Bulletin de la Société belge de Géologie Bulletin van de Belgische Vereniging voor Geologie	100/1-2	pp 195-201	Bruxelles 1991 Brussel 1991

PLANNING AND GEOLOGY IN A COASTAL PLAIN

by

Cecile BAETEMAN & Roland PAEPE [1]

ABSTRACT

Holocene coastal plain deposits are characterized by frequent lateral and vertical facies changes. From a geotechnical point of view, the deposits are very sensitive to compaction, because the moisture content is very high and the bearing capacity very low. These characteristics are at the origin of many technical (and financial) problems when buildings and infrastructural elements are constructed. However, when considering land-use planning with regard to the geological setting, many problems can be avoided.

Two examples of road planning and construction in relation to the occurrence of sand-filled channels are discussed, using profile type maps as a basic source of information.

SAMENVATTING

Een van de typische kenmerken van Holocene kustafzettingen zijn de veelvuldige laterale en vertikale facies veranderingen. Daarenboven zijn deze afzettingen sterk onderhevig aan compactie vanwege hun hoog watergehalte en laag draagvermogen. Deze kenmerken liggen aan de oorsprong van vele technische (en financiële) problemen bij de constructie van gebouwen en infrastructuren. Wanneer echter rekening wordt gehouden met de geologische gesteldheid bij het plannen van de grondbestemming, kunnen veel van die problemen vermeden worden.

Twee voorbeelden met betrekking tot het plannen en aanleggen van een weg in verband met het voorkomen van met zand gevulde geulen, zullen besproken worden. Daarbij worden profieltype kaarten gebruikt als voornaamste bron van informatie.

KEY WORDS

Belgian coastal plain, land-use planning, unconsolidated Holocene coastal deposits, differential compaction, profile-type map.

SLEUTELWOORDEN

Belgische kustvlakte, grondbestemming, nietgeconsolideerde Holocene kustafzettingen, differentiële compactie, profieltype kaart.

1. INTRODUCTION

In coastal lowlands construction of buildings and infrastructural elements, such as roads, canals, bridges, railroads, always brings problems along. The main reason is the unconsolidated condition of the Holocene sediments. This is due to the fact that the sediments were deposited under influence of the rising sea level and never had the occasion to be dewatered in a natural way. The result is that the sediments are characterized by a high moisture content, a low bearing capacity, and last but not least a high compressibility.

[1] Belgian Geological Survey, Jennerstraat 13 - B-1040 Brussel & Earth Technology Institute, Vrije Universiteit Brussel, Pleinlaan 2 - B-1050 Brussel.

But the deposits of a coastal plain are also characterized by frequent and significant changes in lithology (Baeteman, 1987). Complex alternations of peat, clay, silt and sand are moreover cut by highly irregular patterns of sand-filled fossil channels. All these different lithologic units bear their proper geotechnical characteristics.

Consequently in a coastal plain the geotechnical properties of the sediments are different from place to place. The decisive property with respect to these changes undeniably is the compressibility, leading to differential compaction when dewatering and/or loading the deposits.

Civil engineers are very well aware of these geotechnical characteristics ; the high variability and complexity of the sediments are not so well known. Nowadays the engineering technologies allow to solve most of the problems. The question however is, at what price.

The difficulties during and after the construction of infrastructural elements and buildings are not just a technical problem ; it is much more a social problem. From governmental side a lot of money is invested. But also private land owners frequently experience how the house of their dreams literally and figuratively falls down because of geological ignorance of the architect and building contractor. Men have to abandon their plan because they are in the impossibility to bring in the extra funds necessary to cover the unexpected technical problems. Dramatic consequences in such a situation are not to be neglected.

How the proper use of adequate geological information can contribute to our society will be demonstrated by means of an example concerning road building. It should be mentioned that the discussion is related to the experience in the coastal plain only.

