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S T R U C T U R E S

I N T I M E & S P A C E II

LIDIJA KRALJEVIĆ

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LIDIJA KRALJEVIĆ
“ STRUCTURES IN TIME & SPACE II “

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U N I T 1

TRANSPORTATION SYSTEM

Transportation has always been one of the most important aspects of civil engineering. One of the great accomplishments of the Roman engineers was the highway system that made rapid communication possible between Rome and the provinces of the empire.

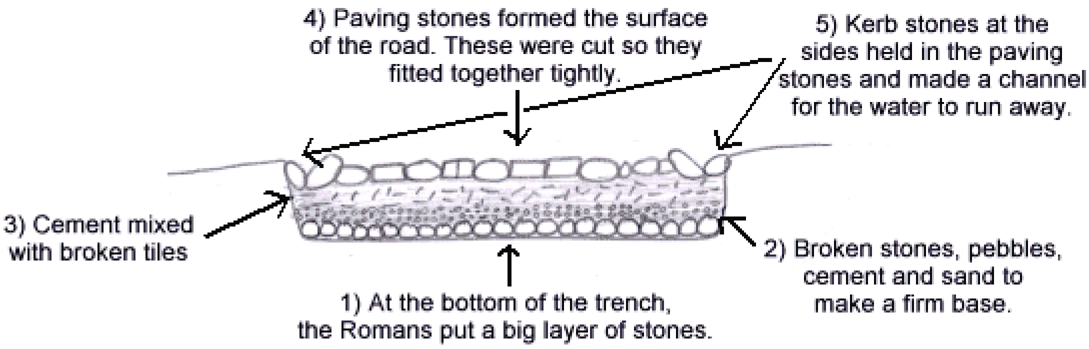

Fig. 1: Cross section of the Roman road

Modern highways are still built according to the principles laid down in the eighteenth and nineteenth centuries by a Frenchman, Pierre Tresageut, the Englishman Telford, and a Scot, John L. McAdam, whose name has passed into English in the words macadam, macadamize, and tarmac.

These men designed the first modern roads that had a firm footing, the surface on which the foundation rested. Their roads also included good drainage and a wearing surface (the top level that directly receives the wear of traffic) that could not be penetrated by water.

McAdam realized that the soil itself could bear the weight of the road when it was compacted or pressed down, as long as it remained dry. He was able therefore to eliminate the heavy cost of the stone foundation by laying a base course of crushed stone on the top of a compacted footing. These roads were adequate during the nineteenth century when wagons and carriages had tires made of iron or steel. When the automobile appeared at the beginning of the twentieth century, however, its rubber tiers broke up the smooth surfaces. Therefore, the top layer was bound together more firmly by mixing the crushed rock with tar or asphalt.

Basically, the roadbuilding had improved in only two ways in the twentieth century. The first improvement involves the use of concrete for the wearing surface. The other is traffic engineering, which has produced the modern express highway, or freeway that has only limited access and maximum safety controls. The angular intersections common on older roads have been eliminated in favor of cloverleaf interchanges or others with even more complicated designs. Extreme curves or steep slopes are minimized so that the traffic can continue to move without slowing down.

When construction on a new highway begins, huge earth-moving machines called bulldozers level the ground along the designated route. Whenever possible, the amount in a cut where earth is being removed should be equal to the amount needed for a nearby fill. Moving earth from a distant point is extremely expensive, and economy is a critical aspect of engineering's work.

After the earth has been moved and shaped according to the design of the road, other machines prepare the footing. The most important of these is probably a vibrating roller, which compacts the earth until it can bear the weight of the base course and wearing surface that will rest on it. In many cases, however, mixing some other material with it must stabilize the soil. This may be bitumen or a grout of concrete or some other substance. The new and complex science of soil mechanics classifies soils and relates those classifications to their load-bearing capacity in a number of different ways.
(abridged from “English in Civil Engineering I ”, Z. Čulić)

JOINTS

Concrete pavements expand and contract with changes in temperature and moisture content. Therefore, unless the pavement is designed so as to allow free movement of the slab, forces may develop in the concrete that will raise or crack it. Cracking cannot be eliminated entirely but experience has shown that, when the pavement slab is provided with transverse joints at reasonable intervals and with well distributed reinforcement between joints, the formation of wide cracks is prevented and the number of visible cracks is materially reduced.

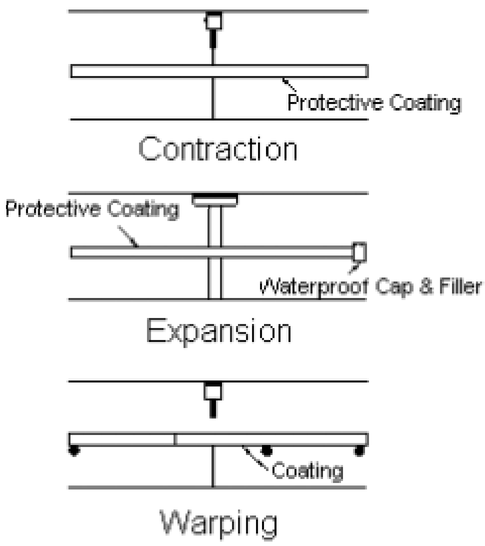

Fig. 2: Joints

Three kinds of joints are used to prevent cracking in pavements, namely, expansion joints, contraction joints, and warping joints. In the case of an expansion joint, which allows for both expansion and contraction, the pavement is divided into separate slabs and a space for expansion, generally filled with a compressible material, is provided between slabs. A contraction joint, however, is intended only for contraction; it is merely a vertical plane of separation cut either entirely or partly through the pavement, and is not provided with the space for expansion.

Warping joints are those constructed to control cracking due to bending stresses caused by the efforts of a pavement slab to assume a warped shape under the influence of the difference in temperature and moisture condition between the top and bottom of the slab.
(adopted from “English for Civil Engineers II “, M. Horvatović)

EXERCISES:

1.TRUE OR FALSE?

1. The principles of road building were laid down by the Roman engineers.
2. Modern roadbuilding has improved in only the two ways in the twentieth century.
3. McAdam introduced a base course into the roadbuilding.
4. Bulldozers compact the earth.
5. A vibrating roller prepares the footing.
6. The wearing surface is the top layer of the road.

2.ANSWER THE QUESTIONS!

1. Who were Tresaguet, Telford and McAdam?
2. What elements did these first modern roads consist of?
3. How did McAdam’s roads differ from these roads?
4. How was the surface of such roads accommodated to automobile traffic?
5. What material did engineers of the 20th century start to apply for the wearing surface?
6. How did traffic engineering improved roadbuilding?
7. What is the first step in the construction of a new road?
8. What is a vibrating roller used for?
9. What does the science of soil mechanics deal with?

3.COMPLETE THE TEXT BY CHOOSING THE CORRECT WORDS FROM THE LIST:
(removal, cross-drainage, pipe, artificial, crowned, underdrainage, intersect, outlets)

The ……. of surface water is known as surface drainage and is accomplished by means of……..road and surfaces, sidewalk slopes, side slopes, ditches, gutters, and …….. drains. The removal of ground water is known as…………. and is accomplished by means of ditches, blind drains, and tile drains. Both surface water and ground water must be carried to ……….., which may be either natural or ………..watercourses or lakes. When watercourses ……… the roadways, bridges or culverts must be used to carry them beneath the travel surface. They are sometimes described as…………

4.FIND SYNONYMS FOR THE FOLLOWING WORDS:

accomplishment, built, footing, to eliminate, complicated, to shape, rapid

5.EXPLAIN IN YOUR OWN WORDS:

highway, wearing surface, crack, foundation, passenger

6.READ THE TEXT ABOUT TRANSPORTATION SYSTEM ONCE AGAIN AND WRITE DOWN THE MOST IMPORTANT INFORMATION IN THE FORM OF THE NOTES.

7.TRANSLATE THE TEXT ABOUT JOINTS.

8.PUT THE SENTENCES INTO THE PASSIVE:

1. They sometimes stabilize soil by mixing it with other soils.
2. They compacted soil by either rolling, impact or vibration.
3. We had used soil mechanics to identify particular soils and their properties.
4. Workers use bulldozers to compact soil.
5. Engineers will set up a manuscript.
6. The digital computer has changed all fields of endeavor.
7. They must attain a balance between the force of gravity and the strength of a structure.

9.CONNECT THE PHRASAL VERBS ON THE LEFT WITH THE VERBS OF THE SIMILAR MEANING ON THE RIGHT:

carry on	test
leave out	eliminate
carry out	continue
get around	discard
cross out	consider
throw away	omit
try out	complete
think over	avoid

U N I T 2

THE HIGHWAY STRUCTURE

The field of highway engineering embraces the following divisions:

1. Design
2. Construction
3. Maintenance
4. Economics
5. Administration, financing and planning

The highway structure embraces the entire right-of-way, which is the area occupied by the highway between the boundary lines with private property on each side, and consists of:

I. The subgrade, which is the soil below the roadway and below the shoulders.

II. The roadway, or traveled portion of the highway; it may consist of one or more courses of road-surfacing material and may include a foundation. It is further described as consisting of a number of traffic lanes, each sufficiently wide to accommodate the vehicle which use it and to provide safe clearance between vehicles in adjacent lanes.

III. The shoulders, which are two strips of earth or other material one either side of the roadway, between the roadway and the inside boundary of the ditch or gutter.

IV. The roadside, which is the area between each boundary line and the edge of the adjacent ditch or gutter; if there are no ditches or gutters, no visible boundary exists between the shoulders and the roadside.

V. The drainage system, which includes ditches, gutters, drains, spillways, culverts, and bridges.

VI. Miscellaneous structures such as guard railing, sidewalks, retaining walls, lighting systems, grade-crossing treatments and signs.

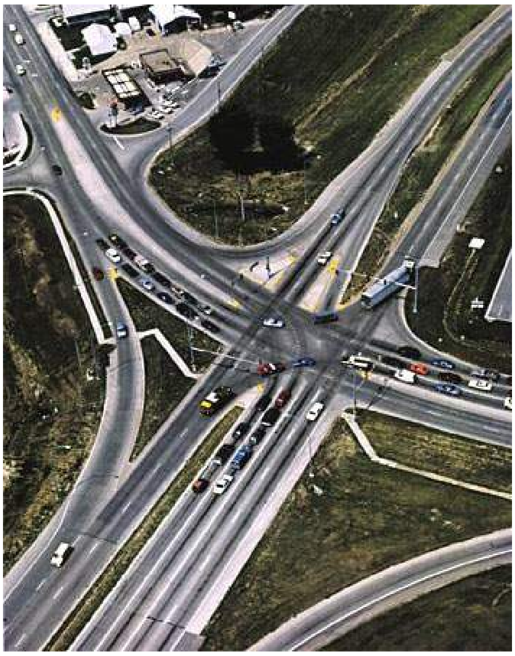

Fig. 3: Aerial view of the modern highway

CLASSIFICATION OF ROADWAY SURFACES

We may classify the various wearing surfaces or pavements into three principal groups:

I. Low-type surfaces: 1. Natural earth. 2. Sand-clay. 3. Gravel. 4. Stabilized soil. 5. Traffic-bound macadam. 6. Some special surfaces including iron ore, shell, lime-rock, etc.

II. Intermediate type surfaces: Traffic-bound and water-bound macadam with bituminous surface treatment. 2. Bituminous road mixes with adequate foundations. 3. "Low-cost bituminous plant mixes with adequate foundations. 4. Cement-bound macadam. 6. Bituminous macadam.

III. High-type surfaces: 1. Concrete. 2. Bituminous concrete sheet asphalt. 3. Rock asphalt. 4. Block pavement.

FLEXIBLE AND RIGID TYPES OF PAVEMENTS

Roadways may be further classified as rigid and flexible. Pavement of Portland cement concrete or those in which Portland cement concrete cases or foundations are used are known as rigid pavements. Gravel, the various types of macadam, asphaltic or bituminous wearing courses supported on gravel, macadam, or bituminous foundations are known as flexible pavements or roadways.

ROUTE LOCATION

Route location fits into the continuum of highway engineering between comprehensive transportation planning and highway design. The process of route location consists of two major parts: a reconnaissance study followed by a location study. The objective of this processes taken as a whole is to determine the most economically highway location between a given set of termini that combines the needs of the travelling public and the interests of the local area in a manner that is environmentally, socially, and politically responsive. The end product of the location study is the documented report of the recommended and approved routing.

Fig. 4: Autostrada del Sole (Italy)

The reconnaissance study is the "search" phase of the process. Data are assembled via maps, pictures, reports, and interviews, then reviewed and reduced to meaningful proportions. Alternative locations are developed and refined with conjunctive feedback from interested agencies, supervised by an advisory committee. The search phase concludes with the documentation of feasible alternative routes in narrative and graphic form. The reconnaissance study is reviewed and approved by the appropriate agencies and the next phase is authorized.

The location study is the "selection" phase of the route location process, done at a more detailed level of engineering. The alternatives developed in reconnaissance are screened and their design refined. The refinement of design begins with collection of additional and more detailed mapping. The horizontal and vertical geometrics of each and stereo-photographic information and applying computer technology whenever possible to spend the refinement. During the design development stage, the location engineer must investigate access considerations and right-of-way requirements for each of the alternatives. The refinement produces a very preliminary design for alternative locations satisfying such factors as adequate traffic service, necessary drainage and structure facilities, joint development proposals, construction phasing plans, and traffic maintenance solutions.

The evaluation of alternatives involves the analysis of cost estimates and the calculation of benefit-cost ratios utilizing annual highway costs and annual road-user costs. The benefit-cost ratios compared among alternatives indicate which location promises the best return on the capital outlay for the improvement. The alternatives are evaluated as to their social, economic, and environmental impact on the affected area. The route location process concludes with the review and approval of the final report document.
(adopted from: "English for Civil Engineering II ", M. Horvatović)

EXERCISES:

1. TRANSLATE THE TEXT!
2. THE EXPRESSION ON THE LEFT WITH ONE OF THE STATEMENTS ON THE RIGHT :

a) Volume	1. A layer of crushed stone that rests on a footing.
b) Wearing surface	2. Science dealing with the classification of different types of soils.
c) Subgrade	3. The top level of a road that directly receives the wear of the traffic.
d) Runway	4. The paved strip on which aircraft land or take off at an airport.
e) Soil mechanics	5. The number of vehicles passing a given point during a specified period of time.
f) Base course	6. The portion of the roadbed prepared as a foundation for the base or surface course.

3. COMPREHENSION: Find answers for the following questions in the text and copy them into your notebook!
   1. What are the various phases of highway engineering?
   2. What does a highway structure consist of?
   3. How are pavements classified?
   4. Copy the definition of a rigid and flexible pavement?
   5. What does the process of route location consist of?
   6. What does the evaluation of alternatives involve?
   7. What is the final stage of the location study?

4. FIND COLLOCATIONS IN THE TEXT THAT CONSIST OF THE FOLLOWING WORDS! (Give as many collocations as possible!)
   ……… study, ……….. location, …………impact
   highway…….., ………… phase, soil………………,
   concrete ………, highway ……….., transportation …………

5. REPLACE THE EXPRESSION WITH THE ONE HAVING A SIMILAR MEANING:

to identify soils	initial outlay
construction technique	soil properties
detailed study	social impact

6. FILL IN THE MISSING PREPOSITIONS:
    1. Highway engineering is concerned …… the following divisions: design, construction, maintenance, etc.
    2. Soil can be compacted …. either rolling, impact, or vibrations.
    3. Concrete train can perform these operations … a rate of about three fourths of a meter per minute.
    4. Soils are classified …… to their properties.
    5. What is the water-supply project based…..?
    6. A highway engineer is interested … the effect of the wearing surface.
    7. A slip is similar … a slide in its effects, but it results …. a different condition.

7. PUT COMMAS WHERE NECESSARY :

The comparison of the relative advantages and disadvantages of the several possible routes studied should take into consideration the traffic and other characteristics of the region which the route is to serve the difficulty of construction the cost of maintenance and all other elements essential to good location and the estimated annual cost and benefits of the improvement. A full knowledge of the design requirements and economics of road building is needed as well as a fairly accurate estimate of the transportation needs and general planning areas.

UNIT 3

S U R V E Y I N G

Before any civil engineering project can be designed, a survey of the site must be made. Surveying means measuring, and recording by means of maps, earth's surface with the greatest degree of accuracy possible.

