their initial success in clay shale, the use of rock moles has expanded rapidly and has achieved significant success in medium-strength rock such as sandstone, siltstone, limestone, dolomite, rhyolite, and schist. The advance rate has ranged up to 300 to 400 feet per day and has often outpaced other operations in the tunneling system. While experimental moles were used successfully to cut hard rock such as granite and quartzite, such devices were not economical, because cutter life was short, and frequent cutter replacement was costly. This was likely to change, however, as mole manufacturers sought to extend the range of application. Improvement in cutters and progress in reducing the time lost from equipment breakages were producing consistent improvements.

American moles have developed two types of cutters: disk cutters that wedge out the rock between initial grooves cut by the hard-faced rolling disks, and roller-bit cutters using bits initially developed for fast drilling of oil wells. As later entrants in the field, European manufacturers have generally tried a different approach—milling-type cutters that mill or plane away part of the rock, then shear off undercut areas. Attention is also focusing on broadening the moles' capabilities to function as the primary machine of the whole tunneling system. Thus, future moles are expected not only to cut rock but also to explore ahead for dangerous ground; handle and treat bad ground; provide a capability for prompt erection of support, rock bolting, or shotcreting; change cutters from the rear in loose ground; and produce rock fragments of a size appropriate to capability of the muck removal system. As these problems are solved, the continuous-tunneling system by mole is expected largely to replace the cyclic drilling and blasting system.

Text 15. WATER INFLOWS

Task: Read the text and translate it in writing.

Exploring ahead of the path of a tunnel is particularly necessary for location of possible high water inflows and permitting their pretreatment by drainage or grouting. When high-pressure flows occur unexpectedly, they result in long stoppages. When huge flows are encountered, one approach is to drive parallel tunnels, advancing them alternately so that one relieves pressure in front of the other. This was done in 1898 in work on the Simplon Tunnel and in 1969 on the Graton Tunnel in Peru, where flow reached 60,000 gallons (230,000 litres) per minute. Another technique is to depressurize ahead by drain holes (or small drainage drifts on each side), an extreme example being the 1968 Japanese handling of extraordinarily difficult water and rock conditions on the Rokko Railroad Tunnel, using approximately three-quarters of a mile of drainage drifts and five miles of drain holes in a one-quarter-mile length of the main tunnel.

Text 16. HEAVY GROUND

Task: Read the text and speak about heavy ground (*its definition, techniques evolved on the job, examples and results*).

The miner's term for very weak or high geostress ground that causes repeated failures and replacement of support is heavy ground. Ingenuity, patience, and large increases of time and funds are invariably required to deal with it. Special techniques have generally been evolved on the job, as indicated by a few of the numerous examples. On the 7.2-mile Mont Blanc Vehicular Tunnel of 32-foot size under the Alps in 1959–63, a pilot bore ahead helped greatly to reduce rock bursts by relieving the high geostress. The 5-mile, 14-foot El Colegio Penstock Tunnel in Colombia was completed in 1965 in bituminous shale, requiring the replacement and resetting of more than 2,000 rib sets, which buckled as the invert (bottom supports) and sides gradually squeezed in up to 3 feet, and by deferring concreting until the ground arch stabilized.

While the ground arch eventually stabilized in these and numerous similar examples, knowledge is inadequate to establish the point between desirable deformation (to mobilize ground strength) and excessive deformation (which reduces its strength), and improvement is most likely to come from carefully planned and observed field-test sections at prototype scale, but these have been so costly that very few have actually been executed, notably the 1940 test sections in clay on the Chicago subway and the 1950 Garrison Dam test tunnel in the clay-shale of North Dakota. Such prototype field testing has resulted, however, in substantial savings in eventual tunnel cost. For harder rock, reliable results are even more fragmentary.

Text 17. UNLINED TUNNELS

Task 1: Read the text and speak about the unlined tunnels.

Numerous modest-size conventionally blasted tunnels have been left unlined if human occupancy was to be rare and the rock was generally good. Initially, only weak zones are lined, and marginal areas are left for later maintenance. Most common is the case of a water tunnel that is built oversized to offset the friction increase from the rough sides and, if a penstock tunnel, is equipped with a rock trap to catch loose rock pieces before they can enter the turbines. Most of these have been successful, particularly if operations could be scheduled for periodic shutdowns for maintenance repair of rockfalls; the Laramie-Poudre Irrigation Tunnel in northern Colorado experienced only two significant rockfalls in 60 years, each easily repaired during a nonirrigation period. In contrast, a progressive rockfall on the 14-mile Kemano penstock tunnel in Canada resulted in shutting down the whole town of Kitimat in British Columbia, and vacationing workers for nine months in 1961 since there were no other electric sources to operate the smelter. Thus, the choice of an unlined tunnel involves a compromise between initial saving and deferred maintenance plus evaluation of the consequences of a tunnel shutdown.

Task 2: Mark the sentences as TRUE or FALSE

1. Numerous modest-size conventionally blasted tunnels have been left unlined if human occupancy was to be rare and the rock was generally good.
2. All zones are lined, and marginal areas are left for later maintenance.
3. The Laramie-Poudre Irrigation Tunnel in northern Colorado experienced only three significant rockfalls in 60 years.
4. A progressive rockfall on the 14-mile Kemano penstock tunnel in Canada resulted in shutting down the whole town of Kitimat in British Columbia, and vacationing workers for six months in 1961.

REFERENCES

1. Tunnel construction techniques and their details [сайт] https://theconstructor.org/construction/tunnel-construction-methods/17167/ (дата обращения 10.10.2020).
2. Tunneling techniques. Basic tunneling system [сайт] https://www.britannica.com/technology/tunnel/Tunneling-techniques (дата обращения 10.09.2020).
3. Tunnels and underground excavations [сайт] https://www.britannica.com/technology/tunnel (дата обращения 10.09.2020).
4. Tunnel construction. From Wikipedia, the free encyclopedia [сайт] https://en.wikipedia.org/wiki/Tunnel_construction (дата обращения 10.09.2020).

CONTENTS

АНГЛИЙСКИЙ ЯЗЫК

ПРОЕКТИРОВАНИЕ, СТРОИТЕЛЬСТВО И РЕКОНСТРУКЦИЯ ЗДАНИЙ И ПОДЗЕМНЫХ СООРУЖЕНИЙ ПРОМЫШЛЕННОГО И ГРАЖДАНСКОГО НАЗНАЧЕНИЯ

ENGLISH

DESIGN, CONSTRUCTION AND RECONSTRUCTION OF BUILDINGS AND UNDERGROUND STRUCTURES FOR INDUSTRIAL AND CIVIL PURPOSES

Методические указания к практическим работам для студентов магистратуры направления 08.04.01

Сост.: *Е.В.Картер*, *В.Н. Ионова*

Печатается с оригинал-макета, подготовленного кафедрой иностранных языков

Ответственный за выпуск *Е.В.Картер*

Лицензия ИД № 06517 от 09.01.2002

Подписано к печати 02.03.2021. Формат 60×84/16.
Усл. печ. л. 1,9. Усл.кр.-отт. 1,9. Уч.-изд.л. 1,8. Тираж 75 экз. Заказ 148.

Санкт-Петербургский горный университет
РИЦ Санкт-Петербургского горного университета
Адрес университета и РИЦ: 199106 Санкт-Петербург, 21-я линия, 2