2. THE STATE OF THE ART

The planning of infrastructural elements in Belgium is based on a series of rigid elements such as economy, population, politics and not at least landed property. However, geology does not belong to the primary factors influencing the planning. Although the Belgian Geological Survey was consulted while the land-use maps for the country were designed, no response could be offered due to a shortage of scientific staff.

Once the infrastructure is planned and construction is decided, soil investigations are carried out, but purely from an engineering point of view. In the case of a road or motorway such investigation consists of the execution of cone penetration tests every 100 m along the proposed route. In addition shallow borings are carried out at regular distance ; in general every 100 or 200 m. The main purpose of these borings is to carry out geotechnical analysis. The borings are all attending more or less the same depth (ca 10 m) independent on the geological setting and revealing samples each half a metre. So far, the geology is not involved in the soil investigation. It is true, engineers still have much more faith in hard figures and diagrams provided by the analysis rather than in the descriptive texts and interpreted cross-sections from a geologist. Besides they trust that these figures give the sufficient information.

It is more a coincidence rather than the rule that the Geological Survey is informed about the existence of boreholes which can be studied if interested. It frequently happened that the road was already in use before a geologist from the Survey ever saw the samples from the borings. Even, many roads and bridges have been constructed without any geological advice at all.

However, a proper knowledge of the detailed geological conditions can contribute a lot to the preliminary investigation. Moreover, the geological knowledge, as it is available at the Survey, can help to a great extent to avoid technical problems, especially by advising the planner for the selection of suitable locations for the infrastructural elements with respect to the particular geological conditions. The following example, one among so many, clearly illustrates the importance and benefit of the geological information.

3. THE CASE

At the end of the seventies a motorway was constructed in the western coastal plain of Belgium, more particularly between Oudenburg and Nieuwpoort (fig. 1). It is a section of an important motorway usually called the "Brugge-Calais motorway" planned to open

