The regional geotechnical database “Databank Ondergrond Vlaanderen-DOV” as a powerful tool for consultation of subsoil information

La base de données géotechniques “Databank Ondergrond Vlaanderen”: un outil performant pour la consultation d’informations du sous-sol

G. Van Alboom, P. De Schrijver, I. Vergauwen
Geotechnics Division, The Authorities of Flanders, Belgium

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ABSTRACT

Databank Ondergrond Vlaanderen (DOV) aims to be the overall database compiling and offering subsoil information of Flanders (Belgium). Actual data consist of drillings, CPT, groundwater wells and groundwater supply licences.

Since the introduction of the website, DOV has proved to be a powerful tool in geotechnical design; data collection form the basis of preliminary design, global inventory and analysis of geotechnical parameters for important infrastructure projects; short time actions can also be taken from interpretation of available data, based on engineering judgement.

However project related soil investigation remains a necessity, and one cannot solely rely on information of subsoil databases for design purposes.

RÉSUMÉ

La Databank Ondergrond Vlaanderen (DOV) se veut être la base générale de données, accumulant et fournissant de l’information sur le sous-sol en Flandre (Belgique). Les données actuelles sont constituées de forages, d’essais de pénétration, de puits d’eau et d’autorisations de prélèvements d’eau souterraine.

Depuis l’introduction du site web, la DOV a démontré qu’elle était un outil performant pour la conception géotechnique; la collecte de données est à la base de tout conception préliminaireainsi que de l’inventaire et de l’analyse globale des paramètres géotechniques pour des projets de grande ampleur.

Pour des actions à court terme on peut également recourir à la DOV, si l’information est interprétée par des professionnels de la géotechnique.

Cependant toute conception de projet doit rester basée sur une investigation du sol sur le site même et ne peut se reporter uniquement aux informations issues de bases de données.

1 INTRODUCTION

In 1996 the database for the subsoil of Flanders (’Databank Ondergrond Vlaanderen - DOV’) is established at the Authorities of Flanders. DOV aims to be the overall database compiling and offering subsoil information of Flanders. Data types today are drillings, cone penetration tests, (CPT) groundwater wells and groundwater supply licences. These data are accessible, free of charge, on the website http://dov.vlaanderen.be.

Within the DOV information system two types of data can be distinguished, namely the alphanumeric and the cartographic data (De Ceukelaire et al. 2003). An overview of this data is given in Table 1. On short term, data provided by others will be integrated in the database. To make the application accessible to new and more internal and external partners a more flexible system is required. Therefore a migration of the original fat-client architecture into a web-based architecture has been set up.

Table 1. Data in DOV

Data type	number
Drillings	118509
Cone penetration tests	48513
Groundwater wells	61305
Groundwater abstraction licences	29681
Interpretations	245755
Samples with lab tests	14148
Subsoil maps	15

2 SUSTAINABLE DEVELOPMENT

During the past ten years most attention has been drawn to the input of the data in DOV. An acceptable quantity of different data types has been reached: the archives of the actual co-operators are almost digitised (Table 1). However the content of DOV is just a small part of all information available in the working field.

Therefore the inclusion of new data of other organisations will be explored in the future, for example data of drilling companies, laboratories, city councils. These new organisations will be given the opportunity to integrate their data into DOV. Quality assurance of these new gathered data will however be a key issue, before import in DOV can be allowed. A flexible data management will be guaranteed with security on record level. This makes it possible to determine which data will be accessible to the different users.

To reach this, the existing DOV fat-client architecture must be migrated into a web-based architecture (see following). The new application based on map services will allow users to view, edit, manage and integrate available data. Fig. 1 shows an example of the edit-tool in the web-based application.

Besides these IT-advantages, this platform forms a start for implementing the upcoming European INSPIRE-directive to exchange data in a flexible way. According to these ideas, DOV should develop to a database that co-operates within and beyond the divisions of the Authorities of Flanders.

3 ARCHITECTURE

The 'DOV migration project' will lead to a web-enabled IT-application, set up in the three-tier-architecture (client tier, service tier and data tier). For the development of the application, the ESRI GIS and mapping software are used.

