EARTHQUAKE SITE RESPONSE STUDY OF ACCRA AREA, GHANA

ETUDE DU COMPORTEMENT DE LA ZONE D’ACCRA (GHANA) EN CAS DE TREMBLEMENT DE TERRE

J.K. AYETEY* and M.B. ANDOH**

Summary

There is no study which relates the geology and engineering soils characteristics with the earthquake damage potential of Accra area. This work studies these factors and attempts an engineering soils map which then serves as the base for seismic risk map showing damage degree zones of the Accra area. The maps could serve as a basis for land-use planning and give engineers a good idea about what to expect at a project site prior to site investigation. Information is obtained on the basis of which together with actual site investigation work should lead to design and construction of structures for appropriate areas to help lessen the earthquake-related loss of life and damage to property in an earthquake.

Résumé

Aucune étude n’avait été réalisée sur les relations entre la géologie et les caractéristiques géotechniques des sols et les dommages potentiels en cas de tremblement de terre dans la zone d’Accra. Le présent travail étudie ces facteurs et présente un essai de carte géotechnique du site qui sert ensuite de base à une carte des risques sismiques de la région d’Accra. Ces cartes peuvent servir de support pour la planification de l’occupation des sols et aussi donner aux ingénieurs les éléments nécessaires lors de la réalisation de projets divers. Ces informations et les études de terrain détaillées réalisées à l’occasion de chaque projet devraient permettre une meilleure conception et une construction de structures susceptibles de réduire les dommages subis en cas de tremblement de terre.

Introduction

Accra, the capital of Ghana lies within a seismic zone with known isoseismals of between nine and seven (Mercalli Scale). The central part is fairly intensely faulted. The line of boundary between the West African Craton and the Pan African mobile belt lies very close to Accra (Liegiois et al., 1963).

It had been suggested by geologists that Accra, the capital of Ghana, should not have been sited where it is. There is an extensive infrastructural and building development and a lot of these have been located with little or no proper consideration of the earthquake site response of the areas being developed. Many development projects have therefore been sited at high risk earthquake areas where these structures will be susceptible to unacceptable damage in the event of major earthquake. Though the structures which have already been constructed may be retained with all attendant risks, it is important that new developments be located at the appropriate areas and the structures themselves properly designed according to the anticipated site response.

This work studies the physical, mechanical and engineering properties of soils and rocks of the Accra area, and together with groundwater and other insitu features of the profiles, computes seismic increments and with the available isoseismals delineates the various degrees of earthquake intensity.

It is hoped that if property developers would examine the earthquake risk characteristics before designing, construction of all important structures as well as a good number of minor residential structures, will not only be saved from unacceptable levels of structural damage but earthquake-related loss of life and damage to property would be greatly lessened.

Topography and Geology

Accra is situated in an area generally low-lying and slightly undulating in places. It is bounded by distinct high ranges on the west, trending northeast — southwest known as the Akwapim ranges. Towards the east it is predominantly undulating, grading into the Accra plains. Part of the Akwapim hills form three small
distinct ridges in the north-east before terminating in the Accra plains. A general idea of the topography is given by the sections A-A, B-B and C-C in Fig. 1.

Geologically, Accra is underlain generally by the Dahomeyan series which are metamorphosed Precambrian sediments now predominantly gneisses, generally hard, foliated and folded. The Togo series, also Precambrian but younger than the Dahomeyan, are generally hard quartzites or recrystallized sandstones with interbedded quartz and micaschists folded with fold axis trending generally northeast — southwest and faulted. Crow (1956) suggests a thrust fault for the contact between the Dahomeyan and Togo series which has caused sliding of the Togo over the older Dahomeyan. The centre of Accra lies on the Devonian shales and interbedded sandstones with the sandstones becoming massive at the base. Those sediments, whose beds are slightly folded and dip generally towards the south at angles between 5° and 25°, are considerably faulted with a rather complex structure. The geology of Accra area is shown in Fig. 2.

The lagoon areas are covered with deposits of unconsolidated lagoon and marine clays and sands. Residual soils on land are made up of patches of lateritic soils on higher areas with sands and clays in the low areas depending mainly on whether the bed-rocks are sandstones and quartzites or shales. The Dahomeyan gneisses although predominantly produce residual clays are also known to produce sands and sandy clays in places.

**Engineering soils distribution and bedrock topography**

The area soils map is shown in Fig. 3. The map was compiled from boreholes drilled in the Accra area during site investigations and traverses run in the area. The controlling factors for the type and distribution of the soils have been bedrock, topography and drainage. Ayetey (1985) gives a schematic sequence of laterization and mass weathering over phyllite. This sequence is identical to what obtains in the study area but the bedrock here is different.

In the central part of Accra where the topography is low and flat, the soils are predominantly clays and sands. Because of the interbedded nature of the sandstones, the occurrence of sands or clays in the residual soils could be quite unpredictable and could also lead to fairly complicating profiles with very variable bedrock topography. Fig. 4 shows a line profile at west central Accra.

Although the geology and structure of the rock formations are relatively simple, the residual soils formed from the rocks have rather complex areal distribution due mainly to petrography and drainage. The variation with depth is generally more difficult to predict in the sandstone areas as well as in some shale areas. This is due to interbedding of sandstone and shale of the Accraian Formation which gives rise to sands, clays, and sandy clays. The Togo series generally form sandy soils, with only the schist zones, which are minor in the area, forming clayey to silty sands. Highly quartzitic gravelly laterites are formed generally above 30 m contour on the Togo Quartzites.

The Dahomeyan gneisses weather into heavy clays in areas where drainage conditions are poor, through sandy clays with improved drainage, to earthy and gravelly laterite over areas about the 30 m contour. The authors find it convenient to deal with the soils under heading which have direct relevance to the soils and their parent material, as follows:

1. **Dahomeyan Gneisses Soils**: Heavy clays and silty-sandy clays in valleys and river courses. In higher ground the clays become lateritic with development of gravel according to point in profile.
2. **Togo Series Soils**: Fine to coarse sands in low lying areas grading through gravelly laterites to highly quartzitic cobbly to gravelly laterites on high ground. Saprolitic horizon is very thin.
3. **Sandstone Series Soils**: Fine to coarse sands in low lying areas, turning silty to clayey where shales are interbedded. On higher ground where drainage is good, sandy to gravelly lateritic soils are prevalent.

![Fig. 1: Topographical sections in Accra.](image-url)