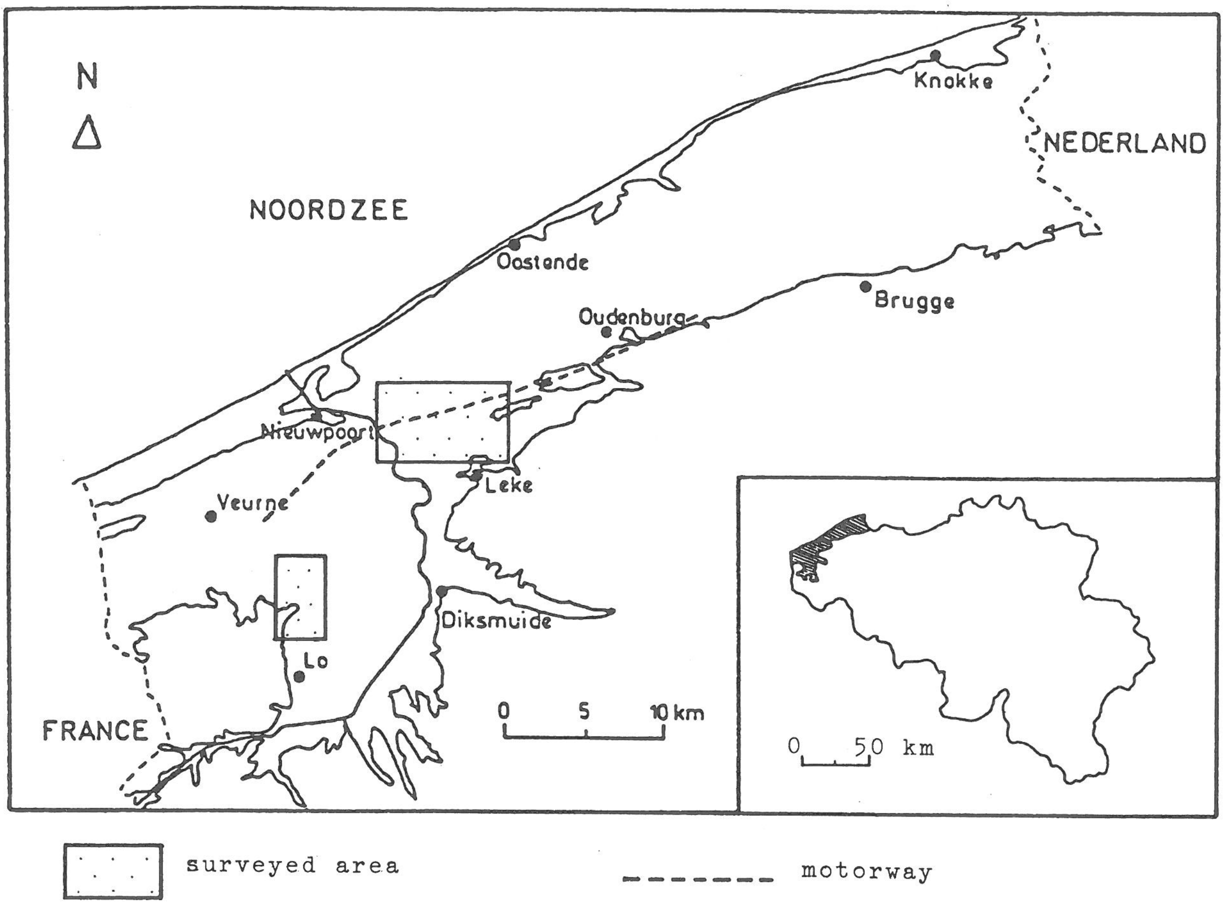

Figure 1 : Location of the Belgian coastal plain with indication of the surveyed areas.

the western coastal plain and to establish a better connection with France.

To construct the road, about 1 to 2 m of the superficial layers are removed and replaced by sand, forming a cunet in this way. Then the cunet is raised by more sand for 1 to 2 m for several months in order to achieve a preload of the unconsolidated sediments. Such a method, which is indispensable for unconsolidated sediments, requires a huge amount of infilled sand. The removal of the superficial layers is done very systematically until a certain depth without taking into account the nature of the sediments. It already has been observed that only the upper part of a 2 m thick peat layer, which locally occurs slightly deeper than in general, was removed. In such a situation the cunet is not very functional since half of the peat layer, being the most sensitive to compaction, is still present.

Since some years now the road shows the well known "washboard" phenomenon due to differential compaction (Hageman, 1984). This can be observed especially in the central part of the surveyed route (at the exit Middelkerke) which now will become one of the money swallowing roads because of the recurrent maintenance costs.

This section of the motorway forms a clear example of how the use of geological information can contribute to decrease the technical problems as well as the financial implication during and after the construction just by selecting the appropriate location of the road in relation to the geological setting. Moreover a huge amount of the already scarce raw materials, like sand, could have been saved as well.

A simple consultation of the renewed geological profile type map (available at the Geological Survey), and even of the well known pedological map, would have highlighted how unfortunate the location of this motorway section has been planned.

Already in 1984, Hageman discussed extensively the problem of site location for buildings and infrastructural elements in coastal lowlands. The author mainly stressed on the fact that suitable geological patterns with res-

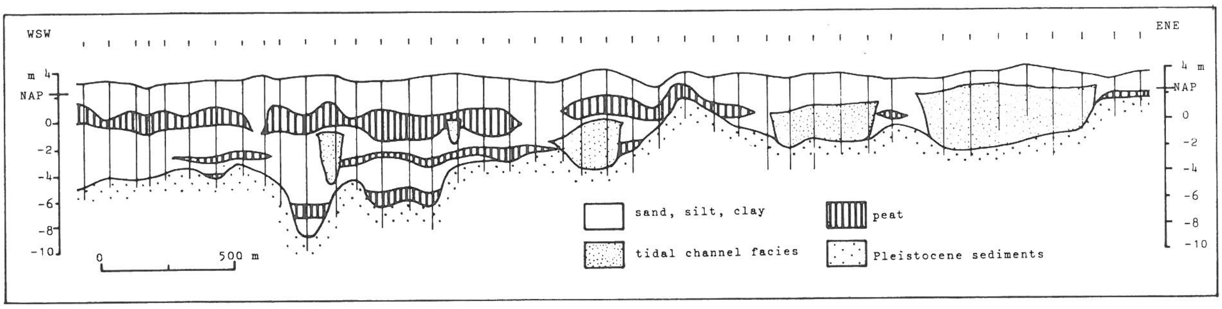

Figure 2 : Cross-section along the motorway delineating the highly variable relief of the Pleistocene subsurface and the frequent changes in facies in the Holocene sequence (The borings have been carried out by the Rijksinstituut voor Grondmechanica).