The client tier, that forms the portal to the user, consists of a web browser and an ArcGIS-client. All the operational tools are accessible through the web browser. It is also possible to use the map services as an ArcGIS-client for more advanced analysis. These two components of the client tier are connected to the second tier (service tier) through the web. Thanks to this concept, the user needs only a PC with an Internet connection, for accessing the application.

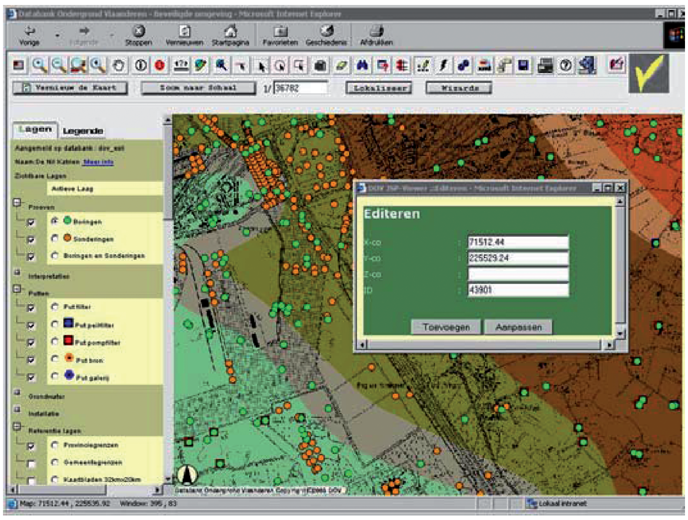

Figure 1. View of the DOV web-application, with the on-line edit-tool.

Figure 2. Closing of the ring road around Antwerp (future trajectory blue lines).

The service tier, that contains all the GIS-tools, forms the heart of the application. This layer offers the possibilities of sharing GIS-data and GIS-tools in an Intranet, Extra-net or Internet environment. The access rights to the application depend on the environment (for example: the extra- and intranet-users have more rights than the Internet-users). This is a flexible system where every adaptation of the application can be done in one place.

The data tier consists of an Spatial Database Engine (SDE). This database not only contains the alphanumerical and geographical data, but also the meta-data (layer-info).

4 USERS AND APPLICATIONS OF DOV

Users of DOV are situated within governmental organisations as well as private consultants. DOV is a multidisciplinary database, offering subsoil information for a wide range of applications: geotechnical design, environmental studies, groundwater moddelling, groundwater policy, minerals extraction policy, scientific research, . . .

For geotechnical design following information can be retrieved from DOV:

- geological and geotechnical profiles (as well tertiary as quarternary layers)
- CPT results (including geological interpretation)
- borehole logs (including geological interpretation)
- groundwater level measurements.

5 USE OF DOV AS A PLANNING TOOL

The closing of the ring around of Antwerp (Fig. 2) necessitates the construction of more than 20 km of highway, with several large and smaller infrastructure elements (tunnels, bridges, . . .).

The most prestigious projects in this masterplan are the Oosterweel tunnel under the Scheldt river and the Lange Wapper bridge, crossing the Straatsburgdock.

In agreement with SAM (studygroup for the masterplan Antwerp) the DOV database was chosen as the main tool for datacollection of in situ tests. As for the moment the DOV database does not include data from private drilling and CPT companies, the DOV-team supported by SAM developed a specific project for extended input of relevant geotechnical data, meeting high quality standards. Specific focus of interest was the geotechnical investigation for the surge barrier on the river Scheldt (project extensively studied in the eighties, but not realised).

The Oosterweel tunnel intersects with the formerly proposed axis of the surge barrier. To make these data available they were digitised from CPT diagrams.

Fig. 3 shows available investigation points after full data inventory (green and orange dots).

Based on this inventory an extensive investigation program of in situ tests was elaborated (laboratory investigation lies outside the scope of this paper).

Specific tests performed were:

- 238 CPT
- 56 borings
- 27 field vane test (at 7 locations)
- 10 pressiometertests
- 6 dilatometertests

Fig. 4 shows inventoried CPT and borings (orange and green dots) and additional CPT (purple dots).

