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GEOLOGICAL ENGINEERING IN CIVIL AND ENVIRONMENTAL ENGINEERING CURRICULA AT UNDERGRADUATE LEVEL IN NIGERIAN UNIVERSITIES: THE WAY FORWARD.

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ABSTRACT

This paper gives a vivid description of Geological Engineering in the context of engineering education (civil and environmental) and in relation to the Nigerian situation in particular.

Programme objectives for its introduction into engineering education curricula in the country are advanced. A detailed syllabus/content of Geological Engineering courses at undergraduate level is equally presented. It considers the dire need for its inclusion in the civil /environmental curricula in order to fill in the existing gap in the application of geological principles to the design of engineering problems. Such inclusion is opined to enhance up to date technological options of geological engineering education and training.

Finally, the paper attempts a definition of roles and responsibilities for members of proposed Board of Geological Engineering and emphasizes the importance of integrating Geological Engineering in other related engineering disciplines.

Key Words: *Geological engineering, engineering, education, curricula, training.*

BACKGROUND

Geological engineering is a study of the origins and properties of earth materials. It is the combination of geology and engineering with emphasis on the conceptual geological and geotechnical processes in relation to civil engineering structures. The main core of the programme is the understanding of the hydro-mechanical relations that govern the interaction between the materials in the sub-surface and civil engineering structures in or on the sub-surface.

Students of Geological engineering are expected to learn about the dynamic relationships existing between the earth's processes and engineering projects. The ability to predict the behaviour of earth's materials is very useful in the design of structures; of mineral extraction

processes in mining and petroleum engineering, in groundwater sources exploration and protection; in planning land design transportation routes and several others.

Currently there is no undergraduate or graduate programmes in geological engineering in Nigerian universities. However, in Obafemi Awolowo University, for instance, a Master of Science degree in Applied Geology with option in Engineering geology/ Hydrogeology is available. This graduate program is faculty of science based. The Civil Engineering Department of University of Lagos is noted to have offered a Master's degree in Geotechnics and Foundation engineering until recently.

In most cases, engineering geology is only taught as complimentary course in the B.Sc Civil Engineering programme. The course content in most cases is very scanty and inadequate for in-depth understanding of geological processes as relate to engineering. For instance, the University of Lagos teaches engineering geology as a 2-unit course at 300 level as the only compulsory course in a five-year programme. The situation is not different in other universities. The available electives do not address such core or basic and fundamental principles of geology. An existence of a serious gap in the interrelationship between the core knowledge base in conventional geology; geological engineering (engineering geology) and civil engineering has been noted. Most programmes where they exist either as applied geology or as geotechnics lacked the necessary core courses in geological engineering.

After more than a decade involvement in the teaching of engineering geology in the civil engineering department at both undergraduate and graduate levels, a serious gap in the application of geological principles to the design of engineering problems had been noted.

This gap, in geological knowledge base has led, in part, to serious failure in engineering projects, which hitherto could have been averted, if proper understanding of the hydro-mechanical relation that governs the interaction between the sub-surface earth's materials and engineering structures is well understood.

The paper highlights the importance of geological engineering as a professional course and calls for its introduction/integration into Civil and Environmental Engineering curricula in our universities.

NEED FOR GEOLOGICAL ENGINEERING EDUCATION

From the foregoing, the importance and the very role of geological engineering to civil engineering projects cannot be over-emphasized.

The programme should be knowledge and skill based, broad and varied to afford the students the opportunity to join the work force or pursue graduate education while establishing the foundation for life-long learning. Hence the prospective graduates of the programme should demonstrate the following post-qualification capabilities: -

- Apply a broad range of geological engineering skills and techniques in an integrated fashion to solve real-world engineering problems involving earth materials and earth processes;
- Obtain meaningful employment or continue their education at the graduate level; and
- Prepare for a long-term successful career augmented with life-long learning experiences.

In addition, graduates must in accordance with the programme curriculum, have demonstrated competence in the following: -

- The ability to apply mathematics through differential equations, calculus-based physics, general chemistry, and probability and statistics through applications to geological engineering principles;
- Proficiency in the engineering sciences including statics, properties/strength of materials, and geomechanics;
- Proficiency in geological sciences that emphasize understanding of geologic principles and processes, such as identification of minerals and rocks, elements of geophysics, field geology, and the ability to visualize and solve geological problems of three-dimensional nature; and
- The ability to apply the principles of geology to design solutions to geological engineering problems, which include one or more of the following considerations: the physical properties of the materials of the earth's crust including hydrogeology; the effects of the processes that form the earth's crust; and the impacts of construction projects, exploration for and exploitation of resources, disposal of wastes, and other activities of society on these materials and processes, as appropriate to the program objectives.