pect to the compressibility and bearing capacity of sediments should be used whenever possible. This in order to avoid technical problems, but also to prevent financial fai-

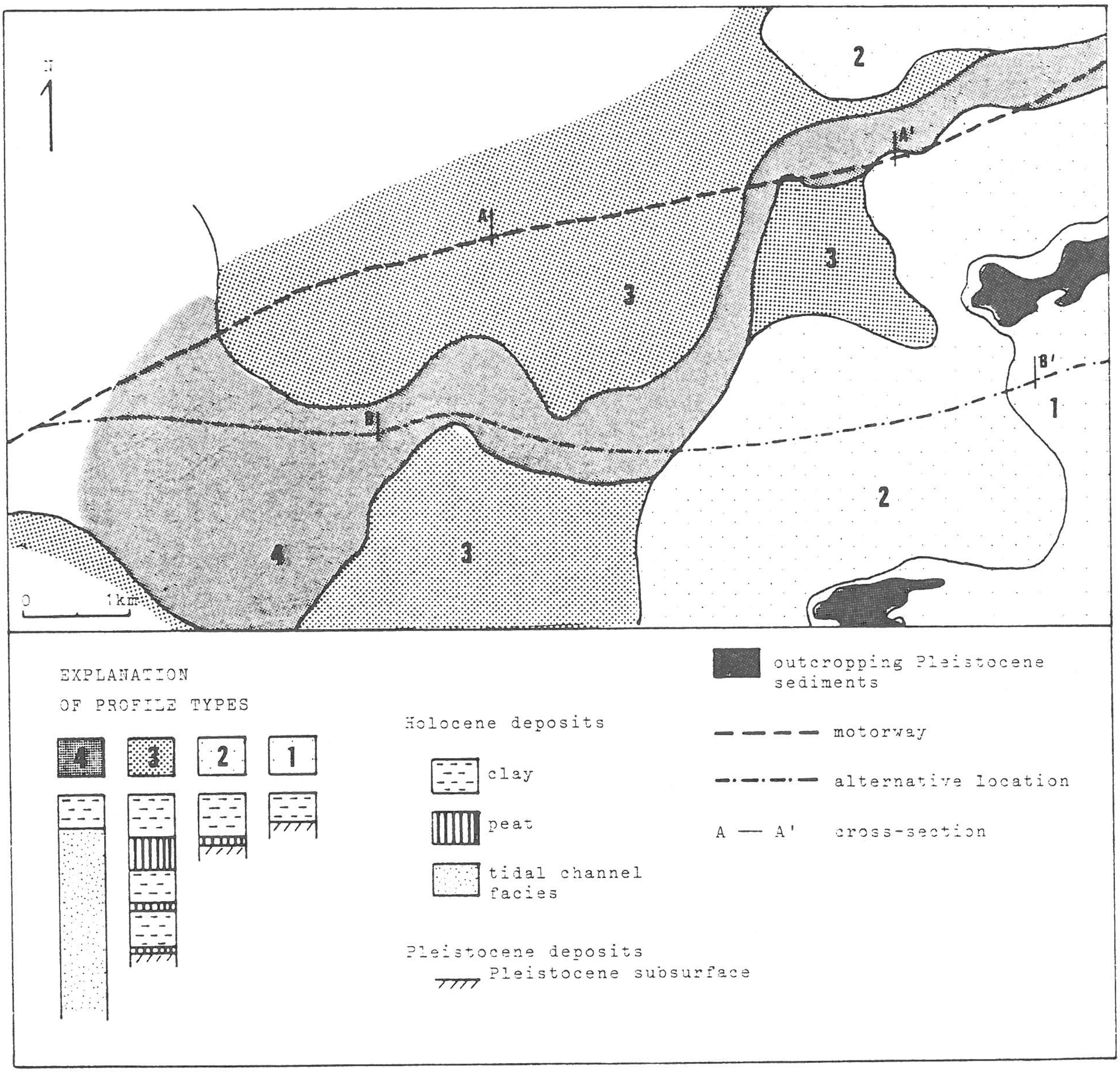

Figure 3 : Simplified profile-type map of the coastal plain east of Nieuwpoort with indication of the motorway. An alternative location is proposed in relation to more suitable road-building conditions of the geological setting consisting of mainly a sand-filled channel in