SIGNIFICANCE OF ENGINEERING GEOLOGY CURRICULUM IN CIVIL ENGINEERING EDUCATION

Abstract

With increasing number of infrastructure projects in India and indications that the next five decades will be punctuated with numerous such projects all across the country, there is an excellent scope for the role of engineering geology in nation development. Characterizing underlying characteristics and potentially dangerous natural processes is how engineering geologists help urban planners and civil engineers build and maintain infrastructure. Realizing the importance of engineering geology, geologists and civil engineers related to infrastructure planning and designing in different infrastructure projects. This paper addresses the need for improving the content of engineering geology for Civil Engineers in India. With advancement in tools and techniques, engineering geological methods now include digital characterization and modeling of the subsurface; new developments in site investigation; testing and performance monitoring. This has been addressed in our paper and suggestions have also been given.

Keywords: Geology, Engineering, Civil engineer, Modeling and Monitoring

Authors

G. M. Moorthy
Department of Geology
V.O.Chidambaram College
Thoothukudi
(Affiliated to Manonmaniam
Sundaranar University Tirunelveli)

C. T. Sivakumar
Department of Civil Engineering
Mahendra Engineering College
Mallasamudram

V. Stephen Pitchaimani
Department of Geology
V.O.Chidambaram College
Thoothukudi
(Affiliated to Manonmaniam
Sundaranar University Tirunelveli)

S. MuthuSamy
Department of Geology
V.O.Chidambaram College
Thoothukudi
(Affiliated to Manonmaniam
Sundaranar University Tirunelveli)

S. Richard Abishek
Department of Geology
V.O.Chidambaram College
Thoothukudi
(Affiliated to Manonmaniam
Sundaranar University Tirunelveli)

I. INTRODUCTION

Geology is a field of science that deals with the study of the Earth (in Greek, Geo means Earth and Logos means Science). Earth science is another name for it. The entire world, its origin, structure, composition, history (including the evolution of life), and the kinds of processes it undergoes are all covered by the study of the earth. The term was originally used in 1778 in the writings of S.B. Saucer, a Swiss chemist, and Jean Andrea de Luc, a scientist of Swiss descent who spent much of his life at Windsor serving as Queen Charlotte's advisor. Geology is an interesting topic. The heartbeat of the earth can be felt through geology. Geologists contribute to the nation by discovering new resources of economically valuable rocks and minerals. A student should be knowledgeable of what is beneath the crust and how long ago the world first formed.

Application of the geologic sciences to engineering practice is known as engineering geology, and it serves to ensure that the geologic elements impacting the location, design, building, operation, and maintenance of engineering works are acknowledged and effectively taken into account. Engineer geologists do research and offer recommendations, analyses, and designs related to human development in the geology and geotechnical fields. The focus of an engineering geologist's work is mostly on the interactions between the earth and its structures or on the analysis of how the earth's processes affect both built structures and human activities.

In addition to the planning, environmental impact analysis, civil or structural engineering design, value engineering, and construction phases of public and private works projects, engineering geology studies may also be carried out during the post-construction and forensic phases of projects. Engineering geologists have worked on projects involving seismic investigations, landslide and slope stability, erosion, flooding, and geotechnical and material properties issues. An engineering geologist is a geologist who has received training, education, and experience in the recognition and interpretation of natural processes, in understanding how these processes affect man-made structures (and vice versa), and in knowing how to mitigate for hazards coming from unfavorable natural or man-made conditions. The protection of people and property from harm brought on by geological conditions is the primary goal of the engineering geologist.

Geological engineering, geotechnical engineering, soil engineering, environmental geology, and economic geology are all practices that are closely related to engineering geology. The practitioner's education or experience is primarily to blame if there are differences in the descriptions of the disciplines' content.

II. CIVIL ENGINEERING

Civil engineering is a professional engineering subject concerned with the design, construction, and maintenance of the physical and naturally built environment, including works such as roads, bridges, canals, dams, and buildings. After military engineering, civil engineering is the oldest engineering discipline, and it was created to distinguish between non-military engineering and military engineering. It is usually divided into a number of sub-disciplines, including environmental engineering, geotechnical engineering, structural engineering, transportation engineering, municipal or urban engineering, water resources engineering, materials engineering, coastal engineering surveying, and construction engineering. There are many different levels of civil engineering, including municipal, national, and international governments, as well as individuals and small and large businesses. The division of civil engineering that deals with the engineering behaviour of ground materials is called geotechnical engineering. Geotechnical engineering is significant in civil engineering, but it is also employed in other engineering fields that are concerned with building in relation to the surface and subsurface ground conditions, such as military, mining, and petroleum. Geotechnical engineering investigates subsurface conditions and materials using the principles of soil mechanics and rock mechanics. It also determines the pertinent physical, mechanical, and chemical properties of these materials, assesses the stability of naturally occurring slopes and man-made soil deposits, determines risks associated with the site, designs earthworks, and builds foundations.