The Faculty

From the above stated objectives, it is obvious that, Geological Engineering should be an interdisciplinary programme involving the Faculties of Engineering and Science, and in particular, the Departments of Geology (Earth sciences) and Civil Engineering. It is equally being suggested that a Geological Engineering Board, which must consist of faculty from both departments, administer the programme.

The faculty must show evidence of understanding professional practice and maintain currency in their respective professional areas. The programme faculty must have the responsibility and sufficient authority to define, revise, implement, and achieve programme objectives in accordance to National universities Commission guidelines.

Faculty Options

The faculty options could be spread as much as possible to afford students the choice of specific interest even though the available options must be based on availability of faculty members. The following probable options of interest:-

Geological Engineering with Geomechanics

This option is concerned with the mechanical behavior of soils and rocks, and construction on, in, or with these materials. It involves the study of rock mechanics in mining, civil and petroleum applications; geotechnical aspects of tailings dams, dikes, hydro-electric dams, and impoundments; landfill and waste repository design; foundation exploration and design for bridges, buildings and large dams; geotechnical and shallow geophysical site investigation; aggregate resource exploration and development; slope stability in mines and along transportation routes; and, design and construction of tunnels, shafts, trenches, and other underground structures.

Geological Engineering with Hydrogeology

This option is related to water supply and quality, fluid flow through soil and rocks, and environmental protection and monitoring related to these areas. It involves groundwater exploration, supply and recharge; surface and subsurface hydrology of lakes and river systems; flow of multiphase fluids (oil, water, gas) in shallow aquifers or deep sedimentary basins (petroleum development); landfill integrity and interaction with rainfall and groundwater; well testing in hydrogeology and petroleum production; and, geochemistry of groundwater, treated effluents, tailings pond seepage waters, waste site leachates, and deep basin fluids.

The option could be expanded to include studies on a broader range of topics in water resource management in order to provide a combined emphasis on surface water and groundwater resources in both technical and social issues.

Geological Engineering with Environmental Engineering

Even though several of the core courses and available electives in the program are expected to be environmental focus, this option should include additional courses in environmental aspects. The option is to emphasize the application of geological engineering to specific environmental problems.

It should be clarified that the above is not a call for an early specialization in the programme. However, it is encouraged that the programme curriculum gives a broad opportunity to students to take courses in many basic and classical areas of geological engineering as possible. Specialization is only recommended at the Masters' level after the undergraduate degree programme has been tested and validated.

EDUCATION AND TRAINING

The basic earth science (Geology, Applied Geophysics) degree requirement is a four-year university degree in Science (B.Sc.) in Nigerian universities. There exist only 18 university departments of geology or earth sciences, 8 of geophysics and applied geophysics, 3 of applied geology and 1 of geology and mining, in all the 44 federal, state and private universities.

The B.Sc in Civil Engineering/Environmental Engineering, in the contrary is a five-year programme. Equally, there are currently 22 university departments of civil engineering, 2 of mining engineering, 1 of water resources / environmental engineering and 1 of civil engineering with hydrology in all the 44 federal, state and private universities. (JAMB, 2001).

The present undergraduate curricula in civil engineering degree programme in Nigerian universities are designed to provide a broad background and to produce graduates that are well qualified to operate in a developing economy; initiate and carry out engineering designs, engage in industrial management; develop the public services; and pursue development and research. Students are being prepared for a life long professional life.

The Bachelor of Science degree in geological engineering programme too must have as focus applications of the principles of geology to design solutions to geological engineering problems.

A student contemplating a career in the geological engineering would be required to have a strong high school background and special interest in the basic sciences and mathematics, an enquiring and open mind, ability to grasp fundamental scientific principles

quickly and easily and to discuss ideas clearly. Basic principles of physics, chemistry, mathematics and biology, and use of deductive reasoning to solve complex scientific problems are essential ingredients. Many of these require a clear understanding of spatial relationships in three or four dimensions

Admission Requirements

The entry point into the geological engineering undergraduate degree programme should be similar to existing admission requirements in Civil Engineering into Nigerian universities. That is, the Senior Secondary Certificate (SSC) or its equivalent with credit passes in five subjects including English language, Physics, Chemistry and Mathematics.

GRADUATION REQUIREMENTS.

In order to be eligible for a degree, a student shall be required to pass a minimum number of 194 units in a five-year programme. In addition to this minimum requirement, 12 to 15 units of university compulsory courses in humanities and social sciences are recommended.

