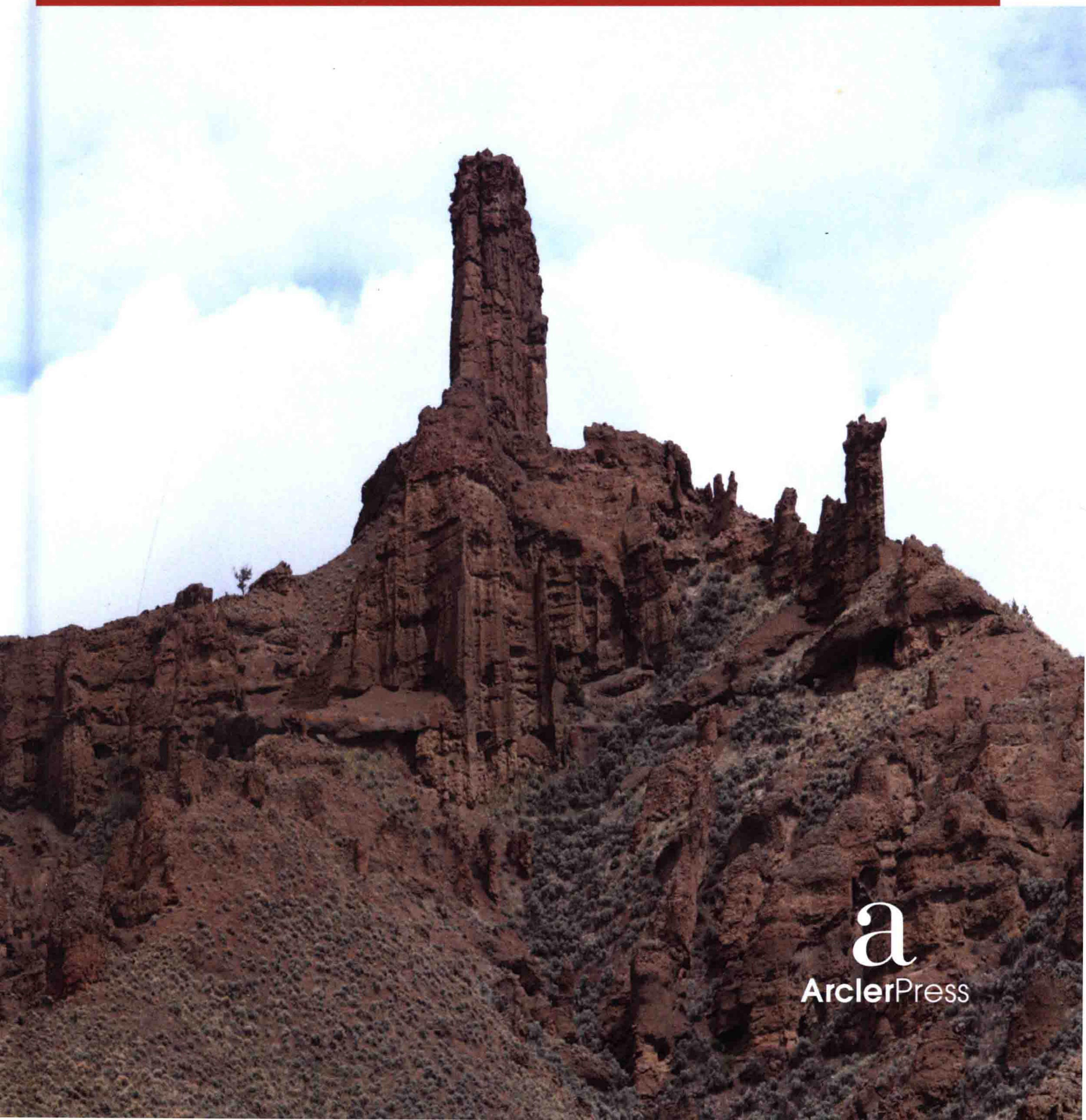
Geology for Civil Engineer

Dr. Tanjina Nur, Ph.D.