Analysis of this huge amount of data (combined with results of laboratory tests) resulted in a division of the trajectory into 10 geotechnical zones, each characterised by a typical soil layering and corresponding soil parameters.

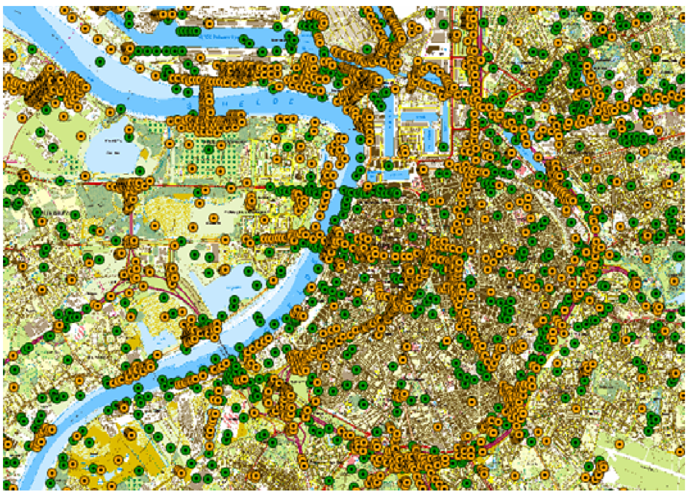

Figure 3. DOV-plot of available results (CPT and borings).

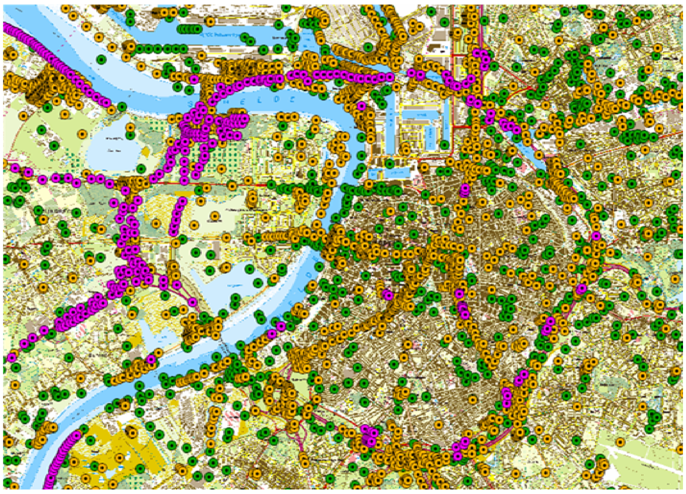

Figure 4. DOV plot of inventoried and additional in situ tests (add a scale).

Specific attention was paid to the detailed investigation and delimitation of a "weel" zone. A "weel" is a zone with deeply disturbed soil conditions, due to important dike failures. The erosion resulting from the huge impact of waterflow, can reach up to 20 meter and more and is followed by sedimentation of mainly very soft clays and silts. Former depth data of the weel intersecting the tunnel axis were refined and improved, as to give detailed contourlines of the weel sediments (as shown in Fig. 5).

The design of the foundation of the Lange Wapper bridge formed another geotechnical challenge. The extremely high loads of the piers had to be transferred to the tertiary Boom clay layer.

The upper zone of this clay layer however is often decompacted, and special attention had to be paid to this phenomenon. Additional CPT near possible bridge pier locations in the dock were performed to complete information from DOV on the Boom clay at this site.