There are two kinds of surveying: plane and geodetic. Plane surveying is the measurement of the earth's surface as though it were a plane or flat surface without curvature. It covers small areas. Computations are made by using the formulae of plane geometry and plane trigonometry. Geodetic surveys are used for larger areas, long lines and precisely locating basic points suitable for controlling other surveys. They take into account the curvature of the earth.

Under these broad classes there are some other types of surveys which have descriptive names:

Land, boundary, and cadastral surveys usually are closed surveys that establish property corners and landlines. The term "cadastral" is now generally reserved for surveys of the public lands.

Topographic surveys are made to obtain data for maps. They provide the locations of natural or artificial features and elevations used in map making.

Fig. 5: Modern theodolite

Route surveys normally start at a control point and progress to another control point in the most direct manner permitted by field conditions. These surveys are used for railroads, highways and pipelines.

Hydrographic surveys determine the shorelines and depths of lakes, streams, oceans, reservoirs, and other bodies of water. Data from hydrographic surveys are needed for studies in waterpower, water supply, flood control, and irrigation.

Construction surveys give locations and elevations for construction work. They are most essential in projects for tunnels, dams, airports, canals, or other major building projects.

Photogrammetric surveys utilize terrestrial or aerial photographs.

E R R O R S

In the measurements of surveying, instrumental errors may arise from imperfection or faulty adjustment of the devices with which measurements are taken; personal errors occur through the observer's inability to read the instruments exactly; and natural errors occur from variations in the phenomena of nature such as temperature, humidity, wind, gravity, refraction, and magnetic declination. Mistakes are unintentional faults of conduct arising from poor judgement or from confusion in the mind of the observer. Mistakes have no place in a discussion of errors. They are detected and eliminated by checking all work.

Kinds of error: The resultant error is the difference between a measurement and the true value. It is made up of individual errors from a variety of sources.

A discrepancy is the difference between two measurements of the same quality.

A systematic error is one that, so long as conditions remain unchanged, always has the same magnitude and the same algebraic sign. An accidental error is an error due to a combination of causes beyond the ability of the observer to control and for which it is impossible to make correction. The magnitude and algebraic sign of the accidental error are matters of chance and hence cannot be computed as can the magnitude and algebraic sign of a systematic error. However, such errors taken collectively obey the law of probability. Probable error is a plus or minus quantity, within which limits, the actual accidental error is as likely as not to fall.

(adopted from:" English in Civil Engineering II", M. Horvatović)

EXERCISES:

1. READ THE TEXT ABOUT SURVEYING AND THEN MAKE NOTES WITH THE MOST IMPORTANT INFORMATION FROM THE TEXT.

2. COMPLETE THE DEFINITIONS!

1. Surveying is……
2. Plane surveying is…..
3. Geodetic surveying is…..
4. An instrumental error is….
5. A personal error is….
6. A natural error is ……
7. A mistake is ………

3. MATCH THE EXPRESSION ON THE LEFT WITH THE REST OF THE SENTENCE ON THE RIGHT!

1. Hydrographic surveys	a) are used to establish property markers.
2. Topographic surveys	b) are made to provide data for maps.
3. Construction surveys	c) are used for railroads, highways, and pipelines.
4. Photogrammetric surveys	d) are used on water and its bounding land

surfaces.

5. Land surveys — e) are based on the use of photographs of land areas to find positions or contours.
6. Route surveys — f) give locations and elevations.

4. COMPLETE THE SENTENCES WITH THE EXPRESSIONS IN THE BRACKETS! (systematic, accidental , resultant, discrepancy, probable)
   ……… error is the difference between a measurement and the true value.
   ………. error is a plus or minus quantity, within which limits, the accidental error is as likely as not to fall.
   ……….error is the difference between two measurements of the same quality.
   ………error is an error due to combination of causes beyond the ability of the observer to control and for which it is impossible to make correction.
   ………error is one that, so long as condition remain unchanged, always has the same magnitude and the same algebraic sign.

5. FIND SYNONYMS FOR THE FOLLOWING WORDS:
   occur, fault, magnitude, result in, plane surface, obtain, essential, device

6. THINK OF COLLOCATIONS WHICH COULD BEGIN OR END WITH…..

natural……..	………. fault
individual……	………..measurement
earth's…….	……….site
public……..	……….feature

7. PUT THE VERBS IN BRACKETS INTO EITHER INFINITIVE OR GERUND FORM :
   1. The engineer decided (make) a survey before (design) the project.
   2. Some modern instruments allow engineers (measure) distances with a high degree of accuracy.
   3. The current trend is (purify) water before it is released back into the environment.
   4. This method is particularly useful when (take) measurements over bodies of water.
   5. When will a student begin (take) courses in his field of specialization?
   6. He was determined (conduct) tests with the new equipment and finally succeeded in (get) the results everyone expected.
   7. Recycling simply means (use) the waste material again.
   8. The need (conserve) and (reuse) our resources has created a challenge.
   9. The process of (solve) a problem may sometimes be very long and difficult.
   10. Wastes are allowed (settle) until they become solid or semisolid.

8.TRANSLATE INTO ENGLISH:

1. Mjerenje kutova, bilo u horizontalnoj ili okomitoj ravnini, važan je aspekt geodetskog mjerenja.
2. Različite vrste geodetskih mjerenja uključuju: mjerenja udaljenosti, određivanja nadmorskih visina, određivanje granica, te drugih fizičkih obilježja terena.
3. Ovi instrumenti usmjeravaju valove prema cilju koji ih odbija natrag pošiljatelju na polazišnoj točki. Tada se vrijeme koje je potrebno valu da ode do cilja i natrag može preračunati u udaljenost.
4. Kako se uz pomoć svjetlosnih ili radio valova mogu mjeriti udaljenosti ?
5. Sistematska greška je za neki instrument konstantna i uvijek slijedi neki određeni fizički zakon, te ju je moguće odrediti i ukloniti.

1.

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U N I T 4

ENVIRONMENTAL/SANITARY ENGINEERING

Sanitary engineering is concerned with providing clean, safe water supply system for towns, cities, and rural areas. It is also concerned with disposing of excess water and waste materials by means of sewer systems. Many aspects of environmental/sanitary engineering are directly related to hydraulic engineering.

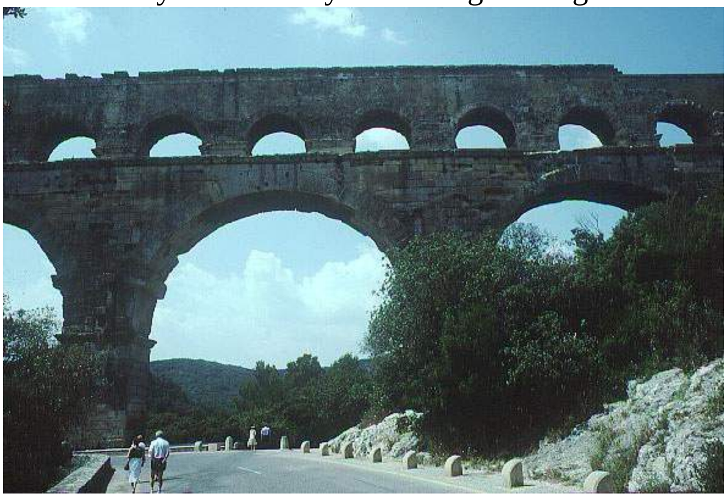


Fig. 6: Roman aquaduct Pont du Gard, Nimes, France.

A great deal of archeological evidence has revealed the importance of water supply system in the ancient world. Probably the most impressive systems in the ancient world were built by Romans, whose aqueducts still stand in modern Italy, Spain, France, and Turkey. Rome itself had a water supply. The water was delivered to fountains, where people collected it in pots and the carried it to their homes. Rome also had a sewer, the part of which is still used today.

In the Middle Ages in Europe, water came from streams and wells. After the connection between water supply and certain diseases was established in the nineteenth century, cities and towns all over the world built safe water supply systems.

New York has had to construct a system that brings water to the city from considerable distances. Water has been delivered to the city's system of holding reservoirs through the longest tunnel in the world, the Delaware Aqueduct, which extends for the most part through bedrock for a distance of 169 kilometers. At some points the aqueduct reaches a depth of 750 meters.

Water supply. A water supply for a town usually includes a storage reservoir at the source of the supply, a pipeline from the storage reservoir to the distribution reservoir near the town, and finally the distribution pipes buried in the streets, taking the water to the houses, shops, factories, and offices. The main equipment is thus the two reservoirs and the pipeline between them. The function of the storage reservoir is to keep enough water over one or several years to provide for all high demands in dry periods, and the distribution reservoir has the same function for the day or the week. The storage reservoir by its existence allows the supply sources to be smaller and less expensive, and the distribution reservoir similarly allows the pipeline and pumps to be smaller and cheaper than they would be if it did not exist.

Water engineers must study the water use per person in their own country and choose a figure based on the most advanced community there. Once the volume of the required yearly supply has been calculated and agreed with all concerned, including the fire department, it is important to make sure that it really is permanently obtainable from the catchment area proposed. The catchment area is the area which drains towards the supply, and the yearly amount of water drawn off to the storage reservoir cannot be more than the rainfall on the catchment area and should usually be very much smaller.

Water purification. There are a number of different methods by which solid wastes can be removed or rendered harmless. Several of them are ordinarily used in combination in treatment plants. One of the processes is filtration. Another is sedimentation, in which wastes are allowed to settle until the become solid or semisolid and can be removed. There are also techniques in which water can be treated by biological means, by using some kinds of bacteria to kill another kinds, or by chemical means, as in chlorination. One of the most successful methods is called the activated-sludge process. It involves using compressed air to increase and control the rate of biological reactions that purify the wastes. In effect, treatment plants speed up natural purification processes so that the water that is finally released from them is essentially harmless. Present-day concern over environmental pollution has increased the demand that waste water should be treated to the fullest degree possible before it is returned to the environment.

(adopted from: “English in Civil Engineering I /II”, Z. Čulić)

EXERCISES.

1. ANSWER THE QUESTIONS:

1. What does environmental engineering deal with?
2. What other branch of civil engineering is it connected with?
3. What kind of water supply did Rome have?
4. Why did cities begin building safe water supply systems in the nineteenth century?
5. What did you find out about New York’s water supply?
6. Mention the main equipment for supplying water!
7. How do engineers plan the water supply and storage equipment?
8. What are the main methods of treating water?
9. What is the main objective of all these methods?

2. COMPLETE THE TEXT WITH THE MISSING WORDS!

(described, relates, measured, quality, refers, depends, range)

With increased pressures of urbanization, water ________ is more important than ever. The term water quality _______ to a condition, or state, of a given parcel of water. Usually it is ______ by such indicators and measurements as temperature, dissolved oxygen, biochemical oxygen demand and total dissolved solids. This table shows some of the commonly ______ parameters. They are representative only: a wide ______ of constituents could be included. This choice ______ upon what might be of interest. This in turn _______ to the purposes for which the water may be used.

3. REPLACE THE UNDERLINED WORD WITH EXPRESSIONS THAT HAVE A SIMILAR MEANING:

1. Sanitary engineering <u>is concerned</u> with providing clean and safe water supply.
2. Its many aspects are <u>related</u> to hydraulic engineering.

3. The system brings water from <u>considerable</u> distances.
4. <u>Vast</u> amounts of trash have also posed problems in disposal.
5. Some kinds of trash can be <u>collected</u> separately.
6. What <u>evidence</u> do we have of the existence of Roman water supply system?

3. COMBINE THE SENTENCES BY USING THE PASSIVE:

Example:
How do they also measure distances?
They apply the stadia principle.
= Distances are also measured by applying the stadia principle.

1. How can they adjust the telescope?
   They can move the telescope about a vertical axis until an object is brought into view.
2. How did they read the vertical angle measurements?
   They used vernier scales.
3. How did the Romans survey the land?
   They developed measuring devices.
4. How have they find relative elevations of widely separated points?
   They have used a series of instrument setups and rod readings.
5. Where can triangulation method be useful?
   They apply triangulation method to surveys of large areas, such as geodetic work.
6. How do they establish a framework of selected points?
   They make control surveys to determine a framework of selected points.

5. GIVE THE NOUNS RELATED TO THE FOLLOWING ADJECTIVES FROM THE TEXT:

   safe, long, increased, important, dry, cheap, high

6. GIVE THE ADJECTIVES OF THE FOLOWING NOUNS FROM THE TEXT:
   length, depth, existence, distance, measurement, purification

7. MAKE SENTENCES IN WHICH YOU WILL USE SOME OF THE ABOVE MENTIONED NOUNS OR ADJECTIVES!

UNIT 5

MECHANICS

What is mechanics? Mechanics may be defined as that science which describes and predicts the conditions of rest or motion of bodies under the action of forces. It is divided into three parts: mechanics of rigid bodies, mechanics of deformable bodies, and mechanics of fluids.

The mechanics of rigid bodies is subdivided into statics and dynamics, the former dealing with bodies at rest, the latter with bodies in motion. In this part of the study of mechanics, bodies are assumed to be perfectly rigid. Actual structures and machines, however, are never absolutely rigid and deform under the loads to which they are subjected. But these deformations are usually small and do not appreciably affect the conditions of equilibrium or motion of the structure under consideration. They are important, though, as far as the resistance of the structure to failure is concerned and are studied in mechanics of materials, which is a part of the mechanics of deformable bodies. The third division of mechanics, the mechanics of fluids, is subdivided into the study of incompressible fluids and of compressible fluids. An important subdivision of the study of incompressible fluids is hydraulics, which deals with problems involving liquids.

Mechanics is the foundation of most engineering sciences and is an indispensable prerequisite to their study. But mechanics is not an abstract or even a pure science; it is an applied science. The purpose of mechanics is to explain and predict physical phenomena and thus to lay foundations for engineering applications.

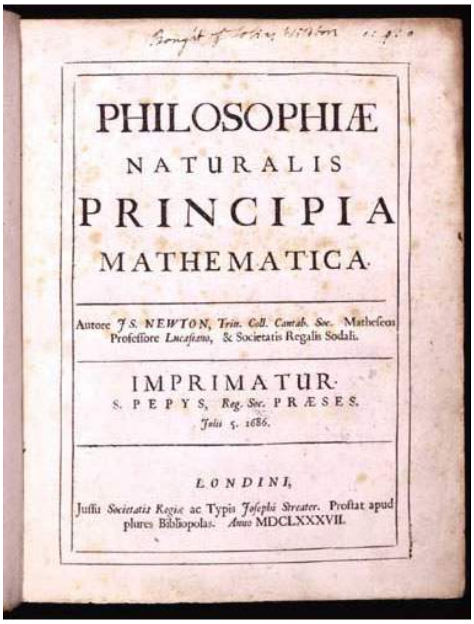
Fig. 7: Isaac Newton

Fundamental concepts and principles.

Newtonian mechanics still remains the basis of today's engineering sciences. It is on Newton's three laws of motion and his law of gravitation that engineering mechanics principally rests. Newton's laws of motion can be formulated as follows:

1. A particle undergoing uniform motion will tend to stay in a state of uniform motion unless acted on by an outside force.
2. If a particle is acted on by an outside force, its motion will change by an amount proportional to, and in the direction of, the outside force.
3. For any action, there is an equal and opposite reaction.

Newton's law of gravitation is: Two material bodies attract each other with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them.



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

Fig. 8

During the latter half of the 19^{th} century, certain experimental results were found to be inconsistent with the predictions of Newtonian mechanics. These inconsistencies led to the formulation of the quantum mechanics of Max Planck and the relativistic mechanics of Albert Einstein. The new mechanics was and is perfectly valid for the prediction of the motion of bodies where the speeds are small compared to the speed of light.

The basic concepts used in mechanics are space, time, mass, and force. These concepts cannot be truly defined; they should be accepted on the basis of our intuition and experience.

The concept of space is associated with the notion of the position of a point P. The position of P may be defined by three lengths measured from a certain reference point, or origin, in three given directions. These lengths are known as the coordinates of P.

In order to define an event, it is not sufficient to indicate its position in space. The time of the event should also be given.

The concept of mass is used to characterize and compare bodies on the basis of certain fundamental mechanical experiments. Two bodies of the same mass, for example, will be attracted by the earth in the same manner; they will also offer the same resistance to a change in translational motion.