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Preface

This book describes the importance of geology in civil engineering briefly. Geology is the study of earth, the materials of which it is made, the structure of those materials and the effects of the natural forces acting upon them and is important to civil engineering because all work performed by civil engineers involves earth and its features. Geology also provides a systematic knowledge of construction material, its occurrence, composition, durability and other properties. The knowledge of the geological work of natural agencies such as water, wind, ice and earthquakes helps in planning and carrying out major civil engineering works. For example the knowledge of erosion, transportation and deposition helps greatly in solving the expensive problems of river control, coastal and harbour work and soil conservation. The first part of the book describes morphology, geology and water quality assessment of catchment and watershed infiltration and erosion parameters from field rainfall simulation analyses. Then we present runoff and soil erosion assessment on forest roads and solution of anti-Seepage for Mengxi River based on numerical simulation. After that, we try to find the optimization of urban highway bypass horizontal alignment using a methodological overview and multidisciplinary approach to a recovery plan of historical buildings using geological data.

In the middle part of the book, we focus on finding inverse parameter identification technique using geotechnical modelling and experimental study on conductivity anisotropy of limestone considering the bedding directional effect. Automatic and topologically consistent 3D regional geological modelling from boundaries and attitudes and dynamic characterization of cohesive material based on wave velocity measurements are also discussed. Then we present back-analyses of landfill instability induced by high Water level and correlation between earthquakes and AE monitoring of historical buildings in seismic areas.

At the end, we try to describe level and contamination assessment of soil along an expressway in an ecologically valuable area and multiple constraints based robust matching for monitoring a simulated landslide. Also subsidence detected by multi-pass differential SAR interferometry in Central Italy by joint effect of geological and anthropogenic factors and assessment of complex masonry structures with GPR compared to other non-destructive testing studies are also discussed. Then maximum-entropy method for evaluating the slope stability of earth dams and temporal and spatial pore water pressure distribution surrounding a vertical landfill are presented briefly.

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INTRODUCTION

Geology is the study of earth, the materials of which it is made, the structure of those materials and the effects of the natural forces acting upon them and is important to civil engineering because all work performed by civil engineers involves earth and its features.

Engineering geology is the application of the geological sciences to engineering study for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works are recognized and accounted for. Engineering geologists provide geological and geotechnical recommendations, analysis, and design associated with human development and various types of structures. The realm of the engineering geologist is essentially in the area of earth-structure interactions, or investigation of how the earth or earth processes impact human made structures and human activities.

Engineering geology studies may be performed during the planning, environmental impact analysis, civil or structural engineering design, value engineering and construction phases of public and private works projects, and during post-construction and forensic phases of projects. Works completed by engineering geologists include; geological hazard assessments, geotechnical, material properties, landslide and slope stability, erosion, flooding, dewatering, and seismic investigations, etc. Engineering geology studies are performed by a geologist or engineering geologist that is educated, trained and has obtained experience related to the recognition and interpretation of natural processes, the understanding of how these processes impact human made structures (and vice versa), and knowledge of methods by which to mitigate against hazards resulting from adverse natural or human made conditions.

Importance of geology in civil engineering

Geology is the study of earth, the materials of which it is made, the structure of those materials and the effects of the natural forces acting upon them and is important to civil engineering because all work performed by civil engineers involves earth and its features. Fundamental understanding of geology is so important that it is a requirement in university-level civil engineering programs.

Civil engineering is the branch of engineering that deals with the design, construction and maintenance of roads, bridges, large buildings, airports, ports, subways, dams, mines and other large-scale developments. It is one of the oldest branches of engineering. Many of the world's great monuments, including the pyramids, the structures of ancient Greece and Rome and the modern steel and glass skyscrapers found around the world, are the result of the successful marriage of civil engineering and geology.

For a civil engineering project to be successful, the engineers must understand the land upon which the project rests. Geologists study the land to determine whether it is stable enough to support the proposed project. They also study water patterns to determine if a particular site is prone to flooding. Some civil engineers use geologists to examine rocks for important metals, oil, natural gas and ground water.

