Geotechnical Mapping, Aid to Environmental Control

Des Cartes Géotechniques pour l'Environnement

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SYNOPSIS Geotechnical Maps are considered to be a vital tool for assisting the multi-disciplinary teams which co-operate in planning a reduction of the impact on the environment of the many projects necessitated by expanding populations and their needs for a better way of life.

INTRODUCTION

A literature search and personal experience will show that the Geotechnical Engineer plays an important role in the necessary multi-disciplinary team which is now common practice in man's shaping of his environment and in dealing with the problems posed. These problems can be broadly classified into the two categories of solving existing problems, such as those problems associated with waste products, and the use of techniques to define, avoid or minimise problems that can occur as a result of man's planned impact on his environment.

The literature search and in particular the Proceedings of the Speciality Session on Geotechniques and the Environment at the 9th I.C.S.M.F.E. in Tokyo in 1977 will show that the bulk of the written papers deal with the solution of existing problems. A reason can be found for this in that there is a great tendency for the environmental lobby to blame the engineering professions for our current woes while calling on these same professions to find the cures to these same problems. This has probably resulted in much of the geotechnical input being devoted to the solution of these problems with a fair degree of success.

It should not be forgotten, however, that man's impact on the environment can occur in many ways other than the effect of waste products. The second category referred to above can be sub-divided into two sub-categories of those activities which cover or destroy any portion of the earth's surface as for example highway networks, housing developments and strip mining and those activities which have an effect on the natural sub-surface regime such as lowering of the water table. Highways, dams, major factories spewing out waste products and similar spectacular projects naturally catch the eye and hence the attention of the environmental lobby. Yet man's impact on the environment in his requirement for living space engendered by the drift to the cities and the population explosion has, in total, had a far greater impact on our environment without attracting the attention of this lobby, which has concentrated its attention on the necessary adjuncts of water, power and transportation required to service the living environment.

Of the many ways in which Geotechniques can assist in providing answers, it is considered that the production of Geotechnical Maps can be a vital tool for assisting the multi-disciplinary team in planning a reduction of the impact on the environment of the many projects necessitated by the expanding population and their needs for a better way of life.

GEOTECHNICAL MAPPING

During the past 30 years, the usefulness of some form of mapping which will define the geotechnical problems likely to be encountered in the planning, design and construction of major projects has become increasingly recognised. In the early stages of the development of what is now recognised as Geotechnical Mapping, it was natural to turn to the work of other disciplines in the Soil Sciences commencing with the Agricultural Soil Maps. Since then many of the allied disciplines have become involved resulting in a wide presentation of the information obtained with a general bias towards the discipline of the mapper. Terrain Evaluation (1967), Symposium on Terrain Evaluation (1968), Speciality Session on Terrain Mapping (1975). In many instances, the presentation is not easily interpreted by the Geotechnical Engineer and has to be re-drafted into a form which can be readily used by the multi-disciplinary team.

In South Africa, the development has been brought about by Geotechnical Engineers, working in close collaboration with Engineering Geologists and has resulted in a Soils Engineering Mapping approach whereby the data is presented in a form which is of immediate visual interpretation to the Geotechnical Engineer and hence to the team.

In its final form the map will show not only the underlying Geology but will also depict the surface soils in such a manner that the soil profile at any point on the map can be visualised. The soils information is depicted in the form of standard soil symbols and the whole approach is based on the mapping of soil units, where a soil unit is defined as an area shown on a soil engineering map or airphoto mosaic which defines an area of reasonably constant soil profile with respect to succession but not necessarily thickness of layer and in which the geotechnical characteristics of each layer are reasonably consistent. The method of presentation is such that the soil profile can be visualised with reference only to the legend on the map. The basic tool for this form of mapping is the airphoto stereopair and it is recognised that the Engineering Geologist is ideally suited to carry out the airphoto interpretation.

The completed map will then clearly depict all problem areas such as areas of expansive soils, areas of potential slope instability etc., and provide a useful guide to planning and to the economic significance of any specific problem areas. For example, if the project is a major suburban development, areas of expansive soils could be allocated to public open space.

The elevation of the topic of Geotechnique and the Environment from a speciality session at the Tokyo Conference to a major session at this conference is a recognition of the attention being paid to the impact of man's endeavours on the environment and on planning to lessen the adverse effects of this impact. It is believed that the Geotechnical Engineer has a role to play in the multi-disciplinary team, if for no other reason but that virtually all projects have to be sited on the earth itself and it is further believed that for effective planning the Geotechnical input can best be provided in the form of a Geotechnical Map, generally prepared from Airphotos allied to a minimum amount of ground truth, i.e. actual field investigation to describe and define the soil units delineated on the Geotechnical map.

SCOPE OF USAGE

In considering the role that Geotechnical mapping can play in assisting the multi-disciplinary team to control man's impact on his environment it is necessary to consider which of man's activities has the greater impact. Like the argument about the chicken and the egg, it is arguable as to which comes first - the development of living and working space or the development of a transportation system. However, it seems logical to consider the usefulness of Geotechnical Mapping in the following order :

(a) The expansion of existing towns and the development of new towns.