An analysis of the project requirements is the first step in a typical geotechnical engineering project in order to identify the necessary material attributes. The next step is a site assessment to ascertain the engineering characteristics of the proposed development, including how it will interact with the soil, rock, fault distribution, and bedrock qualities of the area of interest. The region where the engineering structure will be located needs to be thoroughly investigated on the site. Assessment of the risk posed by natural disasters like earthquakes, landslides, sinkholes, soil liquefaction, debris flows, and rock falls to people, property, and the environment can be a part of investigations.

Structural engineering is involved with the structural design and analysis of buildings, bridges, towers, flyovers, tunnels, offshore constructions like oil and gas fields in the sea, as well as other structures. In order to adequately support and resist those loads, a structure must first be designed. This involves determining the loads that act upon it as well as the forces and stresses that result from those loads inside the structure. The following loads can be considered while constructing the structure: the structure's own weight as well as other dead loads, live loads, moving (wheel) loads, wind loads, earthquake loads, load from temperature change, etc. Structures must be safe for users and effectively perform the purpose for which they were created, according to structural engineering principles (to be serviceable). Due to the nature of the loading circumstances, structural engineering has developed several sub-disciplines, such as wind engineering and earthquake engineering.

The structure's strength, stiffness, and stability will be taken into account during design when it is exposed to loads that could be static, like furniture or one's own weight, dynamic, like wind, seismic activity, crowds of people, or vehicle loads, or transitory, like impacts or temporary construction loads. Cost, constructability, safety, beauty, and sustainability are a few other factors to take into account.

The goal of earthquake engineering is to reduce the seismic risk to levels that are both socially and economically feasible while yet safeguarding society, the natural environment, and the built environment from earthquakes. It has traditionally been regarded as a subset of both structural and geotechnical engineering since it has been narrowly defined as the study of the behavior of structures and geo-structures subject to loading. A greater range of civil engineering specialties as well as social science fields, particularly sociology, political science, economics, and finance, have been added as a result of the enormous costs associated with recent earthquakes. The primary goals of earthquake engineering are:

Anticipate the probable effects of large earthquakes on metropolitan areas and civil infrastructure. Structures should be planned, built, and maintained so that they meet expectations and adhere to building requirements when exposed to earthquakes. A professionally engineered structure does not necessarily need to be very sturdy or expensive. It must be adequately built to withstand the seismic effects with a minimal amount of damage.

Understanding how the earth behaves is essential to civil engineering design because it guides how structures that are built on the ground are designed. It is necessary to anticipate, plan for, and design for challenges that earth materials may provide. Demands for complicated civil engineering projects to be completed in extremely short time frames are a current trend. These projects frequently include time-consuming and challenging planning consultations. The pressure to operate at a very quick, albeit unpredictable, pace that is set by others increases as a result, placing additional strain on all the experts engaged. This is particularly true for the gathering and application of ground-related data needed for project design and construction phases. Numerous environmental, technical, economical, and other external factors can result in significant modifications in scope and detail.

The management of projects that must be completed properly, on schedule, and within budget heavily relies on engineering geologists. In addition to elements that may have an impact on engineering geologists' professional development in the next years, this paper addresses important areas where they can have a substantial impact on a project's outcome.

Geological knowledge is applicable in

1. Soil condition evaluation in foundation engineering
2. Infrastructure engineering - placement of bridges, tunnels, and river meandering zones; quality of stones, lime, cement, etc.;
3. Disaster prevention measures include flood control, river bank management, and canal bridge design.
4. Soil erosion prevention and natural drainage are aspects of land-use engineering.
5. Water Resources Engineering - hydrogeology (reservoir capacity, for example), aquifer and water source and quality, reservoir and navigation channel desilting
6. Environmental engineering - ecological balance, landfill-based solid waste management

Geology plays a very important role in the field of civil engineering. Some applications of the knowledge of geology are given below.

1. It teaches about the materials used in construction.
2. The work it does to control rivers and move goods benefits from its knowledge.
3. Its understanding is useful for building dams.
4. Geotechnical engineers must be familiar with this subject in order to do digging work.
5. For developing a foundation and identifying flaws, it is necessary to have this understanding.
6. For the planning of roads and highways.
7. When constructing tunnels.
8. Before beginning any project, preliminary soil tests must be conducted.
9. Modern, affordable design.
10. Understanding of the types of soil materials that are accessible and how to use them.