A force represents the action of one body on another. It may be exerted by actual contact or at a distance, as in the case of gravitational forces and magnetic forces. A force is characterized by its point of application, its magnitude, and its direction.

The study of elementary mechanics rests on six fundamental principles based on experimental evidence:

The parallelogram law for the addition of forces. This states that two forces acting on a particle may be replaced by a single force, called their resultant, obtained by drawing the diagonal of the parallelogram which has sides equal to the given forces.

The principle of transmissibility. This states that the conditions of equilibrium or of motion of a rigid body will remain unchanged if a force acting at a given point of the rigid body is replaced by a force of the same magnitude and the same direction, but acting at a different point, provided that the two forces have the same line of action.
(adopted from "English for Civil Engineers II", M. Horvatović)

EXERCISES:

1. ANSWER THE FOLLOWING QUESTIONS:

1. What is mechanics?
2. How is it divided?
3. What is the difference between statics and dynamics?
4. What is the purpose of mechanics?
5. What laws does engineering mechanics principally rest on?
6. Name basic concepts used in mechanics?
7. What does the parallelogram law state?
8. And the principle of transmissibility?

2. COMPLETE THE STATEMENTS (WITH THE HELP OT THE TEXT) AND THEN TRANSLATE:

1. The concept of space is associated with…
2. The concept of mass is used to ….
3. A force represents the action of …
4. It is characterized by …
5. Newton's law of motion can be formulated as follows…
6. Newton's law of gravitation is …

3. FIND WORDS IN THE TEXT WHICH MEAN APPROXIMATELY THE SAME AS:

liquid - f…..	idea – c…
strict, firm - r….	to separate – to d…
basic – f…	a lack of success – f…

4. FOREIGN PLURAL:

A large number of foreign words have been absorbed in the English language.
Some of them, especially those belonging to the technical language of science, keep their foreign plural forms.
With the help of a dictionary write plural forms for the following words:

basis, axis, medium, focus, formula, index, matrix, analysis, phenomenon, radius, stratum, hypothesis.

5. TRANSLATE THE SENTENCES:
    a. Galilei i Newton su formulirali osnovne principe mehanike.
    b. Arhimed je dao originalan dokaz za djelovanje poluge.
    c. Mehanika se bavi interakcijom sila koje djeluju na tijelo i na njegovo kretanje.
    d. Cilj mehanike je objasniti fizičke fenomene.
    e. Ova veza dobijena je eksperimentalnim putem.
    f. Galilei je prvi koristio metodu točnog promatranja i kontroliranog eksperimenta za provjeru teorija.

6. INSERT THE RIGHT PREPOSITION:
   Galileo Galelei first used the method ... accurate observation and the controlled experiment to test theories and proved, indeed, that many … them were wrong. …. dropping a heavy and light ball … the Leaning Tower in Pisa, and noting that they reached the ground … almost exactly the same instant, he disaproved the old idea that freely falling objects descended … the ground … speeds proportional … their weight. Galileo proved that … fact all bodies fall, … gravity, … a constant acceleration regardless … their weight.

U N I T 6

WOOD DESIGN & CONSTRUCTION

Wood is remarkable for its beauty, versatility, strength, durability, and workability. It possesses a high strength-to-weight ratio. It has flexibility. It is resistant to many chemicals that are highly corrosive to other materials. It has high shock-absorption capacity. It has good wearing qualities, particularly on its grain. It can be bent easily to sharp curvature. Wood can be used in both wet and dry applications. It performs well at low temperatures. It withstands substantial overloads for short periods. It has low electrical and thermal conductance. It resists the deteriorating action of many chemicals that are extremely corrosive to other building materials. There are few materials that cost less per pound than wood.

As a consequence of its origin, wood as a building material has inherent characteristics with which users should be familiar. For example, although cut simultaneously from trees growing side by side in a forest, two boards of the same species and size most likely do not have the same strength. The task of describing this nonhomogenous material, with its variable biological nature, is not easy.

Fig. 9: Modern wooden structure

With a better understanding of wood now possible, the availability of sound structural design criteria, and development of economical manufacturing processes, greater and more efficient use is being made of wood for structural purposes.

Wood differs in several significant ways from other building materials. Its cellular structure is responsible, to a considerable degree, for this. Because of this structure, structural materials are essentially isotropic, with nearly equal properties in all directions, wood has three principal grain directions-longitudinal, radial, and tangential. Parallel to the grain, wood possesses high strength and stiffness. Across the grain, strength is much lower. Furthermore, a wood member has three moduli of elasticity, with a ratio of largest to smallest as large as 150: 1.

Wood undergoes dimensional changes from causes different from those in most other structural materials. Significant dimensional changes (swelling and shrinkage), for instance, occur because of grain or loss in moisture.

CONCRETE DESIGN & CONSTRUCTION

Concrete made with portland cement is widely used as a construction material because of its many favorable characteristics. One of the most important is a high strength-cost ratio in many applications. Another is that concrete, while plastic, may be cast in forms easily at ordinary temperatures to produce almost any desired shape. The exposed face may be developed into a smooth or rough, hard surface, capable of withstanding the wear of truck or airplane traffic, or it may be treated to create desired architectural effects. In addition, concrete has high resistance to fire and penetration of water.

But concrete has also disadvantages. An important one is that quality control sometimes is not so good as for other construction materials, because concrete often is manufactured in the field under conditions where responsibility for its product cannot be pinpointed. Another is that concrete is a relatively brittle material. Its tensile strength is small compared with its compressive strength. This disadvantage, however, can be offset by reinforcing or prestressing concrete with steel. The combination of the two materials, reinforced concrete, possesses many of the best properties of each. It finds use in a wide variety of constructions, including building frames, floors, roofs, and walls, bridges, pavements, piles, dams, tanks… For a specific structure, it is economical to use a concrete that has exactly the characteristics needed. For example, concrete for a building frame should have high compressive strength, whereas concrete for a dam, should be durable and watertight, and strength can be relatively small.

Workability is an important property for many applications of concrete. Difficult to evaluate, workability, in essence, is the ease with which the ingredients can be mixed and the resulting mix handled, transported, and placed with little loss in homogenity. One characteristic of workability that engineers frequently try to measure is consistency, or fluidity.

Durability is another important property of concrete. Concrete should be capable of standing the weathering, chemical action, and wear to which it will be subjected in service. Much of the weather damage sustained by concrete is attributable to cycles of freezing and thawing.

Watertightness is an important property of concrete that can often be improved by reducing the amount of water in the mix. Excess water leaves voids and cavities after evaporation, and if they are interconnected, water can penetrate or pass through the concrete. Entrained air usually increases watertightness, as also does prolonged thorough curing.

Volume change is another characteristic of concrete that should be taken into account. Expansion due to chemical reactions between the ingredients of concrete may cause buckling, and drying shrinkage may cause cracking. Expansion due to alkali-aggregate reaction can be avoided by selection of nonreactive aggregates. Expansion due to heat of hydration of cement can be reduced by keeping cement content as low as possible, using Type IV cement, and chilling the aggregates, water, and concrete in the forms. Drying shrinkage can be reduced principally by cutting down on water in the mix. But less cement will also reduce shrinkage, as will adequate moist curing.
(adopted from: “English for Civil Engineers I”, M. Horvatović)

EXERCISES:

1. HOW WELL DO YOU REMEMBER? DECIDE WHETHER THE STATEMENTS ARE TRUE OR FALSE:

1. Wood is a good conductor of electricity.
2. Only few materials are cheaper than wood.
3. It has great compressive strength for short periods.
4. Strength is higher parallel to the grain.
5. Thermal expansion of wood is significant.

2. ANSWER THE FOLLOWING QUESTIONS:

1. How does wood differ from other building materials?
2. Make a list of good and bad characteristics of wood as construction material!
3. What dimensional changes does wood undergo?
4. Make a list of good and bad characteristics of concrete as construction material!
5. How can durability and watertightness of concrete be improved?
6. How can volume change of concrete be avoided or reduced?
7. Define workability of concrete?
8. Why do we reinforce or prestress concrete?

3. JOIN THE EXPRESSIONS TO THE CONSTRUCTION MATERIAL THEY REFER TO! (Some expressions refer to both materials!)

	cellular structure
	high resistance to fire
	manufactured in the field
	grain direction
Wood	strength-cost ratio
	strength-to-weight ratio
	inherent characteristics
Concrete	aggregates
	compressive strength
	versatile

4. USE THE FOLLOWING WORDS TO COMPLETE THE SENTENCES ABOUT CONCRETE: durability, reducing, tensile, watertight, ingredients, nonreactive, durable, compressive

1. Its …….. strength is small compared with its …………. strength.
2. The properties of concrete can be varied through control over its …..
3. Drying shrinkage can be improved by …… the amount of water.
4. ……… of concrete refers to capability of standing the weathering, chemical action and wear to which it will be subjected when in use.
5. By selection of ….. aggregates, expansion due to alkali- aggregate reaction can be avoided.
6. Concrete for a dam should be ….. and ……….

5. TRANSLATE THE FOLLOWING TEXT:

Dodavanjem čeličnih šipki ili armature betonu, dobivamo armirani beton. Beton i čelik se savršeno dopunjavaju, budući da beton ima veliku tlačnu, a čelik veliku vlačnu čvrstoću. Osim toga, ova dva metrijala, nakon vezivanja tvore snažnu mehaničku vezu, imaju gotovo isti toplotni koeficijent, pa je čelik u betonu zaštićen od hrđanja.
Armirani beton ima brojne praktične prednosti:

a) izrađuje se lako i ekonomično
b) vezuje razne dijelove građevine u jednu homogenu cjelinu
c) otporan je prema vatri (ako odaberemo kamene agregate)
d) otporan je prema zemljotresu
e) trajan je i lako ga je održavati.

....
....
....
....
....
....
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U N I T 7

CONCRETE DESIGN &CONSTRUCTION II

Strength is a property of concrete that nearly always is of concern. Usually, it is determined by the ultimate strength of a specimen in compression, but sometimes flexural or tensile capacity is the criterion. Since concrete usually gains strength over a long period of time, the compressive strength at 28 days is commonly used as a measure of this property. Concrete strength is influenced chiefly by the water-cement ratio; the higher this ratio, the lower the strength.

Creep strain occurs under a constant long-time load. The concrete continues to deform, but at a rate that diminishes with time. It is approximately proportional to the stress at working loads and increases with increasing water-cement ratio. It decreases with increase in relative humidity. In design of reinforced-concrete beams for allowable stress, the effects of creep are taken into account by reducing the modulus of elasticity of the concrete, usually be 50%. Part of the creep is recoverable on removal of the loads.

Admixtures may be used to control specific characteristics of concrete. Major types of admixtures include set accelerators, water reducers, air entrainers, and waterproofing compounds. In general, admixtures are helpful in improving concrete quality, and their use should be recommended. But some admixtures, if not administered properly, can have undesirable side effects.

Mixing. Components for concrete generally are stored in batching plants before being fed to a mixer. These plants consist of weighing and control equipment and hoppers for storing cement and aggregates. Proportions are controlled b manually operated or automatic scales. Machine mixing (revolving-drum-type mixer or countercurrent mixer) is used whenever possible to achieve consistency of each batch.

Concrete placement. When concrete is discharged from the mixer, precautions should be taken to prevent segregation because of uncontrolled chuting as it drops into buckets, hoppers, carts, or forms.

Fig. 10: Aerial view of the concrete plant

Steel buckets, when selected for the job conditions and properly operated, handle and place concrete well.

Rail cars and trucks sometimes are used to transport concrete after it is mixed. In order to prevent stratification, dry mixers or air entrainment should be used. Chutes are frequently used for concrete placement. But the operation must be carefully controlled to avoid segregation and loss of slump. Discharge should be vertical.

Tremies deposit concrete under water. These are tubes about 30 cm or more in diameter at the top, flaring slightly at the bottom. They should be long enough to reach the bottom. The tremie is raised as the level or concrete rises. Concrete should never be deposited through water unless confined.

Sprayed concrete is applied directly onto a form by an air jet. A gun, or mechanical feeder, mixer and compressor comprise the principal equipment for this method of placement. Because sprayed concrete can be placed with a low water- cement ratio, it usually has high compressive strength. The method is especially used for building up shapes without a form on one side.

Finishing of concrete surface. After concrete has been consolidated, screeding, floating, and the first troweling should be performed with as little working and manipulation of the surface as possible. To avoid bringing fines and water to the top in the rest of the finishing operations, each step should be delayed as long as possible.

Screeds are guides for a straightedge to bring a concrete surface to a desired elevation or for achieving a desired curved shape.

Forms for concrete. Formwork retains concrete until it has set and produces the desired shapes and sometimes, also, desired surface.

Types of reinforcing steel. Steel is embedded in concrete to resist tensile stresses. Steel, however, also is used to take compression, in beams and columns, to permit use of smaller members. It also controls strains due to temperature and shrinkage and distributes load to the concrete and other reinforcing steel. It can be used to prestress the concrete. Most reinforcing is in the form of bars or wires. Their surfaces may be smooth or deformed.
(abridged from: ”English for Civil Engineers “, M. Horvatović)

EXERCISES:

1. ANSWER THE QUESTIONS?
1.How is the strength of concrete determined?
2.What is concrete strength chiefly influenced by? In which way?
3.What is creep? When does it increase/decrease?
4.What do we use admixtures for? Mention some of the major types?
5.What do we use batching plants for?
6.Why is machine mixing used whenever possible? What two types of mixers achieve good results?

2. COMPLETE THE SENTENCES WITH THE HELP OF THE TEXT:

1. Concrete should be discharged from the mixer very carefully in order to …
2. If steel buckets are used properly,
3. When concrete is transported by …and … , there is a risk of …
4. In order to prevent stratification, it is advisable to …
5. Tremies are used for …
6. Air jets are employed for…

4. MATCH THE EXPRESSION ON THE LEFT WITH THE APPROPRIATE STATEMENT ON THE RIGHT:

1. Screeds a)are used to control characteristics of concrete.
2. Formwork b)bring concrete surface to a desired elevation
3. Steel c)is used to prestress concrete,
4. Admixtures d)gives the desired shapes.
5. Chutes e)are employed for concrete placement.

4.FIND ENGLISH WORDS FOR THE FOLLOWING CROATIAN TERMS:

armatura, kalup, vlačna čvrstoća, tlačna čvrstoća, svojstvo, sastojak

5. MAKE SENTENCES WITH THE WORDS FROM THE PREVIOUS EXERCISE.

6. FIND WORDS WHICH MEAN APPROXIMATELY THE SAME:

to complete, frequently, to perform, adequate, rigid, bar, to raise

7. CHANGE THE NOUN OR ADJECTIVE INTO VERB WITH THE SUFFIX -IZE/-ISE:

a. They made the system legal. They ………. the system.
b. We have kept the problem local. We …………. the problem.
c. The engineer will make a summary of the project. He will ……the project.
d. They wanted to make the area urban. They wanted to ………the area.
e. He made a screwdriver act like a magnet. He………. a screwdriver.
f. They have decided to make a canal through the field. They….
g. He changed the liquid into atoms. He …….

UNIT 8

LOADS IN STRUCTURAL DESIGN

Loads. A structure is designed to carry a useful load, usually termed live load, in addition to the weight or dead load of the structure itself.

All loads other than dead load are called live loads. Live loads may be steady or unsteady; they may be movable, or moving; they may be applied slowly or suddenly; and they may vary considerably in magnitude. The live loads which usually must be considered are:

1. the weight of people, furniture, machinery, and goods in building
2. the weight of traffic on a bridge
3. the weight of snow, if accumulations of snow are possible or probable
4. dynamic forces resulting from moving loads
5. forces resulting from the action of wind
6. the pressure of liquids in storage vessels
7. forces resulting from temperature change, if expansion and contraction are impeded
8. the pressure of earth, as on retaining walls and column footings.

Dynamic forces induced by earthqakes should be considered if the structure is to be located in a region where destructive shocks are likely to occur. The development of the atomic and the hydrogen bomb has focused attention on the problem of providing resistance to blast loading.