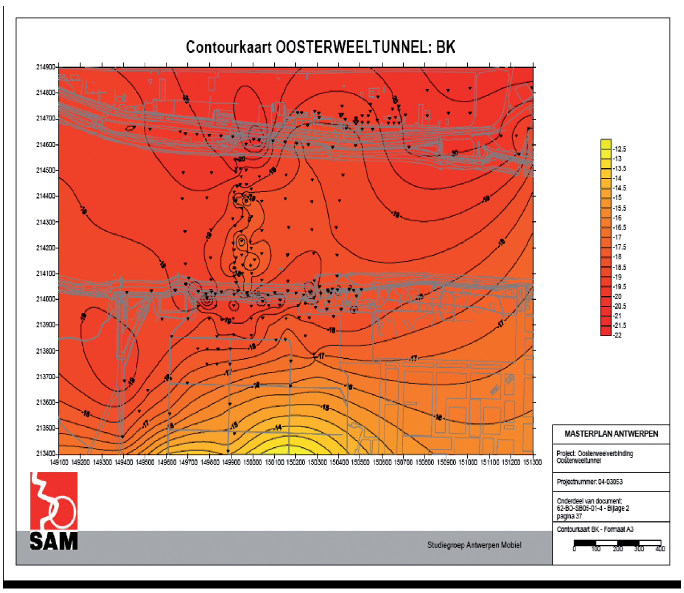

Figure 5. Contour chart with depth data of the central weel at the tunnel location.

DOV was however used to gain information over the complete trajectory of this masterplan, including road and waterways projects:

- making up geological sections
- retrieving CPT results and borehole logs from the database
- planning project and site related in situ investigation programs
- input of new data in DOV, and re-evaluation of the refined geological and geotechnical sections.

6 USE OF DOV FOR SHORT TERM ACTIONS

In January 2005 a quay wall construction along the river Zenne in Vilvoorde collapsed over a length of approximately 100 m. As the road along the river was a very busy traffic artery, the local authority stressed an immediate remedial action.

After concertation between the Geotechnics division and the Waterways department of the Authorities of Flanders, it was decided to proceed as follows:

- In a first stage a configuration with a cantilever sheetpile wall would be constructed to allow the repair of the road construction and restore traffic within the shortest delay. By limiting the extent of this first stage the work could be granted directly to the contractor responsible for general maintenance activities in the specific region, and no time consumery tender procedure was necessary.
- In a second and final stage an anchorage of the sheetpile wall would allow full restoration of quay wall configuration.

For design of the first stage of remedial works a geotechnical profile of the site had to be established. As it was not possible to perform a geotechnical site investigation within the granted delay (primal remedial construction activities were in execution for preventing further erosion, and the necessary sheetpile profiles had to be ordered from directly available stocks within half a day notice). The DOV database was consulted for datacollection:

- geology of the site
- available in situ test results.

The geology of the site revealed alluvial deposits to a depth of approximately 10 m, information confirmed by results from 4 CPT (purple dots on Fig. 6) executed at the opposite river bank and also situated within the alluvial zone along the river Zenne. A profile from the CPT diagrams could be drawn (Fig. 7) forming the input for a geotechnical profile to be used in the design: soil layering as well as geotechnical characterisation (shear strength parameters and densities).

The geotechnical profile for the considered configuration (following interactive design triggered by available sheetpile profiles) is shown on Fig. 8.

Figure 6. Geological information and available in situ tests (CPT), shown as purple dots.

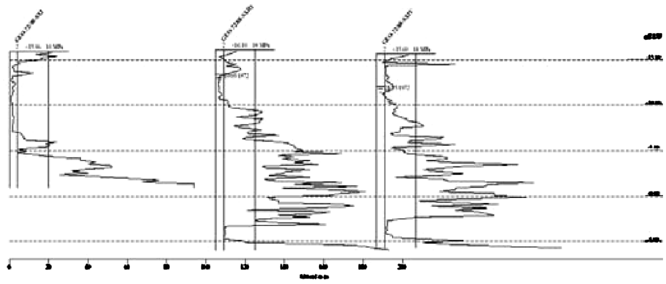

Figure 7. Profile from CPT-diagrams.

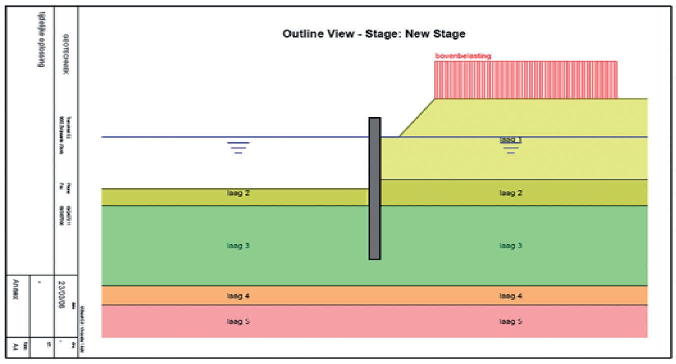

Figure 8. First stage remedial configuration showing geotechnical profile.