What are the applications of geology to civil engineering?

The applications of geology to civil engineering include the identification and assessment of natural resources and potential geological hazards on prospective building sites. Factors such as the design, construction, location and maintenance need to be applied in civil engineering. Studies are commonly conducted during the planning of construction to analyze short and long term geological impact, according to Wikipedia. Factors such as flooding, erosion, slope stability and other hazards must be thoroughly analyzed.

This discipline is called geological engineering. According to the University of Waterloo, geological engineers also contribute valuable knowledge to historic site preservation and land use planning. According to the United States Bureau of Labor Statistics, civil engineers need a bachelor's degree, and one in five hold a graduate degree. Undergraduate degree programs include coursework in several subjects closely related to civil engineering, including engineering geology, environmental engineering and fluid dynamics.

The closest disciplinary relative of geological engineering is engineering geology. Although their names are almost identical, geological engineering and engineering geology are distinct subjects. Topics researched by geological engineers include soil mechanics, landslide mechanics and avalanches.

One of the disciplines most closely related to geological engineering is environmental engineering. The University of Notre Dame reveals that major issues addressed by environmental engineers include water resource development and protection, environmental remediation and the movement of industrial waste through water and sediment. Environmental engineers also study beneficial biofilm promotion and harmful biofilm containment.

Another discipline useful in civil engineering is environmental fluid dynamics, which is closely linked to environmental engineering. Environmental fluid dynamists examine the interaction of ocean currents, sediment movement, wave dynamics, hurricane behavior, tsunami generation and many other phenomena related to fluid movement.

Importance of Geology in Civil Engineering Projects

The value of geology in Mining has long been known but its use in Civil Engineering has been recognized only in comparatively recent years. The importance of geology in civil engineering may briefly be outlines as follows,

- Geology provides a systematic knowledge of construction material, its occurrence, composition, durability and other properties. Example of such construction materials is building stones, road metal, clay, limestone and laterite.
- The knowledge of the geological work of natural agencies such as water, wind, ice and earthquakes helps in planning and carrying out major civil engineering works. For example the knowledge of erosion, transportation and deposition helps greatly in solving the expensive problems of river control, coastal and harbor work and soil conservation.
- Ground water is the water which occurs in the subsurface rocks. The knowledge about its quantity and depth of occurrence is required in connection with water supply, irrigation, excavation and many other civil engineering works.

- The foundation problems of dams, bridges and buildings are directly concerned with the geology of the area where they are to be built. In these works drilling is commonly undertaken to explore the ground conditions. Geology helps greatly in interpreting the drilling data.
- In tunneling, constructing roads, canals, docks and in determining the stability of cuts and slopes, the knowledge about the nature and structure of rocks is very necessary.
- Before staring a major engineering project at a place, a detailed geological report which is accompanied by geological maps and sections, is prepared. Such a report helps in planning and constructing the projects.
- The stability of civil engineering structure is considerably increased if the geological feature like faults, joints, bedding planes, folding solution channels etc. in the rock beds are properly located and suitably treated.
- In the study of soil mechanics, it is necessary to know how the soil materials are formed in nature.
- The cost of engineering works will considerably reduce of the geological survey of the area concerned is done before hand.

Geological Engineer vs. Civil Engineer

Geological and civil engineers sometimes work together, but have very different responsibilities. While geological engineers study the earth's inner and outer surface to evaluate potential mining and infrastructure construction sites, civil engineers design the infrastructure to be built. Both of these engineering jobs require a bachelor's degree to work professionally in their disciplines.

Geological Engineers

Geological engineers can work in different disciplines. Some study mining sites to determine components of the earth and design the best extraction methods at the site. Others study the earth's components to analyze and report whether or not the site is safe to design different infrastructures. They report their findings to civil engineers and managers, then work with them throughout the infrastructure design process.

Civil Engineers

Civil engineers design and supervise the construction of different infrastructures, such as buildings, dams, highways, bridges and airports. After the infrastructure is designed, civil engineers supervise the construction from conception to completion. Civil engineers sometimes specialize in different types of infrastructure.