The primary effect of gravity loads on structures is calculated from their weight; i.e., they are considered to be static loads. However, live loads in motion may produce forces that are considerably greater than those resulting from the same loads at rest. Because of slight irregularities in the track, unbalance of the wheels, and sway, a moving train may exert much larger forces than will a stationary one. On the other hand, the forces resulting from random movement of a crowd of persons are not significantly different from those produced by stationary crowds. Dynamic force caused by motion is called impact, if the effect is equivalent to additional gravity load and lateral or longitudinal force (depending upon its direction relative to the path of the vehicle) when the result is equivalent to load in the horizontal plane. Lateral force may result from motion in a curved path or from the swaying motion of a train on a straight track. Longitudinal forces are caused by acceleration and deceleration of moving vehicles.

The loads and forces for which a bridge may be designed are classified as dead load, live load, impact effect, wind load, longitudinal forces due to traction or friction, centrifugal force, thermal force, earth pressure, buoyancy, shrinkage forces, rib shortening, erection stresses, ice and, current pressure, snow loads, earthquake forces, and other lateral forces.

Determination of the weight of a structure is usually successive process. The first element to be designed is one that does not carry another member. The weight of the first element must be estimated before a design is completed and to estimate corrected to satisfy the final design. As each element is progressively designed, a part of the dead load on the next member becomes more certain.

Live loads are dependent on the type of structure under consideration. These loadings do not necessarily closely resemble the actual loads coming to the structure, but they provide simplified design criteria which result in an equivalent structure.
(adopted from: “ English for civil engineers II ”,M. Horvatović)

EXERCISES:

DO THE FOLLOWING EXERCISES:

1. Write down new words and expressions from the text.
2. Use your glossary or any dictionary to check their meaning.
3. Make notes. Write down only the most important information from the text.
4. Write down at least seven questions and then put them to your friend. Be ready to answer his questions as well.
5. Can you translate the following term and word without looking at the text:
   korisno opterećenje, statičko opterećenje, dinamička sila, udar, trenje, ubrzanje, bočni, uzdužni, njihanje
6. How many words from the text can you put in front of the words load and force to get proper collocations. First try to do the exercise alone and then complete your list with the help of the text.

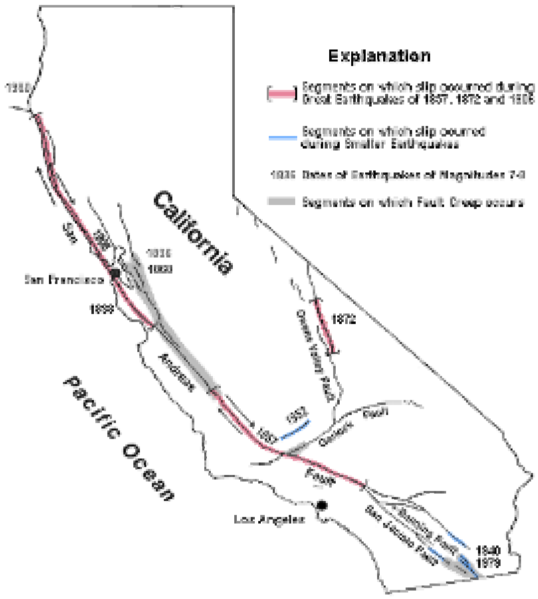
………		……………	
………		…………..	
………		…………..	
………	load	…………..	force
………		………….	
……….		………….	
……….		………….	
………		………….	
………		…………..	

7. COMPLETE THE TEXT WITH THE GIVEN ADJECTIVES:

   (live, dynamic, centrifugal, gravity, dead, longitudinal, thermal)

1. Engineers should take…….. forces caused by earthquakes into account when planning a structure in an earthquake zone.
2. The weight of the structure itself is called……… load.
3. ….. loads in motion are usually greater than those caused by the same loads at rest.
4. The primary effect of …… loads on structures is calculated from their weight.
5. ……and……. force must be taken into account when designing a bridge.
6. ……. forces result from temperature change.

EARTHQUAKE EFFECTS ON STRUCTURES



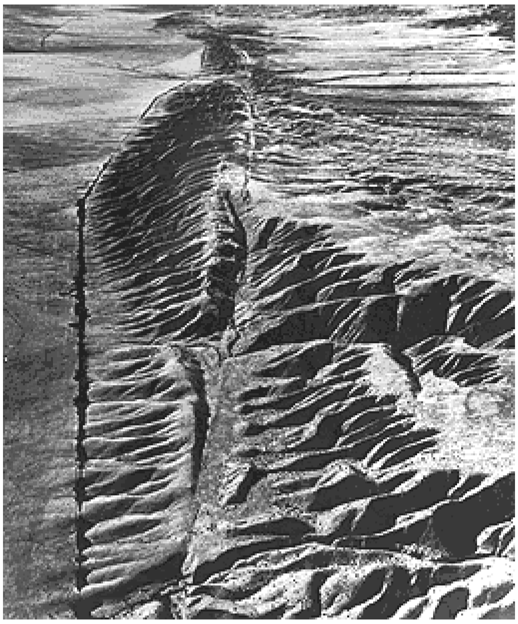


Fig. 11: San Andreas Fault

Earthquakes may be of tectonic or volcanic origin. For tectonic earthquake, the elastic-rebound theory proposed by Professor H. F. Reid offers a reasonable explanation. Because of such causes as thermal contraction of the earth, isostasy, drifting continents, and/or radioactivity and convection currents, there is constant geological activity in the interior of the earth, resulting in accumulation of strains in the faults of earth blocks. When the strains become greater than it can endure, the earth crust ruptures and the strained crust blocks rebound until the strains are wholly or partially relieved. In this process, seismic waves are created which propagate in different directions, sometimes to great distances, depending on the amount of energy released. Displacements on fault planes cause vibrations to be propagated as elastic waves to the surface and cause damage to structures near the source of disturbance.

The building up of stresses may be a slow process, and there may be a long period of unstable equilibrium which may be terminated abruptly by forces such as those resulting from atmospheric disturbances during storms. Such forces which are not directly related to the forces to be released, and possibly insignificant compared with them, are known as trigger forces. Before and after the main shock, there are frequently shocks to complete the adjustments within the earth crust. Those occurring before the major disturbance are called foreshocks and those occurring later aftershocks. These shocks are believed to be due to partial or excessive rebound of the earth masses. Earthquakes ordinarily originate at depths of 7 to 30 miles from the surface, although some deep-seated earthquakes have originated at depths greater than 4oo miles. The point of origin of an earthquake is called the focus, and the point on the earth surface directly above the focus is the epicenter. Volcanic eruptions such as the one which blew off the top of the island of Krakatoa near Java in 1887 can be violent and produce high sea waves and nearby destruction, but the energy release is small compared with earthquakes of tectonic origin.

Earthquake waves. Seismologists distinguish three types of waves set in motion by earthquakes. The type that seems to be most destructive travels over the earth's surface much in the manner of the waves generated by a stone dropped into water. Major wave movements may last from a few seconds to several minutes. Their period, amplitude, and acceleration change rapidly. Periods may vary from 0.1 to 0.2 sec, acceleration from very small values to more than that of gravitation, and amplitudes from fractions of 2.54cm to 23 cm or more.

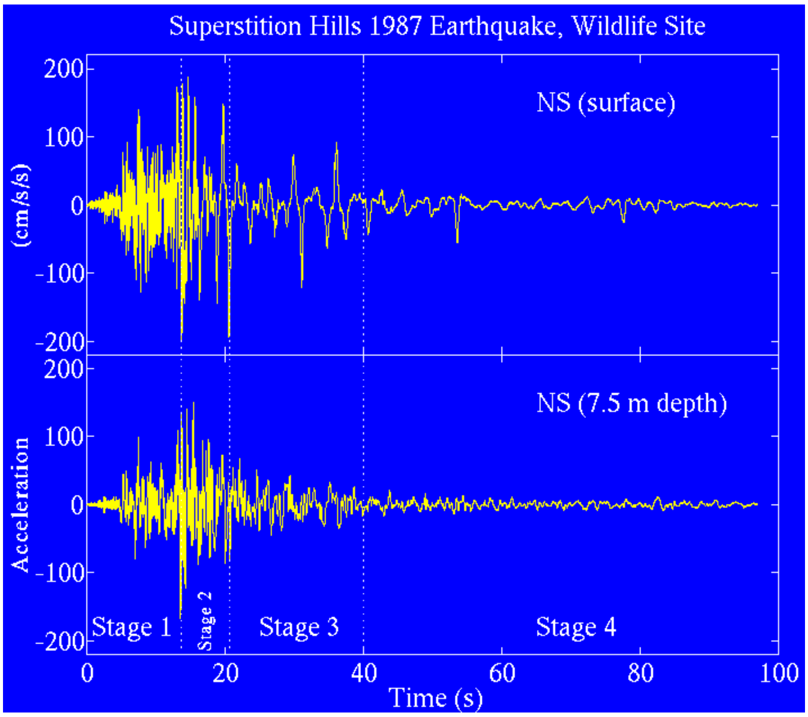


Fig. 12: Accelerogram

A structure's response to an earthquake primarily depends upon its location in the affected region, its orientation relative to the direction of the most violent motion of the earth, its natural periods of vibration as compared with the period of the earth's motion, the nature of the foundations material which supports it, and the physical properties of the materials of which is composed. Evidently, then, it is an extremely complex phenomenon, and it is not surprising to find a considerable difference of opinion among engineers as to how a structure may adequately and economically be made earthquake resistant.

(adpoted from: " English from Civil Engineers II", M. Horvatović)

EXERCISES:

1. COMPREHENSION QUIZ
   1. There are a)three types of waves…
      b)several types of waves…. produced by earthquakes.
      c)only one type of wave …
   2. The most dangerous type is the one that travels…
      a) under the earth's surface.
      b) over the earth's surface.
      c) through the earth's surface.
   3. This wave is similar to the wave set in motion by…
      a) wind.
      b) water.
      c) a stone dropped into water.
   4. The major wave lasts no more than…
      a) few seconds.
      b) several minutes.
      c) one hour.
   5. The point of origin of an earthquake is called…
      a) the focus.
      b) the epicenter.
      c) The foreshock.
   6. Volcanic eruptions release…
      a) less energy …
      b) the same energy… than tectonic earthquakes.
      c) more energy…
   7. Their period, acceleration and amplitute … a) change quickly.
      b)are the same
      c)change very slowly.
   8. Engineers …a)have different opinions about designing earthquake-resistant structures.
      b) agree with each other about designing earthquake-resistant structures.
      c) don't know how to build earthquake-resistant structures.
2. TRANSLATE THE TEXT.

3.COMPLETE THE STATEMENTS WITH THE HELP OF THE TEXT:

a. Earthquakes may be …
b. Trigger forces are…
c. Foreshocks are…
d. Aftershocks are…
e. The focus is …
f. The epicenter is …

4. MAKE AS MANY COLLOCATIONS AS POSSIBLE:

atmospheric	eruption
earth	contraction
thermal	activity
volcanic	disturbance
tectonic	crust
geological	earthquake

5.WRITE THE SUMMARY OF THE TEXT.

…………………………………………………………………………………………………..
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

6.TRANSLATE INTO ENGLISH:

Potres je kratko periodično gibanje tla uzrokovano prirodnim silama i dovoljno jako da ga osjete ljudi ili zabilježe seizmografi. Potres ima nagli početak i kratko traje. Za vrijeme trajanja potresa nastaje osciliranje čestica Zemlje, koje se prenosi od žarišta potresa na sve strane prostornim progresivnim elastičnim valovima. Prvi je val longitudinalan, a drugi transverzalan; prvi se širi brže. Djelovanje potresa je najjače u epicentru i njegovoj najužoj okolini. Intenzitet nekog potresa određuje se prema učincima na građevinama, zemlji i vodi. Magnituda je mjera za energiju potresa oslobođenu u obliku elastičnih valova, a određuje se na osnovi seizmograma. Na Zemlji ima godišnje preko 1000 potresa. U najveće potrese o kojima postoje znanstveni opisi ubraja se Lisabonski potres 1755. U Lisabonu je potres i požar za 6 minuta uništio preko 12 000 kuća, a poginulo je oko 60 000 ljudi. Tsunami, morski val koji je nastao prilikom tog potresa, pojavio se u Lisabonu 20 minuta nakon potresa. Na portugalskoj strani dosegao je visinu od 6 m, a na nekim mjestima i 15 m. Za potresa u Tokiju i Yokohami 1923 g. razoreno je oko 126 000 kuća, a stradalo je 247 000 ljudi (poginuli, ranjeni i izgubljeni). Najčešći su tektonski potresi. Tektonske sile vlaka i tlaka neprestano povećavaju napetost u stijenama. Na mjestu gdje napetost premaši granicu elastičnosti, stijena pukne, pa se dio potencijalne energije elastično napete stijene pretvori u kinetičku energiju elastičnih titraja koji uzrokuju potres.

(adopted from: Enciklopedija leksikografskog zavoda)

UNIT 10

GEOLOGICAL SURVEY

Geophysics is the scientific study of the earth's physical activities. It comprises some other sciences, such as meteorology, gravimetry, geomagnetology, seismology, hydrology, radiometry, etc.

Petrology is the scientific study of rocks and minerals, their composition, structure and formation.

Geology is the scientific study of the earth, including the origin, structure and history of the rocks, soil, etc. of which it is composed.

Fig. 13: Disharmonic folds in quartzite and shale

In addition to measuring surface for civil engineering projects, it is often necessary to make a geological survey.

Geological survey involves determining the composition of the soil and rock that underlie the surface at the construction site. The nature of the soil, the depth at which bedrock is located, and the existence of faults or underground streams are subsurface factors that help civil engineers determine the type and size of the structural foundations or the weight of the structure that can rest on them. In some areas, these can be critical factors. For example, Mexico city rests on a lakebed with no bedrock near the surface; it is also located in an earthquake zone. The height and weight of the buildings must therefore be carefully calculated so that they will not exceed the limits that are imposed by the site.

Geological samples are most often obtained by borings, in which hollow drills bring up cores consisting of the different layers. Other devices that are used in geological surveys are gravimeters and magnetometers. The gravimeter measures the earth's gravitational pull; heavier rocks like granite exert a stronger pull than lighter ones like limestone. The magnetometer measures the strength of the earth's magnetic field. Again, the denser the rock, the more magnetic force it exerts. The third instrument is the seismograph, which measures vibrations, or seismic waves, within the earth. It is the same instrument that is used to detect and record earthquakes. In a geological survey, it is used by setting off small, man-made earthquakes. The waves created by a blast of dynamite

buried in the ground reflect the different kinds of rock under the surface; hard or dense rocks reflect the waves more strongly than soft or porous rocks.
(adopted from: ”English in Civil Engineering I”, Z. Čulić)

EXERCISES:
DO THE FOLOWING EXERCISES:
1.YOUR TEACHER WILL READ YOU THE TEXT ABOUT GEOLOGICAL SURVEY. AS YOU LISTEN, TAKE NOTES OF THE MOST IMPORTANT INFORMATION.

2.ANSWER THE QUESTIONS.

1.What is geophysics?
2.How does geology differ from petrology?
3.What scientific study examines and records the area and features of a piece of land by measuring and calculating?

5. MAKE COLLOCATIONS:

construction	pull
geological	wave
underground	origin
gravitational	site
seismic	survey
earth’s	stream

6. TRANSLATE:

odrediti sastav tla
dobiti geološke uzorke
nalaziti se u trusnoj zoni
mjeriti magnetnu silu
obaviti geološko mjerenje

7. REDUCE THE FOLLOWING RELATIVE CLAUSES:

pumps which are driven by wind
the liquid which was not wanted
a construction firm which is well organized
the moment which is produced by load
ditches which are in the shape of a letter V

8. INSERT THE MISSING PREPOSITION:

a. The beam is subject … bending.
b. These specifications provide … a minimum thickness of metal.
c. Style is dependant … the reader.
d. A series of observations should be made …. different conditions.
e. The builders have been trying to cut down … the amount of hand labor needed at the site.
f. Modern builders are interested … improving the space inside their buildings.
g. A modern building has taken many steps … producing a comfortable and pleasant indoor environment.
h. High land costs in urban areas result … high building.

UNIT 11

MECHANICAL PROPERTIES OF MATERIALS

The important mechanical properties of structural materials are: elasticity, plasticity, ductility, malleability, brittleness, proportionality of stress and strain, stiffness, strength, endurance, toughness and hardness.