To take into account the unavailability of test results at the actual site of collapse itself, a conservative design approach was adopted.

When the site of collapse was accessible for a CPT-truck, an investigation program of 7 CPT was setup (green dots on Fig. 6) in order to verify and refine the adopted geotechnical profile. The refined geotechnical profile resulted in a final quay wall configuration with anchorages.

Consulting DOV (geology and available in situ tests results) thus allowed instant design of a primal remedial concept. Full restoration of the quay wall configuration could be realised later on, when CPT on the site of collapse could be executed.

7 USE OF DOV SHOWING LIMITATIONS AND DRAWBACKS

In order to assure quality of life in a residential nucleus close to harbour extension activities in the left bank area of the Port of Antwerp, a separation dam of approximately 20 m high had to be built.

For preliminary design DOV revealed the availability of a few CPT at the extremities of the dam lay-out (Fig. 9).

CPT results and borehole logs, together with geological information revealed a geotechnical profile with quaternary upper layers with a thickness of 5 to 10 m consisting of soft clays and peat.

Based on this desk study a geotechnical investigation program of 15 CPT and sampling was executed.

As shown on Fig. 10 the in situ tests confirmed the soil layering from DOV data; however one CPT showed a soft layer deposit that was 3 m thicker than on the other investigation points.

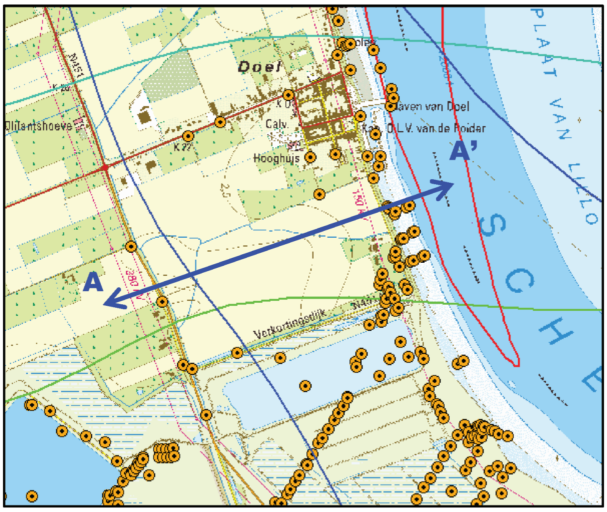

Figure 9. DOV-plot of CPT in vicinity of dam axis AA'.

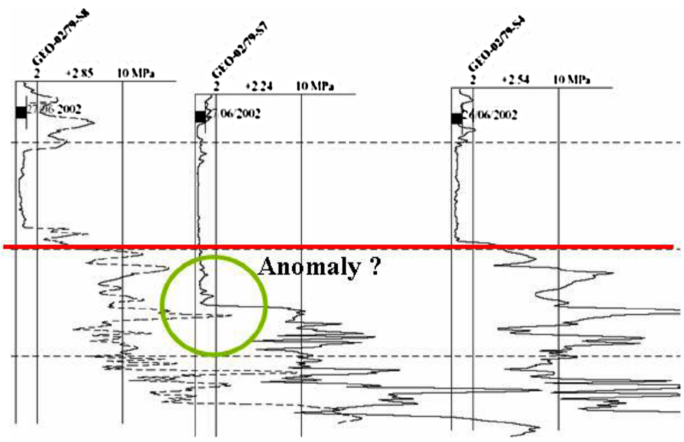

Figure 10. CPT results showing local anomaly.