the west and a thin cover of Holocene tidal flat deposits underlain by basal peat, in the east.

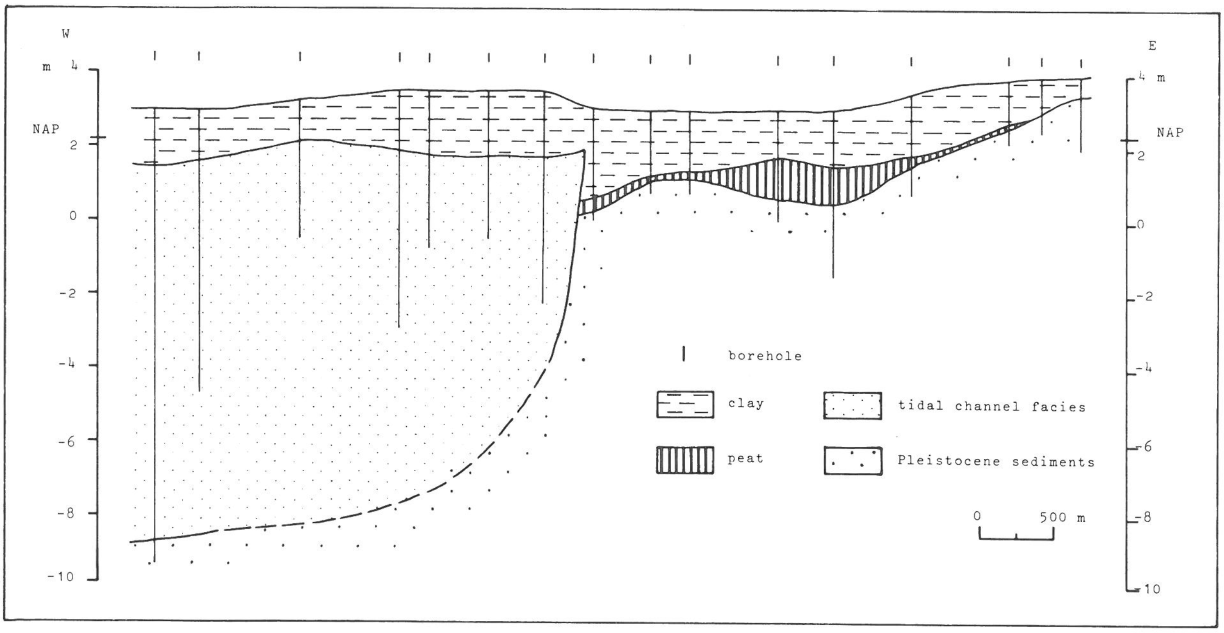

Figure 4 : Cross-section of the Holocene sequence along the alternative location crossing a sand-filled channel in the west and a thin cover of tidal flat clay overlying the basal peat in the east.

lures and the unnecessary use of raw materials. Utilization of sand-filled fossil channels as location for a road is one of the applicable opportunities.