Elasticity and plasticity. Elasticity is that property of a body which enables it to recover its original size and shape after deformation. Plasticity is that property of a body which enables it to retain its deformation after the application and release of a load. Plasticity thus is the opposite of elasticity.

Ductility and brittleness. Ductile materials are capable of undergoing great plastic deformation when subjected to tensile loads. Thus ductility is a property of many metals but rarely is found in nonmetals. Brittleness is the opposite of ductility and brittle materials undergo but little plastic deformation when loaded to failure. Most of the nonmetallic materials of construction are classed as brittle materials. Soft steel, brass and aluminum are examples of ductile metals. Cast iron concrete and brick are examples of brittle materials.

Malleable materials are capable of being beaten into thin shapes. Evidently materials that are ductile are also likely to be malleable. Gold, tin, and lead are examples of malleable metals.

Flexible materials are capable of being bent without breaking. Malleable iron is more flexible than gray iron, soft steel is more flexible than hard steel, and hickory is more flexible than basswood.

Hardness is a quality that has been defined in a number of arbitrary ways. The most common scale of hardness used for engineering materials is the indentation hardness, like the Brinell hardness, which is measured by the indentation of a standard load. There are some other types of hardness as well. Scratch, rebound, cutting and abrasion hardness are other measures of hardness of practical importance.

Resilient materials are those which are capable of absorbing large amounts of energy without suffering permanent deformation. Evidently the combination of low limit would produce high resilient materials.

Though materials are capable of absorbing large amount of energy before rupture. Toughness is evidently dependent upon a combination of high strength and high ductility or high strength and high flexibility. Toughness measures the ability to absorb a shock or sudden blow without rupture.
(adopted from: “English for Civil Engineers II”. M. Horvatović)

EXERCISES:

1. WHICH IS THE OPPOSITE WORD?
   elastic, brittle, hard, tough, stiff

2. GIVE AT LEAST ONE EXAMPLE OF A MATERIAL WHICH IS…
   elastic, plastic, ductile, brittle, malleable, flexible, hard, resilient, tough

3. FIND IN THE TEXT THE SENTENCES, COPY AND TRANSLATE THEM IN YOUR NOTEBOOK:
   Ductile materials are….
   Resilient materials are….
   Plasticity is …
   Flexible materials are…
   Malleable materials are..
   Tough materials are…
   Brittle materials…
   Elasticity is …

4. GIVE THE NOUN CORRESPONDING TO THE FOLLOWING ADJECTIVES:

   flexible, malleable, tough, resilient, long, soft

5. INSERT THE ARTICLES WHERE NECESSARY:

   …physics is … fundamental science of … natural world, but it is not … only such science. ... physics is fundamental because it deals with such features of … world as … time, … space, … motion, …matter, … electricity, … light, and … radiation and some feature of every event that occurs in … natural world can be seen in these terms. … astronomy, … science which tries to understand … moon, … planets, … stars, and … universe beyond … stars, is built on …physics. ... geology is … kind of … detailed "atronomy" of … planet we know … best, our own planet. … meteorology, … physics of our atmosphere, attempts to explain … cause of … weather in … terms of … physics. … chemistry is … science nearly as fundamental for … others as is physics.

.

FAILURE & FRACTURE

Failure is the condition at which a structure ceases to fulfill the purpose. Failure of a bar in tension or compression has a meaning which depends upon the function of the bar and the structure of which it is a part. Failure can mean *fracture*, the actual separation of the bar into two or more parts. Fracture may be of the *ductile* type, which is preceded by appreciable plastic deformation, or it may be *brittle*, with little or no prior plastic action. Many useful materials fracture in a brittle manner in tension under normal environmental conditions and slow application of load. Glasses and ceramics, rocks, plain concrete, and ordinary cast iron are examples of this class brittle materials.

Fig. 14: Fracture of the concrete beam

Fig. 15: Failure due to local buckling

They fracture in a brittle manner under compression as well, but in a quite different mode.

Reversed load from tension to compression or repeated application and release of load can also cause a ductile metal to fracture. Millions of cycles of such loading will cause a *fatigue* fracture well within what is taught of as the elastic range. Relatively few cycles of reversed loading are needed in the plastic range. Fatigue is the lowering of the breaking load of a member by repeated reversals of stress so that the member fails at a much lower stress than it can withstand under static loading.

The word *failure* need not connote fracture. A bar which buckles in compression may do as much damage as one which fractures in tension. A bar which elongates or shortens too much under load so that needed clearances are lost or other critical dimensions are not kept certainly has failed. It may not matter whether the excessive deformation is plastic or is elastic and so fully recoverable.

WORKING LOADS AND THE CONCEPT OF FACTOR OF SAFETY

A structure must be designed so that it functions properly for repeated applications of the working load, the largest load expected in normal operation. Even in the simplest examples, the establishment of the working load is not a trivial matter. Consider a 10-ton shop crane for general use which is to be labeled clearly with a large number 10 and which will be run by experienced operators only. The working load is then 10 tons. Is it? If secret records are kept of the actual loads lifted after the crane is put into operation, it is quite likely that only on rare occasions will the load exceed 4 tons. The 10-ton figure will almost never be reached; yet once every year 13 or even 15 may be recorded. However, the crane was designed with a *factor of safety* against such overload and so could carry the 15. Factor of safety is the ratio of the highest load which can be put on a member to the highest load which it can carry without failure. What is working load? Is it the 10 tons written so plainly, or the 4 tons which is rarely exceeded, or the 15 which may be applied once in five years, or the 12 which includes a dynamic effect with a 10-ton load? All the figures are significant. The 4-ton figure may be the most appropriate choice for the design of rope and of pulley diameter, provided that an occasional 10 or 15 tons can be lifted without failure. The choice for the design of the main structure of the crane is arbitrary. The factor of safety must cover variations on the yield point of the material below the minimum which is specified, variations in dimensions from those of the design, corrosion effects, possible earth tremors, and just plain ignorance.
(adopted from: “English for Civil Engineers II, M. Horvatović)

EXERCISES:
1.ANSWER THE QUESTIONS:
1. What is failure?
2. What happens with a bar if it fractures?
3. Mention some types of fracture!
4. What is fatigue?
5. What is safety factor?

2. TRANSLAE THE DEFINITIONS OF FAILURE, FATIGUE AND SAFETY FACTOR IN YOUR NOTEBOOK !

3. DRAW A LINE UNDER THE CORRECT MEANING OF EACH NUMBERED WORD!

1.precede a) to go before sb/sth in time, order, position
b) to go or take place after sb/sth else in time, space, order
c) to place or put in a position

2. reverse a) to return to a former state or condition
b) to make sth the opposite of what it was
c) to bring sth back in existence

3.damage a) harm caused to sth, making it less attractive, useful…
b) the state of being inadequate or not functioning as expected
c) an aspect of sth that is wrong or not perfect

4.excessive a) very unusual
b) of very high quality
c) grater than what is normal or necessary

5. trivial a) useless
b) of little importance
c) awkward

6.ignorance a) a false idea, belief or impression
b) the state of being ignored
c) a lack of knowledge or information

7. WHAT IS THE MEANING OF THE FOLLOWING WORDS? EXPLAIN IN ENGLISH!

bar, elongate, 10-ton shop crane, shorten, deformation

8. FIND THE OPPOSITE WORD!

useful, lost, normal, clearly, safe, lift, significant, ignorance

9. DRAW A LINE UNDER THE WORD THAT DOES NOT BELONG TO THE GROUP. EXPLAIN YOUR CHOICE!

a)tension, compression, shear, fatigue
b)brittle, ductile, safe, plastic
c)contain, hold, conduct, have
d)enough, entire, whole, complete
e)raise, put off, put up, lift

UNIT 13

STATICALLY DETERMINATE STRUCTURES VS. STATICALLY INDETERMINATE STRUCTURES

Most structures fall into one of the following three classifications: beams, frames, or trusses. A beam is a structural member subjected to transverse loads only, and it is completely analyzed when the shear and moment diagrams are found. A frame, or rigid frame, is a structure composed of members which are connected by rigid joints. A frame is completely analyzed when the variations in direct stress, shear, and moment along the lengths of all members are found. A truss is a structure in which all members are usually considered to be connected by hinges, thus eliminating moment in the members. A truss is completely analyzed when the direct stresses in all members are determined.

Shear and moment diagrams of beams can be drawn when the external reactions are known. In the study of the equilibrium of a coplanar parallel-force system, it has been proved that not more than two unknown forces can be found by the principles of statics. In the case of beams these two unknown forces are usually the reactions. Thus the two reactions to simple, a overhanging, or cantilever beams can be determined by the equations of statics, or these types of beams are statically determinate. If, however, a beam rests on more than two supports or in addition one or both end supports are fixed, these are more than two external reactions to be determined. Statics offers only two conditions of equilibrium for a coplanar parallel-force system, and thus only two reactions can thereby be found; any additional reactions are excessive, or redundant. These reactions cannot be determinated by the equations of static alone, and beams with such reactions are called statically indeterminate beams. The degree of indeterminancy is given by the number of extra, or redundant, reactions.

A frame is statically determinate if these are only three external reactions, because statics offers only three conditions of equilibrium for a general coplanar-force system. If, however, a rigid frame has more than three external reactions, it is statically indeterminate, the degree of indeterminacy being equal to the number of redundant reactions.

A truss is statically determinate if it has not more than three external reactions (two in the case of parallel-force system) and not more than (2j – 3) members, where j is the number of joints. A truss is just internally stable if it consists of a series of triangles. The first triangle is made up of these joints and three members; each successive triangle requires two additional members but only one additional joint. Thus, if m is the number of members in the truss and j is the number of joints, (m – 3) =2(j – 3), or m = 2j-3.
(adopted from: “English for Civil Engineers II”, M. Horvatović)

EXERCISES:

1. THINGS TO REMEMBER:

beams, frames, trusses = linijski nosači
beam = greda
truss = rešetka
frame = okvir
statically determinate structures = statički određene konstrukcije
statically indeterminate structures = statički neodređene konstrukcije
transverse load or horizontal load = poprečno ili horizontalno opterećenje
hinge= zglob
coplanar = komplanaran
redundant= suvišan, u metodi sile znači: statički nepoznat, a kod metode deformacije prevodi se sa: deformacijski nepoznat
indeterminancy = neodređenost

2. TRANSLATE THE TEXT.

3. COMPLETE THE SENTENCES:
   1. Most structures fall into one of the three classifications:_____, _____, and ________.
   2. A ______ is a structure in which all members are usually considered to be connected by hinges.
   3. A ______ is a structure composed of members which are connected by rigid joints.
   4. A _______ is a structural member subjected only to transverse loads.

4. MAKE COLLOCATIONS:

moment ...	system...
rigid ...	diagram...
structural...	load...
transverse...	member...
coplanar-force...	frame...

5. LIST ADJECTIVES(OR NOUNS USED ATTRIBUTIVELY) THAT CAN ACCOMPANY THE FOLLOWING NOUNS:

______ load	_____stress	______force
______load	_____stress	______force
______load	_____stress	______force

6. PUT THE VERBS IN BRACKETS INTO THE CORRESPONDING TENSE (ACTIVE OR PASSIVE):

1. The principal structures that (design) by civil engineers are bridges, dams, tunnels, drainage structures, etc.
1. ---
2. Engineering education (extend) over a wide range of subjects.
2. ---
3. Scientists (try) to be objective.
3. ---
4. In recent years the quantity of scientific writing (increase) rapidly.
4. ---
5. Metals (find) in the earth.
5. ---
6. He already (pay) for the design.
6. ---
7. If you pass the exam, they (ask) you several questions about analytic geometry.
7. ---
8. Galileo (prove) that all bodies fall under gravity with a constant acceleration regardless of their weight.
8. ---

UNIT 14

DEFLECTIONS

In structural analysis the displacements induced by the applied loads are commonly called deflections. The total deflection of a point can be produced by axial or transverse forces which induce direct bending, shear or torsion stresses, or combination of these. It may be said that deflections are an indication of the state of stress within a given material and such furnish a means of correlating stress and strain both theoretically and experimentally. In addition, considerations of deflection (and consequently strain) enable one to set up the compatibility conditions used in solving statically indeterminate structures.

In general there are three different procedures for determinating the deflections of engineering structures. These are:

1. Integration of the deflection differential equation of the beam.
2. The strain energy stored in a structure and the use of the Law of Conservation of Energy (for general engineering structures).
3. Graphical methods (for trusses).

   Deflections are the visible indications of the response of a structure to load. This response is a function of the frequency, intensity, and duration of loading, as well as of the physical properties of the materials forming the structure. The response is ordinarily quite complex since most actual loads are very variable both as to intensity, duration, direction and frequency. Also the physical properties of the material forming the structure are not necessarily uniform. It would appear impossible, therefore, that anything less than a statistical analysis can take into account the possible variations in loading and materials that actually occur in the usual engineering structures.

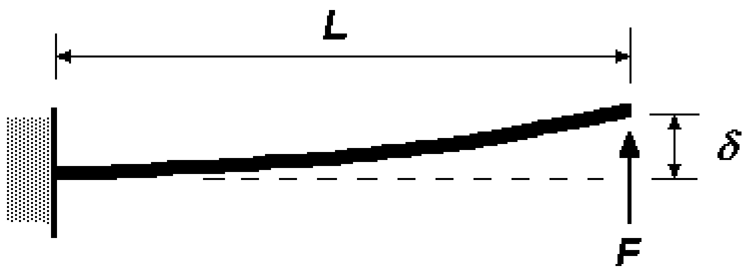


Fig. 16: Deflection of the cantilever beam

However, in engineering-type analysis, it is possible to make simplifying assumptions which enable one to solve for displacements, stresses, and other elastic quantities, to a sufficiently accurate degree for engineering purposes.

1. Assumptions made in engineering structural analysis.
   The ordinary methods of structural analysis are based upon the following fundamental assumptions.
   1. The material is homogenous and isotropic.
   2. The material is stressed within elastic limit.

3. Displacements are small enough that stresses, deflections, etc., computed from applied loads assumed acting through the undeflected positions will not materially change as the displacements take place.
4. The surface effects of external loads are negligible.

2. Methods of computing deflections.
Several methods of computing deflections have been developed and are commonly used. Some of these methods originate from considerations of forces in equilibrium, others from the Law of the Conservation of Energy. Thus, we may speak of the equilibrium approach and of the energy approach to the solution of deflection problems.
(adopted from: “English for Civil Engineers II “, M. Horvatović)

EXERCISES:

1. MATCH THE EXPRESSION ON THE LEFT WITH THE STATEMENTS ON THE RIGHT.

1. axis	a) the same in all cases and at all times
2. furnish	b)an adequate quantity of sth
3. correlate	c)an imaginary line through the center of an object, around which the object turns
4. uniform	d)correct and exact
5. sufficiently	e)to provide smb/sth with sth
6. accurate	f)to have a mutual relationship or connection

2. ANSWER THE QUESTIONS:
   1. How can deflections be defined?
   2. What do deflections furnish?
   3. What do considerations of deflections enable us to do?
   4. What are the general procedures for determining the deflections of an engineering structure?
   5. What is the response of a structure to load?
   6. Why is this response very complex?
   7. What are the fundamental assumptions made in engineering structural analysis?
   8. What do equilibrium and energy approach to the solution of deflection problem originate from?

3. COMPLETE THE TEXT WITH THE MISSING WORDS FROM THE LIST:
(applies, constant, basic, stating, sufficient, external, receive)
The Law of Conservation of Energy is a _____ law of physics. There are many ways of ______ this law in the different fields of physics where it ________. For our purpose it will be _______ to state the following form: If a structure and the _______ loads acting on it are isolated so that these neither _______ nor give energy, then the total energy of this system remains ________.

4. SUPPLY THE CORRECT WORD IN THE BLANKS (follow the given example):

VERB	ADJECTIVE	NOUN
persist	persistent	persistence
		connection
differ		
		practice
	calculable	
indicate		
		extension

5. TRANSLATE THE TEXT

6. READ THE TEXT ONCE AGAIN. SEARCH FOR THE MAIN IDEAS IN THE TEXT AND WRITE A SHORT SUMMARY.

UNIT 15

FOUNDATIONS

Foundations (footings) are bases, usually of concrete, placed on the ground so as to spread a vertical load over it. Bases which carry horizontal load, for example under arches, are usually called abutments.