(b) The development of transportation systems.

(c) The supply of services to the towns and cities.

(d) The location and planned development of natural resources.

Expansion and development of towns :

In general it can be stated that the slow growth of towns has automatically resulted in development in areas where geotechnical problems are of minor economic importance, leaving those areas, where geotechnical problems can occur, relatively untouched e.g. areas subject to flooding or areas of expansive clays. As the town developes so does the need for expansion which can take two major forms - the need for better class suburbs for the wealthier and the need for low cost housing for the less well-to-do. The first group can afford the necessary measures to soften the impact on the environment but the second group cannot. Yet the very growth of the town seems automatically to force the low cost housing schemes into the problem soil areas with the resultant increase in cost. It is probable that the reason for this is one of planning somewhat in isolation since in many cases such areas are conveniently nearer the centre of the town because the town, in expanding, has by-passed such areas.

The production of geotechnical maps can play an important role in multi-disciplinary planning in defining such areas. Effective cost analyses can be made to develope in the most economical way. In those comparatively rare cases when a completely new town is planned, it must be evident that having a geotechnical map of the area available will be of very great assistance to the multi-disciplinary team in assessing priorities. Problem areas can, in the first instance, be reserved for public open space or for the areas of high rise structures where additional foundation costs can have a lesser effect than for houses. Modifications to such initial planning constraints can then be made with a full knowledge of the implications. Figure 1 shows a portion of a geotechnical map for a town which is in the process of rapid expansion and which is in an area where expansive soils predominate. Kantey and Templer (1974). A fine example of the use of geotechnical mapping in the planning of a new town can be found at Lilongwe, the new Capital of Malawi. Hill, Kaplan, Scott (1967).

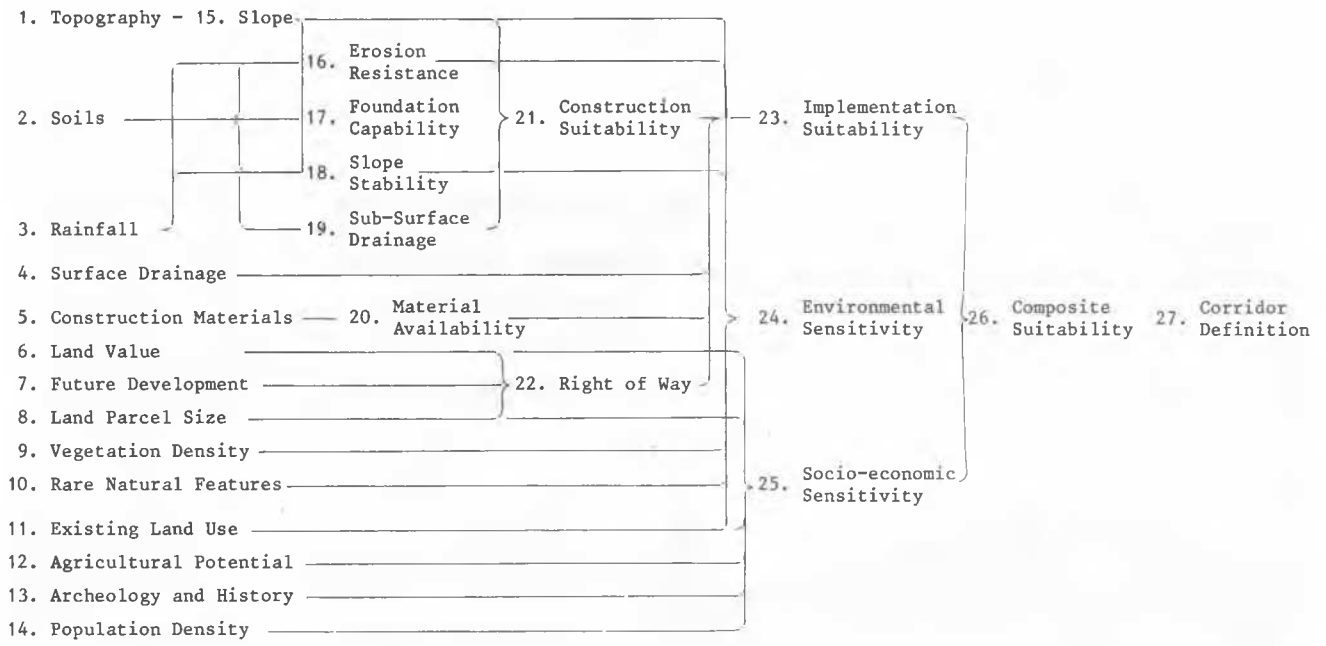
Transportation Systems :

It is in the planning of Highways that Geotechnical mapping is most widely used in South Africa and where it offers a broad scope for lessening the impact of highway construction on the environment. Martens (1979) has described a multi-disciplinary approach for major highways and produced Table 1 to illustrate his approach.