In many cases, geological and civil engineers work together to decide what materials to use and how to stabilize the structure. The process ensures the ground the infrastructure is built on can support it safely. After careful analysis of the geology of the location, geological engineers prepare reports and work with civil engineers to help select the best materials to use and suggest areas that require additional reinforcement.

Geotechnical Engineer

A geotechnical engineer uses his education and experience to guard and maintain the earth's physical environment in conjunction with the development of major public and private projects. His expertise in civil engineering construction and design enable him to safely investigate and analyze sites and determine their present and future stability. These projects normally involve major changes to the physical environment, and often include tunneling and the construction of major structures like buildings, bridges, dams, airport runways, and towers.

The success of a geotechnical engineer depends on his consistently accurate and reliable calculations and analytical skills. He utilizes specialized computer software to create two- and three-dimensional prototypes and to prepare complex mathematical evaluations and analyses of planned and existing structures. Creating and marketing project proposals and requests for geotechnical inquiries are also major job responsibilities of a geotechnical engineer.

The majority of a geotechnical engineer's job requires teamwork, as most projects also require the skills of geological engineers, hydrogeologists, and other earth science professionals. All these specialists contribute to gathering information to find solutions and address project challenges. This process often entails materials assessment, design research, and structural analysis to ensure the safest and most-cost effective choices are made.

Depending on the scope of the project, a geotechnical engineer may also be required to do field testing of erosion, settlement, and slope factors, and to analyze the results in a laboratory. Other daily activities regularly include the preparation of feasibility studies and the analysis of foundations and earth settlement patterns. Results and recommendations are made to clients based on these assessments. The geotechnical engineer is often required to meet with clients to evaluate their needs, address their concerns, and make recommendations on how their objectives can best be achieved within the project's budget and time constraints.

A geotechnical engineer must not only have a strong inquisitive nature, he must also be self-motivated to seek out creative solutions that simultaneously satisfy the client, regulatory agencies, and industry ethics. This requires him to keep current on emerging engineering methods and techniques and incorporate new technologies with established and proven processes. Good working relationships with environmental and engineering testing and consulting services provide the engineer with dependable and accurate resources.

In addition to having a bachelor's or master's degree in a science field such as engineering geology or civil, ground, or geotechnical engineering, many positions require accreditation from the Institution of Civil Engineers (ICE) or other engineering organizations. A background in client relations and project management is desirable. Basic computer skills and proficiency in written and oral communications are also advantageous.

Importance to a Civil Engineer

The earlier studies of Civil Engineering couldn't see the design of a structure should be preceded by a careful study of its environment, particularly foundations material on which the structure was to be placed. When the St. Francis Dam in Southern California failed in 1928 with a loss of many lives and damages in millions of dollars, the civil engineering profession awoke to the idea that the careful design of a structure itself is not all that is required for the safety of structures. After the failure of St. Francis Dam, the need of environment exploration with proper interpretation of the results was understood by all. Geology (in Greek, Geo means Earth, ology means study of or Science of) is a branch of science dealing with the study of the Earth. It is also known as earth science. The study of the earth comprises of the whole earth, its origin, structure, composition and history (including the development of life) and the nature of the processes.

Relevance of geology to civil engineering

Most civil engineering projects involve some excavation of soils and rocks, or involve loading the Earth by building on it. In some cases, the excavated rocks may be used as constructional material, and in others, rocks may form a major part of the finished product, such as a motorway cutting of the site or a reservoir. The feasibility, the planning and design, the construction and costing, and the safety of a project may depend critically on the geological conditions where the construction will take place. This is especially the case in extended 'greenfield' sites, where the area affected by the project stretches for kilometers, across comparatively undeveloped ground. Examples include the Channel Tunnel project and the construction of motorways. In a section of the M9 motorway linking Edinburgh and Stirling that crosses abandoned oil-shale workings, the realignment of the road, on the advice of government geologists, led to a substantial saving. In modest projects or in those involving the redevelopment of a limited site, the demands on the geological knowledge of the engineer or the need for geological advice will be less, but are never negligible. Site investigation by boring and by testing samples may be an adequate preliminary to construction in such cases. The long term economics depends on the engineering safety of the manmade constructions. Durability and maintenance free service of the dams, canals, structures like aqueduct etc. is only possible if engineering safety of them is assured. As every structure is related to rock beneath, proper geological investigations are of utmost importance.