A foundation may be built in one of many different materials. It may be of timber (below ground water level) or of steel joints encased in concrete, of reinforced concrete or plain concrete without reinforcement, or for a breakwater in the sea merely of rock. Structures built on strong rock generally need no foundation since rock is usually as strong as concrete, and goes much deeper. All that is needed on rock is a little concrete or mortar to make the surface level.

The main problem in the design of the foundations of a multi-story building under which the soil settles is to keep the total settlement of the building within reasonable limits, but specially to see that the relative settlement from one column to the next is not great. If one column settles much more than its neighbor, the building will certainly crack and may look as if it is breaking in pieces. Obviously every structural designer wishes to avoid this impression, even if it is a wrong one, as it often is.

The design of a multi-story building on compressible soil is difficult and therefore extremely interesting. Compressible soils are like sponge, sinking most where the pressure is greatest and the load is largest. Thus even if all the foundations are designed for the same bearing pressure the largest foundation will sink the most because it has the load. The exact calculation of these different bearing pressures is extremely difficult but at least this is now the aim of foundation designers.

One solution, which however is rather expensive because it may involve a deep excavation, is to dig out a quantity of soil which weighs exactly as much as the dead load of the building plus the quantity of live load which is likely to be on it. This depth of it should be such as to make sure that the loaded building will be carrying no more load after the structure has been put up than it carried before, there will in theory be no general settlement. In fact, however, for various reasons some foundations will sink.

Foundation engineering is the science of founding structures, that is, the techniques of transmitting load to the foundation material, which may be rock or soil. Site investigation always precedes a foundation design. Such an investigation may vary from a superficial inspection, allied with examination involving the testing of samples of the foundation material. The primary object of all these activities is to determine the safe bearing power of this stratum. Another important factor usually determined at the same time is the ground water level. The most usual construction materials are wood, masonry, concrete, and steel. The aggressive influences of water, soil, or rock on these materials have to be taken into account when selecting such materials for use.
(adopted from: “ English in Civil Engineering II “, Z. Čulić)

EXERCISES:

1.TRUE OR FALSE?

1. Nowadays, the majority of foundations are built of concrete.
2. It is not necessary to lay the foundation for the structure planned to be built on compressible soil.
3. One of the most challenging problems in foundation engineering is the design of the foundations of very high structures.
4. Rock foundations can be as strong as concrete foundations.
5. Foundation engineering does not deal with ground water.

2. COPY AND TRANSLATE THE SENTENCES BEGINNING WITH…

1. Foundations are…
2. The main problem in the design of the foundations…..
3. Compressible soils are like…
4. Foundation engineering is …
5. Site investigation …
6. Such an investigation…

3. WRITE QUESTIONS TO THE FOLLOWING ANSWERS!

1. Of timber, steel, reinforced concrete..
2. To keep the total settlement of the building within reasonable limits.
3. They are like sponge.
4. To determine the depth at which a satisfactory bearing stratum occurs and the safe baring power of this stratum.
5. The ground water level.
6. Because water, soil or rock can have aggressive influence on these materials.

4. WRITING A GOOD SUMMARY

It is often necessary to have long compositions in a condensed form. This brief summary should be in your own words and it must accurately state the main idea of the original. Skill in summary writing is essential for scientists, researchers of all kinds, newspaper writers and government officials. Here are some guidelines that will help you to write a good summary:

a) Read the original selection carefully. Search for the main idea.
b) Find the meanings of any words you do not know.
c) Read the selection again.
d) Determine which parts of the selection are essential.
e) Write down the key words or phrases.
f) From your notes, and from your own interpretation of the main idea, write your summary.

Following these guidelines write the summary of the text about foundations!

UNIT 16

TYPES OF FOUNDATIONS

The term rock and stone are often used synonymously, but there is actually some distinction between them. Both of these terms apply to the same material but, in general, if geologic formations are being considered, the term rock is used while smaller pieces of rock are called stone. However, this distinction between rock and stone is not always made. Rock is divided into three classes according to their method of formation. These classes are igneous plutonic, sedimentary, and metamorphic. They are also divided into classes according to their chemical composition. If rock is found within a few feet under the surface of the ground or if it is within economic reach, it is used to support the foundations. This applies especially to structures which, when only partly destroyed, endanger life and property, as, for instance, dams. But the mere fact that a structure is built on rock does not guarantee its stability. Stability means that the foundation will neither overturn nor slide under the load of the superstructure, the active earth pressure, the water pressure, or its own weight and that no shear failure will occur. Before the foundation plans are prepared, an investigation should be made to determine the character of the foundation material, which will be required to support the structure. In its natural position, soil serves as the support for the foundations of most structures, whereas the foundations for some of the major structures are carried to rock if rock is readily accessible.

For constructing the substructure, an excavation must be provided. Its size, depth, for the excavation, etc., and shape are governed by the dimensions of the substructure.

Types of foundations. The type of foundation must be selected with due regard to the superstructure and its loads (permanent load and live load), the properties of the foundation material and the elevation of the ground water table. If the bearing stratum occurs within a few feet of the surface of the ground, a shallow footing is advisable, which, however, must be protected against frost.

When the bearing stratum lies at some depth below the ground surface, or below water and the loads are heavy, deep foundations are often provided.

If the bearing stratum is some distance below the ground level, or below the bottom of the excavation for the structure to be supported, piles are driven into the bearing stratum (or moulded in situ) instead of taking out an extensive and deep excavation. Therefore, piles generally act as columns to transmit the weight of the structure from an upper level through an intervening stratum of soft ground to a harder stratum (which may be rock, compact gravel or sand, or firm clay), at a lower level.

The term caisson is derived from the French word, caisse, meaning box. There are three forms of caissons used in constructing foundations under water. i.e. the box caisson (open at the top and closed at the bottom), the open caisson (open at the top and bottom), and pneumatic caisson (open at the bottom and closed at the top and utilizing compressed air).

Box caissons are used in constructing bridge foundations under water. The caisson, which may be constructed of timber, concrete, or steel, is towed into position, filled with concrete or stone masonry and sunk until it rests on the river bottom which has been prepared to receive it. Box caissons are not applicable for buildings.
(adopted from: “English for Civil Engineers II “, Z. Čulić)

EXERCISES:

1. ANSWER THE QUESTONS:
   1. When is the term rock used?
   2. How are smaller pieces of rock called?
   3. When is rock used to support the foundations?
   4. What does stability of a structure mean?
   5. What does the selection of the type of foundation depend on?
   6. How does the bearing stratum influence the type of the foundation?
   7. What are the three forms of caissons used in constructing foundations under water?
   8. Explain when and how are box caissons used?

2.COMBINE THE PARTS OF SENTENCES:

a) The caisson	1. examine the bearing stratum.
b) The base which carries horizontal loads	2. is used to construct under water.
c) Foundation engineering	3. forms the base of a building
d) Site investigations	4. deals with the transmission of load to foundation material.
e) The foundation	5.is usually called abutment.

3.CHOOSE THE WORD WITH THE SAME OR SIMILAR MEANING:

1. Stratum
   A)layer
   B)depth
   C)ground level

2. Slide
   A)to move smoothly along an even, polished or slippery surface
   B)to lose balance and fall
   C)to move quietly, quickly or easily

3. Pile
   A)support
   B)column
   C)stick

3. TRANSLATE:

Temelj je dio konstrukcije koji služi raspodjeli sila i momenata reakcije konstrukcije, a nalazi se između osnovne konstrukcije građevine i temeljne plohe odabrane za prijenos sila u tlo. Temelji ovise o konstruktivnom karakteru građevine. Mogu biti plitki, duboki, masivni ili raščlanjeni u pojedine stupove ili više stupova. Izbor dubine temelja ispod površine tla zavisi o sastavu i osobinama tla. Temelj treba postaviti u dubinu u kojoj osobine tla odgovaraju zahtjevima sigurnosti. Najmanja dubina temelja ovisi i o klimatskim uvjetima. Sezonski mogu nastati promjene volumena tla upijanjem vode ili njenim isparavanjem u zoni prijenosa sila.

Iako je temelj nevidljivi dio građevine, njegovo se značenje ne smije podcijeniti jer u suprotnom može doći do katastrofalnih posljedica. Zato se projektiranju temelja mora posvetiti barem istotoliko pozornosti, koliko i ostalim dijelovima konstruktivnih elemenata građevine. Počinje se ispitivanjem tla, najprije da se ustanove razni slojevi u tlu i njihovo prostiranje, a zatim da se na uzorcima u laboratoriju odrede parametri volumenskih promjena pod opterećenjem i parametri čvrstoće. Tada možemo početi s projektiranjem temelja koji će biti sigurni i ekonomični.

(obrađeno “Geomehanika III“ E. Nonveiller)

UNIT 17

VECTORS

As you read the text about vectors, choose the most appropriate word in the brackets.

We (deal, concern) with many physical quantities in engineering. They can be (divided, separated) into the two groups: scalar and vector quantities. (Both, together) they have size or magnitude, but only vector quantities (possess, obtain) direction. Mass, volume and length are scalar quantities. Force which we (indicate, measure) in newtons, possesses magnitude and direction. Force,then, is a vector quantity. Other examples are acceleration and velocity.

A vector quantity is a quantity (whose, which) pertinent characteristics can be (represented, drawn) by a vector. A vector is a line segment or simply a line whose distinctive (properties, qualities) are length, direction and sense. The length of a vector is the linear (direction, distance) between the extremities. Direction is measured in terms of the angular orientation of the vector with respect to some reference line. If we (consider, refer) the vector to have been generated by a moving point, the sense of the vector is (determined, stated) by the order in which the point coincides with extremities.

(abridged from: "English in Civil Engineering II", Z.Čulić and "English for Civil Engineers I", M.Horvatović)

EXERCISES:

1.ANSWER THE QUESTIONS:

1. What are the two groups of physical quantities we deal with in engineering?
2. What do they have in common?
3. How do vector quantities differ from scalar quantities?
4. Give several examples of vector and scalar quantities?
5. How can vector quantities be represented?
6. What is a vector?
7. What is the sense of the vector determined by?

2. FOR EACH WORD IN COLUMN 1 FIND A WORD IN COLUMN 2 WHICH MEANS APPROXIMATELY THE SAME:

1	2
size	case
instance	taking away
concept	magnitude
approximately	idea
removal	roughly
discover	find out

3. TURN INTO THE PASSIVE VOICE:
    1. They have given back to physics new materials.
    2. Galileo Galilei used the method of accurate observation and the controlled experiment.
    3. If you drop a flat board on the surface of a still pond of water, you can hear a loud splash.
    4. They classify waves by their direction.
    5. The teacher will read the whole paragraph twice.
    6. They had laid concrete highways in sections.

4. SUPLY THE CORRECT PREPOSITIONS:
    1. Taking notes differs__ dictation.
    2. The knowledge .. the past was synthesized … the new knowledge of the 17-century science ... a general theory … Newton.
    3. We should get acquainted __ the three simple stresses.
    4. A truss consists __ a straight members connected at joints.
    5. What are resilient materials capable __ ?
    6. What are limes classified __ ?

5. TRANSLATE:

U građevinarstvu je često potrebno opisivati količinu i odnos. Slikovni prikaz nekih veličina možemo dati upotrebljavajući vektore. Skalarne veličine se mogu jednostavno opisati , tako da izrazimo njihov iznos pomoću odgovarajuće jedinice mjerenja. Na primjer, masu tijela možemo izraziti kao količinu grama. Graf daje vizualni prikaz odnosa i često ga je lakše razumijeti nego zakon. Složenija vrst grafa je monograf. On može pokazivati vezu između više od dvije varijable. Složeniji monografi se izrađuju na posebnom papiru i mogu imati tri dimenzije.

(„English in Civil Engineering II”, Z. Čulić)

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U N I T 1 8

W E L D I N G

Welding process. Welding is a process of joining metal parts by means of heat and presure, which cause fusion of the parts (resistance welding) or by heating the matal to the fusion temperature, with of without the addition of weld matal (fusion welding). The eight principal groups of welding include brazing, flow welding, resistance welding, induction welding, arc welding, thermit welding, gas welding and forge welding. Brazing includes a group of welding methods in which nonferrous filler metal is melted at a temperature lower than the melting point of the parts being connected and the attachment is accomplished by capillary attraction of the metals. The flow welding processes are accomplished by pouring metal over the joint to be welded until the connection is heated to welding temperature.

In forge welding the members are heated and the weld is made by means of pressure or hammer blows. A common type of forge welding is that done by blacksmith. The heat required in resistance welding is supplied by the resistance of the material being welded to an electric current passed through the parts; pressure is used to force the parts together. Induction welding is a process in which coalescence is produced by the heat obtained from resistance of the work to the flow of induced electronic current, with or without the application of pressure.

A group of welding processes known as thermit welding is accomplished by placing superheated liquid metal and slag. Resulting from a chemical reaction between metal oxide aluminum, around the parts to be joined. Gas welding is done with gas flames used to melt the metal, and with arc welding is produced by an electric arc; some of the processes use pressure, and metal may or may not be added.

The welding processes that are most important to the structural engineer are arc and gas welding. The arc welding method has two principal subdivisions. These are classified as carbon electrode and metal electrode. A majority of structural welding is done by the electric-arc method. Gas welding is usually accomplished by the use of the oxyacetylene flame and the addition of weld Mattel. The oxyacetylene flame is also an important tool for flame cutting and for the preparation of material for arc welding.

Types of welds. There are two principal types of welds – the fillet weld and the butt weld. Because of the manner in which the welded parts meet, these welds have various shapes.
Welds are classified according to their position as flat, horizontal, vertical, and overhead; according to their type as groove, fillet, plug and slot; and according to the type of joint as butt, lap, tee, corner, and edge.
(ADOPTED FROM: “English for Civil Engineers II ” M.Horvatović)

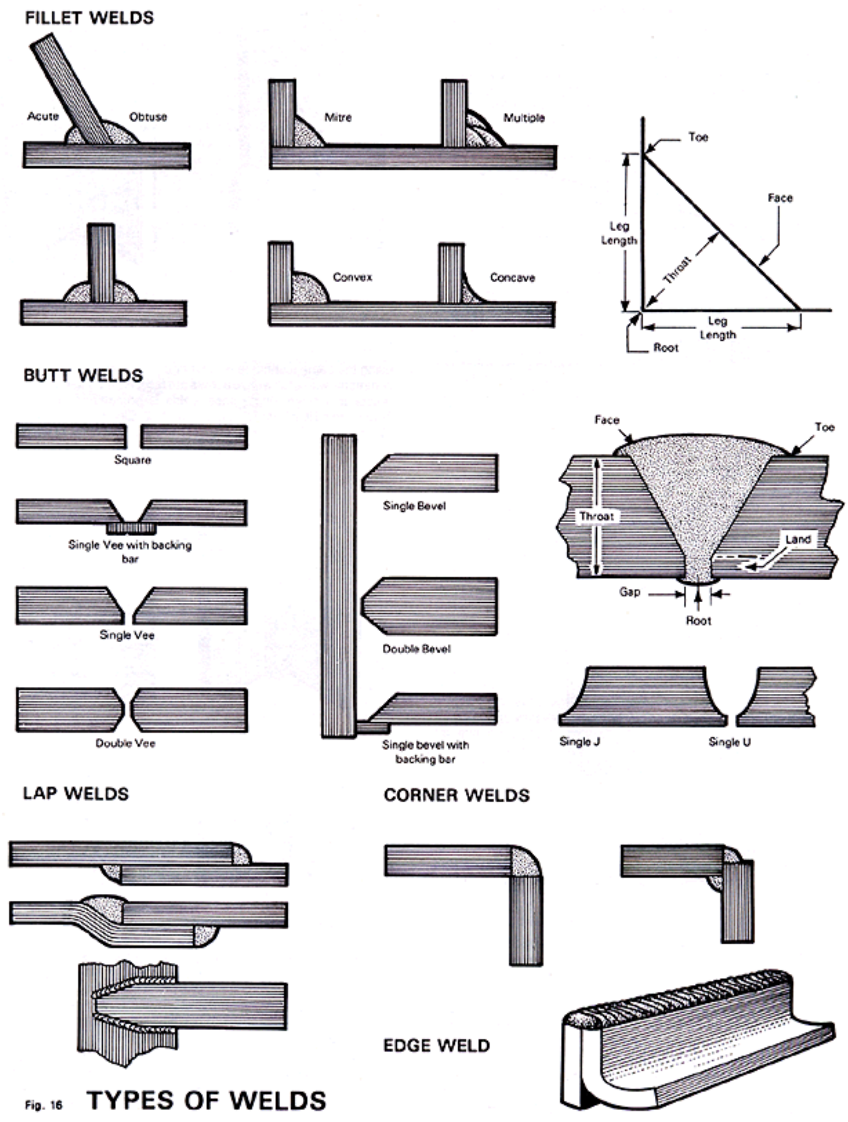

Fig. 17: Types of weld

EXERCISES:

THINGS TO REMEMBER:

Welding	Joint
Weld	Oxyacetylene flame
Brazing	Fusion
Flow welding	Fillet weld
Resistance welding	Butt weld
Induction welding	
Arc welding	
Thermit welding	
Gas welding	
Forge welding	
Melting point	

1. COPY THE WORDS INTO YOUR NOTEBOOK AND TRANSLATE!

2.COMPREHENSION QUIZ:

1. In welding, metal parts are joined by means of:
   a) pressure and heat b) bending c) hammering
2. There are a) two…
   b) five… principal groups of welding.
   c) eight…
3. A common type of welding is that done by:
   a) forger b) welder c) blacksmith
4. The welding processes that are most important to the structural engineer are:
   a)fusion and arc welding b) resistance and gas welding c) arc and gas welding
5. a) Gas welding..
   b) Thermit welding…is done by the oxyacetylene flame and weld metal.
   c) Arc welding …
6. Fusion welding is accomplished by:
   a)melting the metal b) heating the metal c) hammering the metal

3.IN THE FORM OF NOTES WRITE DOWN THE MOST IMPORTANT INFORMATION FROM THE TEXT

4.SUPPLY THE CORRECT TENSE OF THE VERBS IN BRACKETS:

1. If three forces meeting in a point are in equilibrium, they (form) a closed triangle.
2. If the lower part of a mass of dry soil had come into conntact with water, the water (rise) in the voids…
3. If we(have) time, we would finish laboratory test.
4. No sinking would have occurred if the soil (be) hard stiff clay.
5. The road surface (buckle) if there were no room for expansion under the summer sun.
6. We can approximate the actual expected setlement if we (know) the distribution of pressure at the base of the footing.
7. If the cost were reasonable, the design(be) accepted.