It should be noted that, of the 22 items listed in the main portion of the table, 7 items are directly concerned with Geotechniques and 4 related. Of the balance, 5 can be obtained from the same stereo pairs of airphotos while the remaining 6 items are socio-economic.

TABLE 1

DIAGRAM TO SHOW HOW A SENSITIVITY ANALYSIS IS PROCESSED IN A CORRIDOR LOCATION STUDY.



Many of the benefits are carried through from the planning to the construction stage. Using the Geotechnical Maps, borrow pits are carefully located so as to avoid unsightly scars and where possible away from the public eye. Top soil is carefully stripped, replaced after completion of borrow and seeded. Cuts and fills are landscaped where possible and all possible means adopted to restore vegetation, preferably during construction but certainly as soon as possible after construction. It goes without saying that final location is often varied to allow of the highway blending into the landscape and thus lessen the environmental impact.

It is not often that, in a country like South Africa, new railway lines are required. Where such are required, however, the same endeavours to lessen the impact are employed. It is understandable, however, that, due to the more stringent requirements of grade and curvature, improvements in location to suit environmental needs are seldom possible. Indeed, in some respects, the opposite is the case when improvements to existing lines are planned. Nevertheless, the aforementioned requirements for borrow pits, cuts and fills have been carried into the railway scene.

The Supply of Services to Towns and Cities :

The quality of life demanded today requires that our towns and cities are supplied with water and power and kept in an acceptable state by adequate stormwater and sewerage disposal. In order to achieve this requirement, many of the facets have a definite impact on the environment. Dams, pipe lines, power lines, canals for irrigation, readily spring to mind. Geotechnical mapping can play its part in the planning and design of such services. The maps will define areas of comparatively easy excavation for pipe lines, canals or service reservoirs where the vegetation can be restored rapidly and routes can be located to avoid unsightly excavations in rock. Areas of erodable soils can be defined to assist in adequate stormwater disposal and, as always, borrow pits for construction materials can be located in the least harmful areas.

The Location and Planned Development of Natural Resources :

It is in the field of natural resources that Geotechnical mapping is starting to play an important role. Naturally occurring construction materials are essential to the building and construction industry but too many instances have occurred where such materials are locked in by uncontrolled urban encroachment necessitating the location of resources borrow pits in environmentally unacceptable and indeed uneconomic locations. A systematic investigation of such resources in the vicinity of major growth points such as reported by Meissner (1978), can provide a valuable addition to a multi-disciplinary planning team. When such a resources map is extended to cover raw minerals which are amenable to open cast mining, environmental controls can be more readily planned and imposed.

FIG. 1

SOILS ENGINEERING MAP NEWCASTLE BOROUGH & ADJOINING AREAS

COMPILED FROM AN UNCONTROLLED AERIAL PHOTOGRAPHICAL MOSAIC

500 0 500 1000 1500 m

SCALE APPROX 1 : 15 000

LEGEND

A	ALLUVIUM	Dark grey to dark brown clayey silty SAND over ECCA Sandstone and Shale or Dolerite Expansive
Gw	GULLY WASH SOIL	Dark grey to olive brown silty to clayey SAND containing scattered calcareous nodules over ECCA sandstone and Shale or Dolerite Highly expansive
C.H	CLAYEY HILLWASH SOIL	Dark grey to brown clayey silty SAND over ECCA sandstone and Shale Highly expansive
kwd		Dark grey to dark red brown clayey silty SAND over residual Dolerite Highly expansive
S.H	SILTY HILLWASH SOIL	Light to dark brown silty SAND with scattered ferricrete over ECCA Sandstone and Shale Moderate to highly expansive
kwd		Light to dark red brown silty SAND with occasional ferricrete and scattered Dolerite pebbles and boulders over residual Dolerite Slightly to moderately expansive
S	SANDSTONE GRIT AND SHALE	Interbedded sequence of yellow to buff coarse grained micaceous Sandstones Grits and dark coloured Shales, often containing coal seams
D	DOLERITE	Blue grey where fresh brown to grey green and sandy to gravelly where weathered to decomposed. Dolerite.
D/S		Red brown sandy to clayey decomposed to weathered residual Dolerite over weathered to fresh ECCA Sandstone and Shale
		Dolerite Dyke
D		Assumed soil rock boundary
CD		Waste Coal Dumps

- Main roads
- Secondary roads
- Minor roads and useful farm tracks
- Railway line
- Major farm boundaries
- Dam
- Drainage line
- River
- △ Trigonometrical beacon
- ● Profile Sample location
- Existing borrow pit
- * Old Existing Mine Shaft

CONCLUSIONS

Multi-disciplinary teams are proving to be best able to tackle the problems of planning to reduce man's impact on the environment. The Geotechnical Engineer has an important part to play in such a team and can best present the information he gains in the form of a geotechnical map drawn up in a manner that is readily digested by other members of the team.

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