Engineering geology importance

Engineering geology provides a systematic knowledge of construction material, its occurrence, composition, durability, and other properties. Examples of such construction materials are building-stones, road materials, clays, limestone, and laterite. The knowledge of the geological work of natural agencies such as water, wind, ice and earthquake helps in planning and carrying out major civil engineering works. For examples, the knowledge of erosion, transportation, and deposition helps greatly in solving the expensive problems of river control, coastal and harbor work and soil conservation. The knowledge about groundwater that occurs in the subsurface rocks and about its quantity and depth of occurrence is required in connection with water supply irrigation, excavation and may other civil engineering works. The foundation problems of dams, bridges, and buildings are directly concerned with the geology of the area where they are to be built. In these works, drilling is commonly undertaken to explore the ground conditions. Geology helps greatly in interpreting the drilling data. In tunneling, constructing roads, canals, and docks and in determining the stability of cuts and slopes, the knowledge about the nature and structure of rocks is very necessary.

Before starting a major engineering project at a place a detailed geological report, which is accompanied by geological maps and sections, is prepared. Such a report helps in planning and constructing the project. The stability of the civil engineering structures is considerably increased if the geological features like faults, joints, folding, and solution channels etc. in the rock beds are properly located and suitably treated. In the study of soil mechanics, it is necessary to know how the soil materials are formed in nature. For a major engineering project, precise geological survey is carried out and results thus obtained are used in solving engineering problems at hand. The cost of engineering works will considerably be reduced if the geological survey of the area concerned is done before hand.

Role of the engineer in the systematic exploration of a site

The investigation of the suitability and characteristics of sites as they affect the design and construction of civil engineering works and the security of neighbouring structures is laid out in British Standard Code of Practice for site investigations. The sections on geology and site exploration define the minimum that a professional engineer should know. The systematic exploration and investigation of a new site may involve five stages of procedure.

These stages are:

1. Preliminary investigation using published information and other existing data;

2. A detailed geological survey of the site, possibly with a photo-geology study;

3. Applied geophysical surveys to provide information about the subsurface geology;

4. Boring, drilling and excavation to provide confirmation of the previous results, and quantitative detail, at critical points on the site; and

5. Testing of soils and rocks to assess their suitability, particularly their mechanical properties (soil mechanics and rock mechanics), and either in situ or from samples

In a major engineering project, each of these stages might be carried out and reported on by a consultant specializing in geology, geophysics or engineering (with a detailed knowledge of soil or rock mechanics). However, even where the services of a specialist consultant are employed, an engineer will have overall supervision and responsibility for the project. The engineer must therefore have enough understanding of geology to know how and when to use the expert knowledge of consultants, and to be able to read their reports intelligently, judge their reliability, and appreciate how the conditions described might affect the project. In some cases the engineer can recognize common rock types and simple geological structures, and knows where he can obtain geological information for his preliminary investigation. When reading reports, or studying geological maps, he must have a complete understanding of the meaning of geological terms and be able to grasp geological concepts and arguments. For example, a site described in a geological report as being underlain by clastic sedimentary rocks might be considered by a civil engineer to consist entirely of sandstones. However, clastic sedimentary rocks include a variety of different rock types, such as conglomerates, sandstones and shales or mudstones. Indeed it would not be unusual to find that the site under development contained sequences of some of these different rock types—say, intercalated beds of sandstone and shale, or sandstone with conglomerate layers. Each of these rock types has different engineering properties, which could affect many aspects of the development work such as core drilling into, and excavation of, the rock mass, and deep piling into the underlying strata.