III. FEASIBILITY STUDY

At the feasibility study stage of a project, numerous stakeholders (e.g., consultants, contractors, etc.) are interested, but their information is limited, particularly about site geology, etc. The engineering geologist's contribution to the project at this nascent stage would be to provide preliminary data on regional and site geology based primarily on collection and collation of already-existing published or unpublished literature and maps. For instance, published geological maps on a scale of 1:63,360 or 1:25,000 by the Geological Survey Department, along with their memoirs or internal files, would be the first indication of what rock formations the proposed highway would cross, as well as foundation rocks at a construction site, structural disposals, seismic activity, etc.

IV. SITE INVESTIGATION

The main role of the engineering geologist in civil works is in the site investigation stage. It is the responsibility of the engineering geologist to provide, as complete as possible, the *Site Characteristics*. Site characterization would encompass a broad spectrum of topics such as detailed site geology (surface and subsurface), physical, chemical and mineralogical properties of soils and rocks at the site, groundwater characteristics, etc. While the traditional surface geological mapping has its definite place in the site investigations stage, much more subsurface data need to be acquired from boreholes or drilling planned and executed in association with the geotechnical engineer. The accompanying soil/rock samples, properly logged and tested in the laboratory, coupled with various field tests (such as the Standard Penetration Test, borehole permeability test, etc.), would provide additional information on site characteristics from which a 3-dimensional picture of the site can be constructed. In addition, borehole and laboratory test data provide some degree of quantification of information essential for engineering works.

Site visits and site surveys conducted by the engineering geologist accompanied by the geotechnical design engineer would be most beneficial to both parties as the geologist can highlight potential geology-related problems to the engineer, while the engineer can bring to the geologist's attention for the critical zones (e.g. high-rise versus playground) where more detailed study is required.

In the planning of boreholes or a site investigation program, it is the engineer who decides on locations and concentrations of boreholes in relation to his proposed civil works, and the geologist uses these borehole data for interpreting subsurface geology. However, additional boreholes can be requested to aid geological interpretations, such as in the case of limestone bedrock with its associated complex karst topographic features.

V. DESIGN

Though processes vary by country, the design phase, which includes various design calculations, is solely the domain of the geotechnical engineer in Malaysia. The geologist and the engineer may have worked together to examine the design parameters gleaned from the site study step, but it is the engineer's decision which design factors to enter into the calculations. It is helpful for the engineering geologist to understand what design parameters the engineer is searching for so that he may be of more assistance with the site investigation job. Obtaining design parameters (for example, strength parameters) is one of the objectives of the site investigation phase. The engineering geologist must comprehend some of the engineering-related challenges associated with the proposed project in order to meet the needs or requirements of the engineering project, or at the very least be aware of them. Therefore, challenges (and consequently requirements) associated with a tunnelling project would be different from those associated with a dam foundation or a highway cut-slope, etc.

VI. CONSTRUCTION

The construction stage is perhaps the most interesting stage of the project, since various activities are on-going (and many things can happen!), such as massive excavation works, etc. It is at this stage that new exposures are made available, and it is ideal for the engineering geologist to check and confirm (or otherwise) his "predicted/interpolated/extrapolated" geology or soil profiles. Moreover, various minor or major geological features such as dikes, faults, buried channels, etc. may be exposed for the first time since they may have been missed by boreholes. In any case, a revision or update of the detailed site geology is possible at the construction stage. The involvement or input by an engineering geologist would thus be most useful at the construction stage. Variations from anticipated or predicted ground conditions can be highlighted, new geological features noted, and to use the words of Rawlings(1972), *ominous geological symptoms* brought to the attention of the engineer for appropriate action. The author's experience shows that because of the considerable time delay (several years sometimes) between site investigation and construction, the geologist's input or involvement is heavy during the site investigation stage, but is then "phased out" or "omitted/forgotten?" come construction time since "ALL" the geological information is already available in the S.I. Report/Engineering Geological Report! Occasionally, the geologist gets called in when something happens (eg. collapse) to provide input on geology-related factors.

VII. POST-CONSTRUCTION

Post-construction performance monitoring forms part of civil engineering works, and is very much the domain of the engineer. In cases of post-failure (whether during or after construction) investigations, such as ground subsidence, landslides/slope failures, etc., geological input is again required to provide an idea of the material involved, possible mechanisms and causes of failure, etc. (again confining to geology-related factors only!) Post-failure investigations will invariably lead to remedial and other engineering works outside the scope of works of the geologist.

VIII. CONSTRUCTION MATERIALS

The engineering geologist makes an essential contribution to civil works by searching for construction materials such as rock aggregates (quarry site study), soil fill materials (borrow pits), sands, and so on. The ideal way to carry out the detailed quantification or evaluation of quantities would therefore be in close collaboration with the material engineer, which would require boreholes, etc.

The purpose of this short note is to provide a basic overview of the engineering geologist's involvement in civil engineering projects at various phases.

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