The cross-section along the motorway (fig. 2) demonstrates in the first place that the Pleistocene subsurface has a highly variable relief. This is an important factor for road building, because these Pleistocene sediments, consisting of coversands, are known to be relatively more consolidated, hence having a much greater bearing capacity than the coastal Holocene sediments.

In the Holocene deposits quite a lot of variations can be observed too. The eastern part of the motorway crosses twice a sand-filled channel. The sequence of the central part is much more complex and consists of an alternation of peat and clastic tidal flat sediments. Besides, the tidal flat sediments are characterized by frequent changes of sand, silt and clay layers with irregular geometry, all having different geotechnical properties. To the west of the studied section, the sequence consists of mainly sandy sediments overlain by one peat layer in turn covered by clay.

It is obvious that dewatering and/or loading this road-section will unavoidably lead to significant differential compaction. Even if the upper 2 m of sediments are removed and replaced by sand, differential compaction occurring within a different timespan for each lithologic unit, will take place. This is not always so evident for the engineers carrying out the preliminary investigation. It is true, far too often the sediments underlying the upper peat layer are regarded as being homogeneous, bearing uniform geotechnical characteristics.

The unfortunate location of the motorway is clearly illustrated by a fragment of the geological profile type map. For the sake of clearness a very simplified profile type map (fig. 3) was drawn, based on the special profile type map made at the Geological Survey and showing the Holocene sequence in great detail. The simplified profile type map consists of only four profile types which however give sufficient information for this purpose. Profile type # 1 represents a thin cover of clay sediments overlying directly the Pleistocene deposits. In # 2 a basal peat, with a thickness ranging between few cm and about 1 m, is covering the Pleistocene surface. In the areas where the Pleistocene surface is occurring at a greater depth, profile type # 3 is found consisting of an alternation of clay, silt and sand on the one hand, and one or more peat layers on the other hand. Basal peat may be absent or present. Finally # 4 represents the tidal channel facies. It should be mentioned that the sequence of these fossil tidal channels does not always consists entirely of homogeneous sand. At the outsides a sequence of clay with a thickness of several metres is frequently found. Such a kind of data is delineated on the special profile type map.

The simplified profile type map demonstrates that the concerned section of the motorway crosses for a great part profile type # 3, the area which is most sensitive to compaction. The geological setting of the region, however, offers more suitable areas and an alternative location is proposed (fig. 3). In the east, about 2.5 km more to the south of the motorway, the Pleistocene surface, hence the relatively consolidated sediments, is at a high elevation. The Holocene deposits along that alternative location are, in the eastern part, restricted to a cover of tidal flat clay underlain by a basal peat reaching a maximum thickness of 1 m (fig. 4). With respect to road-building, this part offers suitable conditions, because it has a good bearing capacity and very low compaction rate. Besides, a cunet would remove all the compressible Holocene layers. More to the west the fossil tidal channel could be used as the central part of it is sand filled and requires only simple foundation engineering provisions. Very limited compaction would occur which moreover would happen very quickly (which is not the case for clay and peat). On the other hand these sediments will not yield differential compaction. This alternative location certainly would not result in a washboard-road, very important for the maintenance costs after few years.

This case study unfortunately is not unique. But the road is constructed and the endless maintenance of the washboard can start.

The role and utility of the geologist, however, is not to study and discuss endless accomplished facts, but to advice and inform civil engineers and planners before decisions are made. But the dialogue is not always evident.

Thanks to the detailed systematic mapping in the coastal plain, resulting in profile type maps, simplified maps can easily be made for the purpose of e.g. construction of infrastructural elements. An example is shown in fig. 5. A planned road, located north of Lo (fig. 1), is crossing frequently different kinds of sequences, and more particularly the sequence consisting of an alternation of peat and clay. The washboard is guaranteed.

Shifting the location of the road slightly to the west and selecting the areas represented by profile type # 1, 2 and 4 will also here avoid differential compaction and high maintenance costs once the road is in use.