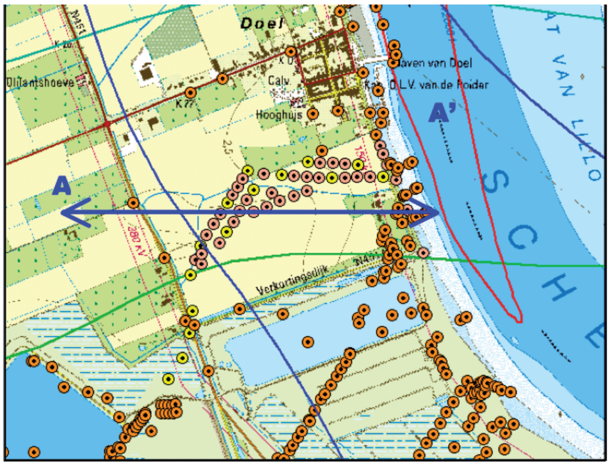

Figure 11. DOV-plot of additional CPT for dam construction.

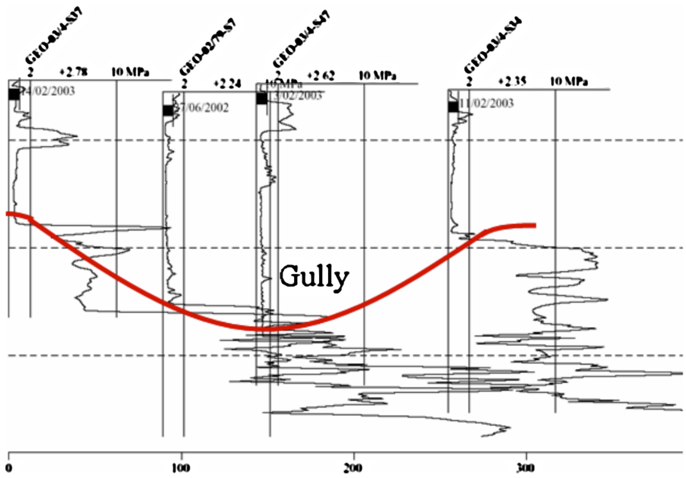

Figure 12. CPT results showing gully.

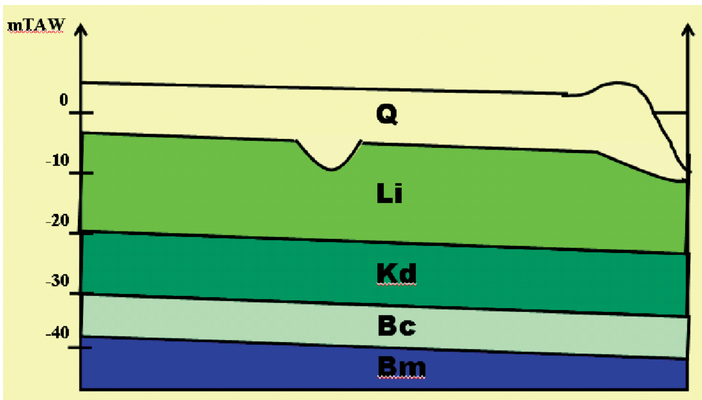

Figure 13. Geological section with gullies along dam section.

After consultation of historical maps the possible existence of gullies due to erosion near the site of the dam was revealed.

Supplementary closely spaced CPT clearly showed the existence of gullies (Figures 11–13).

Due to these specific geotechnical conditions a staged construction technique was adopted, monitored with settlement, water pressure and inclinometer measurement.

Special attention was paid to the damsections intersecting with the gullies. Site and project related soil investigation proved once more to be indispensable, and design solely based on information from DOV would have been quite inappropriate.

8 CONCLUSIONS

Geotechnical databases form a powerful tool for preliminary design and well planned geotechnical investigation programs.

Moreover such databases can be used for inventory and evaluation of test results for important infrastructure projects.

For planning short time actions geotechnical databases have proven to be very useful as well. But one should always bear in mind that the availability of these data does not make specific and project related soil investigations superfluous, as shown in the last example.

The geotechnical database, referred to in this paper, namely the Regional Database of the subsoil of Flanders (DOV), is very popular among all professionals involved in geotechnical design. The free availability is certainly an important asset, but also the user friendly web-based IT-structure, with GIS facilities attracts potential users.

Last but not least, the continuous effort to improve the accessibility of the database, and the available of new and additional data have to add to the success of DOV.

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