Field Work/ Industrial Experience

Fieldwork shall be a necessary part of geological engineering training, and field trips and field projects should be offered in each year of study. The fieldwork shall require students to use geological field methods to carrying out site investigations related to a specific geological engineering problem. Students shall be expected to undergo a mandatory specialized instruction in field safety. In addition to the geological engineering field school, students are expected to undergo compulsory Industrial Experience of not less than 26 weeks during the second semester of Year IV and the long vacation period

Academic Program

A generalized five-year programme for Bachelor of Science in Geological Engineering is thus presented: -

100 LEVEL

First Semester	Courses	Units
	Chemistry for Engineers I&II	7
	Engineering Mathematics I (Linear Algebra)	3, 1=4
	Engineering Mathematics II (Calculus)	3
Second Semester		
	Digital Computation	2
	Electrical Engineering	4
	Geological Engineering Concepts	3
	Engineering Mathematics ll (Calculus)	3
	Physics for Engineers l&ll	6
	Humanities/Social Sciences	8

200 LEVEL		
First Semester	Courses	Units
	Introductory Structural Geology	3
	Statics and Mechanics	3, 1=4
	Advanced Eng. Maths(Calculus)	3
	Probability and Statistics	3
	Mechanics of Materials	3
	Humanities/Social Sciences	4
	Geological Eng. Report	2
Second Semester		
	Mineralogy 1	3
	Stratigraphy and Earth History	3
	Applied Geophysics I	3
	Fluid Mechanics	3
	Differential Equations	2
	Seminar	1
	Geological Eng. Report	2

300 LEVEL		
First Semester	Courses	Units
	Geotechnical Engineering 1	3
	Lab Analysis and Field Sampling	4
	Geochemistry	3
	Petrography	3
	Seminar	1
	Soil Mechanics	3
	Geological Eng. Report	2
Second Semester		
	Introductory Sedimentology	3
	Geological Mapping	3
	Engineering Geology I	2
	Hydraulics	3
	Geotechnical Engineering II	3
	Water Supply Engineering	2
	Structural Geology	3

400 LEVEL		
First Semester	Courses	Units
	Geological Engineering Design I	4
	Engineering Geology II	3
	Foundation Engineering I	3
	Subsurface Methods	3
	Environmental Engineering II	2, 1
	Rock Mechanics	3
	Numerical Methods	2
Second Semester	Industrial Experience	12

500 LEVEL		
First Semester	Courses	Units
	Applied Geophysics II	3
	Engineering for Solid Waste Management	3
	Design of Water System	2
	Environmental Engineering III (Wastewater Treatment)	2, 1
	Rock Mechanics II	3
	Civil Engineering Practice	2
	Engineering Designs	3
	Final Year Project	3
Second Semester		
	Geological Engineering Design II	3
	Geotechnical Engineering III	3
	Foundation Engineering II	3
	Engineering Law	3
	Pavement Structural Design	2, 1
	Finite Element Analysis	3
	Environmental Laws/Regulations	2
	Project	3

Electives (6units)
Fundamentals of Petroleum Production
Design of Urban Water System
Urban Hydrology
Applied Geomorphology
Flow Through Porous Media
Applied Sedimentology
Groundwater Modelling
Applied Geophysics 3
Contaminant Transport
Quaternary Geology
Earth and Mineral Resources
Advanced Structural Geology

PROFESSIONAL PRACTICE

Academic and professional recognition is the very ultimate of any new programme to enable professional practice after training. The existing criteria and standards for accreditation of engineering profession by the Council for the Regulation of Engineering in Nigeria (COREN) could be applied while the experiences so far acquired over the years by COREN shall be of immense help in this direction. A new accreditation Board could be fashioned out within COREN to take care of Geological Engineering practice. However, the accreditation and regulation should be in conjunction with the Nigerian Mining and Geosciences Society.

Career

The demand for the expertise to be offered by Geological Engineers shall cover such resource-development areas that play major roles in the national economy. Employment opportunities could be varied or specific. Career opportunities could be sought in the

following areas: Civil Engineering Firms; Environmental Consulting Firms; Geotechnical and Soil Engineering Firms and Government Agencies.

CONCLUSION

The introduction of geological engineering will require redevelopment of the existing curricula of classic civil engineering programme. The Bachelor's degree study level in Geological engineering should not be seen as encroaching into engineering but an integration that is very necessary for the advancement of civil engineering education and practice.

The integration process of Geological Engineering into Civil Engineering should be gradual and should not be towards a kind of unification. It is believed that such a process shall enhance and promote diversification of specialties i.e. Environmental Engineering, Civil Engineering or Geological Engineering.

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