5.TRANSLATE THE TEXT:

Faktori koji utječu na izbor profila

Vrlo važan proces u projektiranju konstrukcije je određivanje materijala za uporabu i oblika i obima pojedinačnih elemenata konstrukcije. Ovoj proceduri prethodi analiza koja pruža podatke o iznosima smicanja, direktnog opterećenja i momenta savijanja u elementima. Izbor profila ovisi o mnogim čimbenicima.

Čvrstoća je faktor koji obično utječe na konačni izbor profila. Elementi moraju imati takve karakteristike koji će pružiti zadovoljavajući faktor sigurnosti protiv otkazivanja nosivosti (failure) od svih očekivanih opterećenja kao što su: stalno i promjenjivo opterećenje, dinamički udari, vjetar, te zemljotres. Katkad se obraća pozornost budućim opterećenjima koja bi mogla nastati zbog skupljanja, puzanja, temperaturnog rastezanja (extension) konstrukcije ili diferencijalnog slijeganja i rotacije (conversion) temelja.

(adopted from: “English for Civil Engineers II “, M.Horvatović)

U N I T 19

HOW TO PLAN A HOUSE –SPECIFICATIONS

When a house is to be built the drawings and the specifications are usually submitted to a number of contractors, each of whom makes an offer to build the house complete in accordance with them for a certain money. When all of the offers or bids or tenders, as they say are called, have been received, the owner decides which of them he wishes to accept (usually the lowest). Then a legal agreement called a contract is written out and signed by both the owner and the contractor. The drawings and the specifications are made a part of this contract. What it amounts to is that the contractor agrees to build and finish the house, carrying out all of the work shown on the drawings or called for by the specifications, for a certain sum of money, and the owner agrees to pay the contractor the said sum of money, provided that the work is done in accordance with the drawings and specifications.

As a rule some third party, usually the architect, is stated in the contract to the one who shall decide whether the work has been properly done and whether the contractor is entitled to receive payment. In case of serious dispute the matter may be taken to the courts and a judge may have to make a decision. With this in view as a possibility the specifications ought to be made so clear and so complete that there can be no doubt in a judge's mind as to what was agreed upon. The existence of a good specification tends to keep disputes out of courts. Of course, the contractor cannot be expected to furnish any item which has not been called for by the drawings or the specifications, and therefore great care must be taken to see that they are complete and provide for everything which is really wanted and the kind of workmanship which is expected.

In addition to serving as a source of information to the estimator in the contractor's office, who makes up the bid for the work, the specification also serves as a guide to the superintendent who is in charge of the actual building work. For both these purposes it is essential that whatever information or instruction there may be given relating to any part of the work can be found quickly and easily. To accomplish this, the specifications should be arranged in an orderly manner by trades, and insofar as possible in the order in which the work is done. Thus for the general trades the masonry, including excavation, should come first and painting and glazing last, followed by the mechanical trades, such as plumbing, heating and electric wiring. First of all, however, there will be a section called General Conditions, which set fourth the relations between the Owner and Contractor and includes a number of clauses covering things which the contractor has to do which do not properly form a part of the work of any of the subtrades covered by the other section.

All of the items should be grouped together under the headings of the trades to which they belong. The trade headings should be, for a house, about as follows: Excavations, Masonry, Carpentry, Lathing and Plastering, Roofing and Sheet Metal Work, Marble and Tile Work, Linoleum, Painting and Finishing, Glazing, Plumbing, Heating, Electrical Work.

A somewhat abbreviated typical specifications for a house would read as follows:

Examination of the site. It is understood that the Contractor has examined the site and is familiar with all the conditions, which might affect the execution of this contract and has made provision therefore in his tender.

Trees, shrubbery and lawns shall be carefully protected by the General Contractor from injury, which might result from any operation connected with the execution of this contract.

All water which may be required by all trades in connection with the execution of this contract shall be provided and paid for by General Contractor, who shall make connection to water mains, and provide, install and maintain necessary piping, water meter, house bibs…
Guarantee. The acceptance of this contract carries with it a guarantee on the part of the Contractor to make good any defects in the work of the building arising or discovering within two years after completion and acceptance of same by the Architects, whether from shrinkage, settlement or faults of labor or materials.

EXERCISES:

1. ANSWER THE QUESTIONS:

1. Why are the drawings and the specifications submitted to a number of contractors?
2. What is a contract? Who is it written out and signed by?
3. What do the contractor and the owner agree about in the contract?
4. What is the function of the third party in the contract?
5. Why should the specification be made clear and complete?
6. Who is the superintendent?
7. How should specification be arranged?
8. What is the purpose of the General Conditions?
9. Mention all the trades needed in building a house?
10. What is a guarantee?

2. TRANSLATE THE FOLLOWING WORDS:

Superintendent
Tender
Contractor
Owner
Judge
Estimator

3. MATCH COLUMN A WITH COLUMN B AND THEN USE THE EXPRESSIONS IN YOUR OWN SENTENCES:

A	B
In charge	the site
To agree	provision for
To sign a	about
To accept	conditions
To make	the bid
General	a contract
To examine	of

4. GIVE ONE WORD FOR THE FOLLOWING EXPRESSIONS OR EXPLANATIONS:

a) water pipes in a building

b) a detailed description of the workmanship of the works
c) place where law-cases are heard
d) bid
e) building agreement to do a work at a fixed price
f) one of the persons or sides in a legal agreement

5. MAKE COLLOCATIONS:

preliminary …	general…	metal…	building…
…	…	…	…
. ..	…	…	…

6. GIVE THE OPPOSITE OF THE FOLLOWING WORDS:

agree, dispute, finish, acceptance, understand, quickly, easily

7. MAKE THE SUMMARY OF THE TEXT.

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UNIT 20

JOB PLANNING AND MANAGEMENT

This chapter deals with the planning that is necessary prior to starting actual construction on a project. Such planning should facilitate the construction by establishing:

1. The time for delivering materials
2. The types, quantities, and duration of equipment needs
3. The classification and numbers of laborers needed and the periods during which they will be needed
4. The extent to which financial aid, if any, will be needed
5. The time required to complete the project

A contractor should do some of this planning prior to bidding a project, since planning frequently will reveal factors which will affect the cost of the project, and thus will influence the amounts shown in a bid.

Construction activities. Most projects are divided into construction activities to facilitate job planning. A construction activity is a portion of a project, which may be performed by a classification of laborers or perhaps a single type of equipment. For example, in constructing a reinforced-concrete retaining wall the project might be divided into the following activities:

1. Excavate earth, machine.
2. Excavate earth, hand.
3. Build forms.
4. Place reinforcing steel.
5. Place concrete.
6. Cure concrete.
7. Remove forms
8. Finish concrete surface.
9. Backfill with earth.

In planning the construction of a highway requiring a new location the project might be divided into the following activities:

1. Move to the project and set up the plant.
2. Clear and grub the right of way.
3. Perform the earthwork, cut and fill.
4. Excavate for drainage pipe.
5. Place the base material.
6. Place the pavement.
7. Shape the shoulders.
8. Clean up and remove the plant.

In order to estimate the progress in constructing the project, the job planner should determine the quantity of work to be constructed for each activity expressed in an appropriate unit. Then he should estimate the probable rate, at which the work will be performed, allowing for estimated loss in time owing to bad weather or any other cause. From this information it will be possible to estimate starting date and completion date for each activity. The estimated starting date and completion date for each activity should be determined. In scheduling the activities the job planner should consider the desirable sequential relationships between the activities. For example, in constructing a concrete foundation unit it will be necessary to complete the excavation before concrete can be placed.

The Critical Path Method. During recent years the critical path method of planning, analyzing, and controlling a construction project has become a useful tool for engineers, architects, contractors, and others who are associated with construction. Many government and private agencies require the preparation and use of this method when planning the construction of a project.

In order to analyze a project by using the critical path method it is necessary to divide the project into activities. The number of units of work required to complete each activity should be determined. Then the time required to complete each activity, considering available equipment and labor should be estimated in appropriate units, such as days, weeks, or months. Also, it is necessary to determine the time sequence in which the activities should be constructed. For example, concrete for a beam can not be placed until the forms have been erected and the reinforcing steel has been placed.

Each activity should be identified by a symbol or an appropriate description or both, and listed in column form, with the duration of the activity, together with the activities, which immediately precede and follow it. Then the inter-relationship of the activities can be indicated by a network or arrow diagram.

Scheduling Resources. If construction on a project is to proceed efficiently and at the scheduled rates, it is necessary to know accurately the types and quantities of resources that will be needed and the dates on which they will be needed. Resources include materials, equipment, and labor, by classification and quantities. An analysis of the information obtained from the critical path study will enable the project planner to know in advance whereat resources will be needed in arrange for them to be available when they are needed.

Delivering materials. The arrow diagram or the time-grid diagram may be used as a guide in specifying the delivery dates for materials. Materials should be delivered to a project before they are needed. However, excessively early delivery is not desirable because of the possibility that materials might deteriorate or might congest working areas in which storage space is limited.

Scheduling Equipment Use. An equipment use schedule is prepared before the project is started to establish the types, quantities, and dates for equipment need.

Scheduling Laborers. Employment schedule may be used in determining the classification and numbers of laborers required for a project.

(adopted from: “English for Civil Engineers II “ M. Horvatović)

DO THE FOLLOWING EXERCISES:

1. What should job planning establish?
2. Why should a contractor do some of this planning prior to biding a project?
3. Copy and translate the sentence which explains the term *construction activity* ?
4. Make a list of activities planned for constructing a reinforced-concrete retaining wall!
5. Copy the activities, which are planned in the construction of a highway!
6. What is the critical path method?
7. How can the project planner know in advance what resources will be needed?
8. Complete: Resources include…

READ THE TEXT AND THEN TRANSLATE:

Safety engineering

Accident prevention should be an essential part of the program of any contractor who expects to enjoy a successful career in this activity.

An accident prevention program should be inaugurated on every project in order to reduce the cost of construction measured on terms of:

1. Human lives sacrified
2. Temporary and permanent injuries to workers
3. Loss of materials resulting from accident
4. Loss of or damage to equipment
5. The cost of workmen's compensation insurance
6. Loss of time because of accidents

Classification of Construction Accidents.

Extensive surveys indicate that the causes of construction accidents may be grouped as follows:

1.Uncontollable contact between men and equipment or between men and materials, such as cranes, trucks, and material storage

2. Failure of temporary structures, such as forms, scaffolds, ramps, ladders, cofferdams, cuts, etc.

3.Inherent engineering hazards, such as the use of explosives, presence of injurious gases, toxic dusts, etc.

4.Unsafe practices of individual workers or personal hazards resulting from the carelessness of workers.

(adopted from:"English for Civil Engineers II", M.Horvatović)

A P P E N D I X

DIFFERENTIALS & INTEGRALS

The nature of differentials. In engineering, we are often concerned with the rate at which something changes or accelerates. We are interested in the velocity as well as position of a moving piston or a projectile. To deal with these quantities and relate them in equations, we define them in terms of differentials, which are merely the values of the differences between successive values, when these latter are taken sufficiently close together.

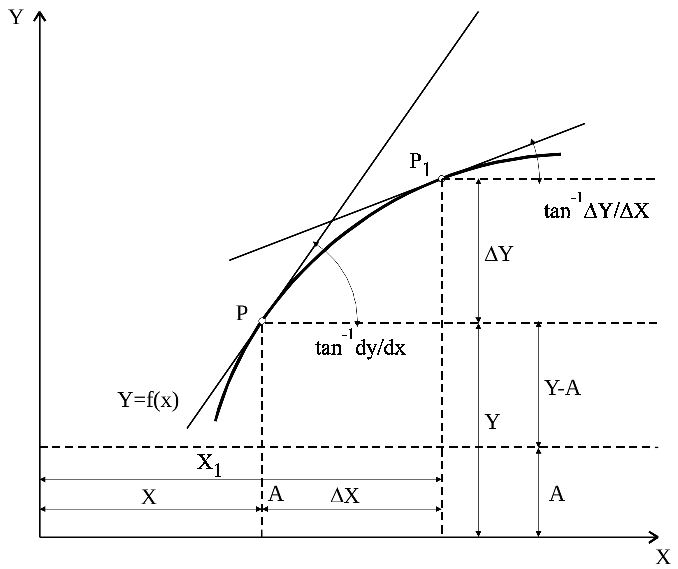

Fig. 18: Relation between *dy/dx* and $\Delta y / \Delta x$

If we tabulate the values of a continuous function $y = f(x)$ (*read: y is equal to a function of x)*, for x = 1,2,3, etc., and we can find that the differences $\Delta f(x)$ between successive values in the table could be used to calculate intermediate values, such as $f(x+1/4)$. Thus, any value of $f(x)$ can be found by addition from a series of values of $\Delta f(x)$, just as any value of $\Delta f(x)$ can be found by substraction from a series of values of $f(x)$.

In Fig. 17., two points P and P1 on the curve $f(x)+A$ are shown at *x*, *y* and x_1, y_1. The line connecting the points is a chord of the curve, which has a slope equal to the ratio of the differences in *y* to that in *x*:

$$\frac{y_1 - y}{x_1 - x} = \frac{\Delta y}{\Delta x} = \frac{\Delta f(x)}{\Delta x}$$

Suppose now that P_1 is brought continually nearer to *P*, so that Δx and Δy both become smaller. At the limit, when Δx and Δy are sensibly equal to zero and P_1 almost coincides with *P*, the slope of the chord becomes the same as that of the tangent to the curve at *P* and is equal to

$$\left(\frac{\Delta y}{\Delta x}\right)_{\Delta x \to 0} = \frac{dy}{dx} = \frac{df(x)}{dx} = f'(x)$$

When the differences between successive values of *x* and *y* is small, we call it a differential instead of a difference and designate it by *dx* or *dy* instead of Δx or Δy. Even though *dx* and *dy* are themselves negligibly small or zero, their ratio is finite. Whereas there are many possible values of Δy at a point *P* on a curve, depending on how long a chord is considered and whether it is on the up or the down side of *P*, there is only one value of *dy/dx* at *P*. And it makes no difference what the value of the constant term *A* is.