4. CONCLUSION

Technical problems during construction and high maintenance costs of infrastructural elements are inherent to the geological condition of coastal lowlands. But with the use of geological information, a great deal of the problems can be avoided and money as well as raw materials can be saved. However, for coastal lowlands in particular, it is of vital importance that the geological information is detailed. Generalizing the interpretations and extrapolation over great distances can only result in false conclusions. It is also insufficient to consider only the superficial layers. The three-dimentional distribution, or geometry of the different strata must be known.

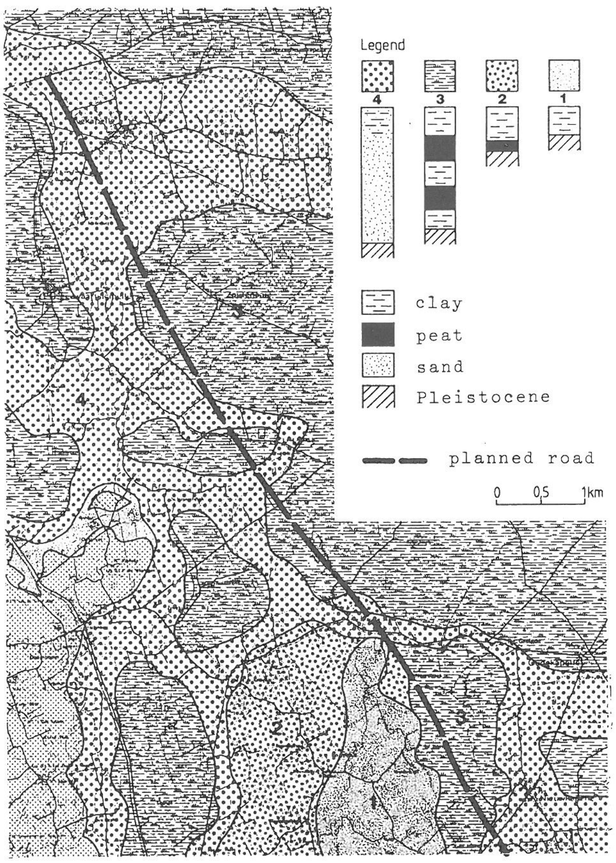

Figure 5 : Example of a simplified profile-type map of the area south of Avekapelle (NGI Topographic Map : Lampernisse-Diksmuide). The map clearly exhibits the occurrence of an important sand-filled channel which could be use as base for the road. The planned road is redrawn from the Land-use Map (Gewestplan).

The only way to fulfil these conditions is offered by the profile type map, representing the entire sequence of a sedimentary body in a three-dimentional manner. To be useful, the legend of the map must be drawn up in a comprehensive way. Plain descriptions of the sediments are preferable, rather than the classical stratigraphical terms, meaningless to non-geologists.

Such a geological profile type map, surveyed in detail, forms an inexhaustible basic source of information. Only on base of such a map, any kind of geologically related thematic map can be deduced quickly and easily, without any further intensive research.

However, the maps should be consulted and used. Therefore their existence must be proclaimed broadwise. Civil engineers, planners, managers, decision makers and politicians should be aware of the technical and social applications of this source of geoscientific information. Only in that manner, land-use planning can be done in an efficient and responsable way. Technical problems can be avoided, and raw materials can be saved. Hence financial failures are avoidable too.

REFERENCES

BAETEMAN, C., 1981 - An alternative classification and profile type map applied to the Holocene deposits of the Belgian coastal plain. *Bull. Belg. Ver. Geol.*, ***90***: 257-280.

BAETEMAN, C., 1987 - Mapping a coastal plain. Problems concerning mapping units. *Geobound*, ***1***: 3-9.

HAGEMAN, B.P., 1984 - Geological information, a vital element in environmental planning with emphasis on coastal plains. *Geol. J.B.*, ***A75***: 93-123.

HAGEMAN, B.P., 1989 - The application of Quaternary geology in coastal areas. *In* : De Mulder & Hageman (Eds), *Applied Quaternary Research*, Balkema, 43-63.

Manuscript received on 2 May 1991 and accepted for publication on 13 September 1991.