By dealing with the ratios of these vanishingly small quantities, or differentials, we are considering perfectly definite relations between curves and their tangent lines or between quantities and their rates of change. The ratio of *dy* to *dx* is called the derivative of *y*, with respect to *x*. For brevity, this is often written $f'(x)$ *(f'= f prime (praim))*, as in Eq. 8-2, or simply y'.

For example, if a car passes a point *P* at 3:00 o'clock and P_1, 50 km away, at 4:00 o'clock, we have $\Delta y = 50$ km and $\Delta x = 1$ hour, so that the average speed (slope of the chord of the position-time curve) was 50 km per hour. If the speed of the car was exactly the same all the time, the derivative of the distance with respect to time was also 50 km per hour. If the speed varied from moment to moment, the derivative would be found by plotting a position-time curve, and measuring the slope at the moment considered. When the car is not moving, its position, or distance from *P*, does not change, so that the differential *dy* equals zero.

Just as the change in distance per unit of time, *dy/dx*, is the speed, so that the change in speed per unit of time,

$$\frac{d}{dx}\left(\frac{dy}{dx}\right) = \frac{d^2y}{dx^2}$$

is the acceleration. The n*th* derivative of any function is written $d^n f(x)/dx^n$, or simply $f^n(x)$. There is a close relationship between the n*th*-order difference in a table of successive values of *y* and the n*th* order derivatives of *y*.

If the values of *y* are tabulated for smaller and smaller increments, Δx, the increments Δy will appraoch equality with the derivative times Δx or $y'\Delta x$.

VOCABULARY:

Differential – diferencijal
Rate – brzina, iznos
Piston – klip
Tabulate – klip (u cilindru)
Table – tabela
Chord of the curve – tetiva
Slope – nagib
Coincide with – poklapati se sa
Negligibly – zanemarivo malo
brevity - sažetost
plot – ucrtati u mapu
nth-order difference – diferencija n-tog reda
increment – prirast, povećanje
differentiation - diferencijacija

DIFFERENTIAL EQUATIONS

In any scientific or technological field, such as astronomy, chemistry, engineering, physics, etc., the formulation of a natural law is regarded as completely precise and definitive only when it is expressed as a mathematical equation. This equation effectively relates the quantity, or function, upon which the attention is focused, with the independent variables such as time, position, etc., upon which it may depend. Now it is frequently – even prevalently – the case that the equation which does this involves, besides the function itself, also one or more derivatives. Such an equation, specifically one in which a derivative or derivatives occur, is called a differential equation. The following are examples of such equations:

$$\frac{dy}{dt} = -ky \qquad (1)$$

$$m\frac{d^2y}{dt^2} = -k^2y \qquad (2)$$

$$\left\{1+\left(\frac{dy}{dx}\right)^2\right\}\frac{d^3y}{dx^3} - 3\frac{dy}{dx}\left(\frac{d^2y}{dx^2}\right) = 0 \qquad (3)$$

If this *y* stand for the function, and either *t* or *x* is the independent variable. The symbols *k* and *m* are used here to stand for specific constants.

Classifications. Differential equation is classified in the first instance into several broad categories, and these are in turn subdivided into many subcategories. Of the former the most important are (a) the category of the so-called ordinary differential equations and (b) that of the so-called partial differential equations. When the function involved in the equation depends upon only a single variable its derivatives are ordinary derivatives, and the differential equation is classed as an ordinary differential equation. If, on the other hand, the function depends upon several independent variables, so that its derivatives are partial derivatives, then the differential equation is classed as a partial differential equation.

Whichever the type may be, a differential equation is said to be of the n*th* order if it involves a derivative of the n*th* order but no derivative of an order higher than this. The differential equations

(1),(2) and (3) are all ordinary differential equations. They are respectively of the first, second and third order. The equation

$$\frac{\partial u}{\partial t} = k^2 \left[\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} \right]$$

is an example of a partial differential equation. It is of the second order. The theories of ordinary and partial differential equations are markedly different. In almost all respects the former is the simpler.

VOCABULARY:
Prevalently – prevladavajući
Ordinary differential equation – obična diferencijalna jednadžba
Partial – parcijalna, djelomična
Order – red
Markedly – primjetno, uočljivo

MATRICES

Definitions and notation

A matrix of order *mXn* is an arrangement of elements in *m* rows and *n* columns as follows:

$$[a] = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$$

The elements a_{ij} of the matrix can be real numbers, complex numbers, or functions of variables. The first subscript *i* designates the column position. Rows are counted from the top to the down and columns from left to right.

A (mXn) matrix in which all elements $a_{ij} = 0$ is called null matrix or zero matrix.

Square matrix. When matrix has an equal number of rows and columns *(m=n)* it is called a square matrix. The diagonal of a square matrix, which extends from the upper left to the lower right and contains elements, $a_{ii}\ (i = 1, 2, ..., n)$ is known as its *principal diagonal*.

A *symmetric matrix* is a square matrix in which $a_{ij} = a_{ji}$ for all *i* and *j*; that is, the matrix is symmetric about the principal diagonal.

A *diagonal matrix* is a square matrix with nonzero elements only on the principal diagonal; that is, $a_{ij} = 0$ for $i \neq j$, and $a_{ij} \neq 0$ for $i = j$.

An *identity matrix* or a *unit matrix* is a diagonal matrix with all the elements of the principal diagonal equal to unity, $a_{ii} = 1, \ (i = 1, 2, ..., n)$.

The *determinant* $|a|$ formed from all the elements of a square matrix is known as the *determinant of* $[a]$.

A single number is a square matrix of order 1x1, known as a *scalar*.

Column matrix: A matrix of order m x 1 with *m* rows and a single column is known as a *column matrix* or *column vector,* and is designated by brackets as we did for the force and displacement vectors $\{F\}$ and $\{u\}$.

Transpose of a Matrix. When corresponding rows and columns of a matrix $[a]$ are interchanged the resulting matrix is called the *transposed matrix* of $[a]$ and is designated as $[a]^T$ (some books use a prime, $[a]'$).

Row matrix. A matrix of order 1 x n with one row and *n* column is known as a *row matrix* or *row vector*. We shall designate a row matrix as transpose of a column matrix. Hence $\{F\}^T$ and $\{u\}^T$ are respectively row matrices of force and displacement

$$\{u\}^T = [u_1, u_{2,} ..., u_n]$$
$$\{F\}^T = [F_1, F_2, ..., F_n]$$

INVERSE OF A MATRIX

An inverse of a square matrix $[a]$ is a square matrix of the same order, which will yield the identity matrix when it premultiplies or postmultiplies $[a]$. The inverse of $[a]$ is designated as $[a]^{-1}$, hence, from this definition

$$[a]^{-1}[a] = [I]$$
$$[a][a]^{-1} = [I]$$

The inverse of a matrix $[a]$ is defined only when $[a]$ is a square matrix, and it exists only when the rows and columns of $[a]$ are independent, or when $|a| \neq 0$.

The maximum number of linearly independent rows or columns of $[a]$ is called the *rank* of $[a]$. Hence when the rank of a square matrix $[a]$ is equal to its order (that is, $|a| \neq 0$), it has an inverse.

A square matrix $[a]$ is said to be singular when $|a| = 0$, and nonsingular when $|a| \neq 0$.

Computing the Inverse of $[a]$ *from its Cofactors*. Given a nonsingular matrix $[a]$ of order *n* we can find its inverse by using aquations in the following form:

$$\sum_{j=1}^{n} a_{ij} A_{kj} = |a| \qquad \text{for } i = k$$

$$\sum_{j=1}^{n} a_{ij} A_{kj} = 0 \qquad \text{for } i \neq k \qquad (1)$$

As a first step we construct a new matrix of the cofactors A_{ij} of the elements a_{ij} of $[a]$.

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1n} \\ A_{21} & A_{22} & \dots & A_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ A_{n1} & A_{n2} & \dots & A_{nn} \end{bmatrix}$$

The transpose of this matrix is called the *adjoint* of $[a]$ and is designated compactly as $adj[a]$.

PARTITIONED MATRICES

It is often convenient to partition a matrix by introducing vertical and horizontal lines as follows:

$$[K] = \begin{bmatrix} 4 & 2 & -6 & 6 \\ 2 & 4 & -6 & 6 \\ .... & .... & .... & .... \\ -6 & -6 & 12 & -12 \\ 6 & 6 & -12 & 12 \end{bmatrix} = \begin{bmatrix} [K]_{11} & [K]_{12} \\ [K]_{21} & [K]_{22} \end{bmatrix}$$

each array of numbers bounded by the original brackets and the newly introduced lines is called a *submatrix*, and the original matrix in partitioned form is referred to as a *partitioned matrix*. The submatrices are conveniently identified by subscripts as if they were elements; that is, first and second subscript designate row and column position respectively.

VOCABULARY:

order-red
row-red (matrice)
column-stupac (matrice)
null matrix, zero matrix-nul matrica
square matrix-kvadratna matrica
identity matrix, unit matrix-jedinična matrica
nonzero-koji nije nula, različit od nule
force vector-vektor sila
displacement vector-vektor pomaka
row matrix-redna matrica
column matrix-stupčana matrica
rank-rang
premultiply-prethodno pomnožiti
postmultiply-naknadno pomnožiti
nonsingular-nesingularan
partitioned matrix-dekomponirana matrica
submatrix-podmatrica

GLOSSARY

A

abrasion hardness – otpornost na trošenje, habanje
abutment – upornjak
accelerator – dodatak za ubrzavanje vezivanja (stvrdnjavanja)
activated sludge – aktivni, živi mulj
adjacent – susjedni
admixture – dodatak
advisory committee – savjetodavno povjerenstvo
aftershock – naknadni udar
allowable stress – dopušteni napon
angular intersection – kutno raskrižje
arc welding – lučno zavarivanje

B

base course – međusloj, vezni sloj kolovoza,noseći sloj kolovozne konstrukcije
baswood – lipa
batch – punjenje mješalice; batching plant – tvornica betona
benefit – korist, dobit
bending stress – naprezanje pri savijanju
blind drain – podzemni dren (hidr.)
block pavement – zastor od kocaka, kaldrma
brittle – krhak, lomljiv
buoyancy – plovnost

C

cadastral – katastarski
carpentry – tesarski radovi
cart – kolica
catchment area – slivno područje
cement bound macadam – cementni makadam
chute – lijevati beton niz cijev, cijev za betoniranje
clearance – razmak
compact – nabijati, zbijati
compressible – stlačiv, koji se da stijesnuti
confined – pod pritiskom
conjunctive – spojni, vezni
consolidation – učvršćavanje

contraction joint – prividna spojnica
construction survey – snimanje objekata
coplanar – komplanaran
corner joint – ugaoni, kutni var
correlate – dovesti u uzajamni odnos
crack – pukotina, naprslina
creep strain – plastična deformacija
cross drainage – poprečna drenaža
crowned – zaobljen
culvert – propust
curing – njega betona
current pressure – pritisak izazvan riječnom strujom
curvature – krivina
cut – iskop, usjek
cutting hardness – otpornost rezanju

D

deflection – progib
deteriorating – štetno djelovanje
discrepancy – razlika, neslaganje
displacement – premještanje (geol.), pomak
dissolved – otopljen
distribution reservoir – razvodni spremnaik
ditch – jarak, kanal
double tee joint – križasti spoj
drain – cijev za odvodnjavanje, dren, drenažna cijev
drying shrinkage – stezanje uslijed sušenja
ductility – duktilnost, rastezljivost

E

edge joint – spoj po rubu
elastic- rebound theory – teorija elastičnosti
entraintment - uvlačenje zraka u beton
errection stress - napon od montaže
excess water – suvišna voda
expansion joint – dilatacijska spojnica

F

face of weld – lice, prednja strana vara
failure – (s)lom, otkazivanje konstrukcije
feasible – izvodljiv, praktičan, moguć
fill- nasip

fillet weld – kutni zavarak
fin - neravnina
floating – glađenje (žbuk.)
flow welding – zavarivanje rastapanjem
footing – stopa temelja
foreshock – prethodni udar
forge welding – kovačko zavarivanje
formwork – (fina)oplata
fracture – raspuklina, pukotina
friction – trenje
furnish - snabdjeti

G

glazing - zastakljivanje
grade-crossing – prijelaz u nivou
grain – vlakanca (drvo)
groove - žlijeb
grout – cementno miljeko
guard railing – ograda
gun (concrete) – betonski top
gutter – otvoreni kanal (pored ceste), žlijeb, oluk

H

hickory – hikori (američki orah)
hinge – zglob
hopper – ljevkasti koš (za beton)
hydrographic survey – hidrometrija

I

impede – smetati
incompressible fluid – nestlačiva tekućina
indentation hardness – otpornost na zarezivanje
indeterminate – neodređen
induction welding – indukcijsko zavarivanje
inherent –bitan, svojstven
intersection – presijecanje, presijecati

J

joint – spoj, spojnica

jet – mlaz

L

lap joint – preklopni spoj
land survey – zemljišno premjeravanje
lathing – oblaganje letvama, žbukanje
level – ravnati
low-type surface – površina koja podnosi vrlo lako ili lako opterećenje

M

macadam – makadam
malleability – kovkost
marble and tile work – keramičarski radovi
mechanical feeder – razastirač
miscellaneous – različit, raznolik

O

outlet – ispust
outley – izdatak, trošak
overhead weld – viseći var

P

pavement – kolovozni zastor, pločnik
pipeline – cjevovod
plane surveying – niža geodezija
plant – građevinska mehanizacija
plastering – žbukanje zidova
plug – klin, čep
propagate – raširiti se

R

rail car – vagonet
random – slučajan
rebound – odskočiti, odbiti se
reconnaissance – rekognosciranje, pripremno istraživanje

redundant – suvišan
refinement – pročišćavanje
render – vratiti
resilient- elastičan, gibak
resistence welding – elektro-otporno zavarivanje
retaining wall – potporni zid
reversal loading – povratno opterećenje
revolving-drum -type mixer (countercurrent mixer) – mješalica s bubnjem koji se okreće
rib shortening – ukrućenje rebara
right-of-way- dionica, trasa ceste
roadside – tlo uz cestu
roadway – kolovoz
rock asphalt – pirodni asfalt
route location – određivanje trase, trasiranje

S

scratch hardness – tvrdoća zaparivanja
screed – letvica za ravnanje
screeding - ravnanje
set accelerator – dodatak za ubrzano vezivanje
shear – posmik
sheet asphalt – pješčani asfalt s kontroliranim granulacijskim sastavom
sheet metal work – limarski radovi
shrubbery - grmlje
shoulder – bankina
sidewalk – bankina, pješačka staza
slip - klizanje
slope- nagib, kosina
slot - prorez
slump – slijeganje betona
spillway – preljev
sprayed concrete – ubrizgavajući beton (torkret beton)
stereo – trodimenzionalni
stiffness - krutost
storage vessel – posuda za skladištenje tekućine; storage reservoir – akumulac. bazen
strain energy – rad deformacije; strain – pomicanje,deformcaija
stratum - sloj
subgrade – posteljica
superintendent – nadzorni inženjer
surveying – geodezija, geodetsko premjeravanje terena;geodetic surveying – viša geodezija
swelling – bubrenje

T

tarmac – katranski makadam
tee joint – T-spoj
tender – ponuda, javno nadmetanje
thawing – otapanje, odmrzavanje
thermit welding – termitsko zavarivanje
traffic lane – saobraćajna traka
topographic survey – topografsko snimanje
toughness – žilavost, otpornost
traction – vuča
transmissibility - provodljivost
treatment plant – uređaj za pročišćavanje
tremie – lijevak,cijev za lijevanje betona pri podvodnom betoniranju
trigger force – pokretačka sila
troweling – obrada, glađenje zidarskom žlicom

U

ultimate strength – granična čvrstoća

V

vibrating roller – vibracioni valjak
void – šupljina, pora

W

water-bound macadam- vodom vezani makadam
water meter – vodomjer
wearing surface – gornji(habajući) sloj kolnika
weathering – trošenje, raspadanje
working load – dopušteni napon

Y

yielding point – granica istezanja

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