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# Assessing damage for Herkenbosch, The Netherlands, due to the Roermond earthquake of April 13, 1992

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## Abstract

During the April 13 1992 Roermond earthquake the town of Herkenbosch suffered extensive damage. To examine the extent of the damage a door to door enquiry survey was carried out. 75% of the households replied to the survey, which is based on "yes" or "no" replies to questions on the residents' experience during the earthquake, the damage to their homes and other observations. The replies were entered into a database. Examples of selected replies are given to show their geographical distribution. The study requires further input data to enable more effective use of the information.

To facilitate this, the present database is structured in a way that further information can be easily added; for example reports from the *Rampenfonds* (Disaster Fund) survey, municipality information on house lay-outs and building details, and ground conditions. With sufficient data the survey should indicate which house styles or building methods are vulnerable to earthquake damage and identify those factors which influence such damage.

## 1. Introduction

Subsequent to earthquakes two types of damage survey are normally carried out; one for reparations and one for research. In the Netherlands several surveys were executed soon after the Roermond earthquake; one for the Disaster Fund and a macroseismic KNMI survey[6]. In addition an earthquake survey team from the UK visited Heinsberg in Germany and Roermond in the Netherlands[12]. The disaster fund was set up by the government to compensate damage to private homes exceeding *f*5,000 and hence required house-surveyor's reports to assess the damage. The KNMI (Royal Netherlands Meterological Institute) sends a questionnaire to all municipalities in the

Netherlands to determine the intensity distribution on the MSK scale, examples of which are given in Houtgast[8]. The UK earthquake survey team went to Heinsberg and Roermond to assess visual damage to buildings and to determine earthquake resistance to damage of buildings.

The Engineering Geology Section at Delft University of Technology had been involved in earthquake potential damage studies in the area of the Peelrand Fault[10] and hence considered the earthquake as an opportunity to confirm the predictions of the study as well as to determine interaction of ground profiles and building structure during earthquakes.

This study consists of several stages which this paper outlines and the results and progress obtained thus far. Restricted by limited resources, the town of Herkenbosch was selected for the study. A questionnaire was compiled and distributed to each household. Subsequently, information was (and still is) being compiled on the subsurface conditions. Additional information remains to be obtained from the Disaster Fund archive and from the municipality records/planning offices on house plans.

The research initiative at Delft has been stimulated by an existing mapping research project. The Engineering Geology Section works on an engineering geological mapping project concentrating on the southern part of the Province of Limburg[9]. Thematic maps were made of central Limburg for the earthquake study by Lap [10] and a special engineering atlas was made of Venray (north central Limburg) by Winkoop [15]. A similar project is concentrated on Amsterdam[7].

## 2. Survey

Throughout this investigation a close coordination between the municipality of Meelick, Herkenbosch and Vlodrop (municipality of Roerdalen) and the research group has been maintained. A questionnaire (Fig. 1) was compiled and distributed to each household in Herkenbosch. Additional information may have been desirable; the questionnaire is a compromise between obtaining relevant information and encouraging the householders to answer the questions. Some questions may be confusing or subjective, however, the questions allow correlation with earthquake damage intensity scales (MMS, JMA, MSK-64 and Eurocode-MSK-(EMS). Macroseismic intensity maps are determined from these scales and have been applied, with limited success, on an urban scale at Herkenbosch for which the assessment method is given by den Outer et al. [11]. A similar approach can be found in for San Francisco City[1]. About 1000 questionnaires were distributed in October 1992 to the households and collected in the same week by door to door calls. Self addressed postage-paid envelopes were left with those households who did not answer the door.

The questionnaire was accompanied by a covering letter explaining its purpose. People could phone two civil servants at the municipality, should they have problems with the questions (no calls were made). The survey was advertised in advance in a local weekly parish newsletter. In total 700 replies

Name

Address

☐ cross if applies. Multiple boxes may be crossed.

1. Did you awake as a result of the earthquake vibrations? ☐yes ☐no

2. When you woke were you:
   ☐calm ☐anxious ☐very anxious ☐frightened ☐very frightened

3. Did you experience an earlier earthquake in the Netherlands? ☐yes ☐no
   Did you experience an earthquake abroad? ☐yes ☐no

4. Construction year of your house ☐before 1900 ☐after 1900 construction year: 19__

5. Number of floors ☐1 ☐2 ☐3 or more ☐basement/cellar ☐attic

6. House foundation: ☐piles ☐no piles ☐do not know

7. Ground type in garden: ☐gravel ☐gravel and sand ☐sand ☐silt/clay ☐do no know

8. As a result of the earthquake: The damage that you have had exists of the following:

   inside:
   ☐cracks in ceiling ☐cracks in wall ☐existing cracks increased in size
   ☐toppled objects ☐no damage
   the most damage was ☐upper storey(s) ☐lower storeys ☐both storeys the same

   outside:
   ☐cracks side-walls, ☐cracks front ☐cracks rear ☐cracks parapet ☐toppled parapet ☐toppled chimney ☐damage roof ☐no damage

   leakages pipes: ☐gas ☐water ☐drainage ☐central heating

9. Did you observe any fissures/ fractures or other unusual features in your garden or land: ☐fractures ☐sand eruptions ☐settlements ☐leaning trees or pylons ☐other unusual features:
   Can you give a sketch of approximately any damage has occurred in your house/building:

10. We would appreciate any further comment about the earthquake:

Would you like us to send you the results of our research then we will send them early 1993 to you ☐yes, please.

Figure 1: Earthquake survey questionnaire for Herkenbosch residents (translated from Dutch)

were received.

Subsurface information comprises an essential supplement to the information from the questionnaire. The municipality provided site investigation information for several sites in Herkenbosch. Additional site investigation information is being obtained through exiting archives of site investigation companies and from the RGD (Geological Survey of the Netherlands). All information is being compiled into a database named SEIS (Seismic Engineering Information System) from which thematic engineering geology maps are being produced[14].

## 3. Information processing

The multiple choice answers from the questionnaire were entered semi-automatically in an ASCII file. The information was then transferred to a relational data base, Paradox-3, with the household addresses. The topographical survey coordinates of each household were entered using the geographical information system (GIS) ILWIS from ITC (Int. Inst. Aerospace Sur. and Earth Sciences, Enschede). The information is based on a municipality map[4] and the 1:10 000 topographical map of Herkenbosch[3].

Our relational data base allows further expansion to accommodate additional types of information to be entered such as details of the house construction, the subsurface data or any other information such as that from the damage survey. The data are linked as long as the item of data has a common reference number.

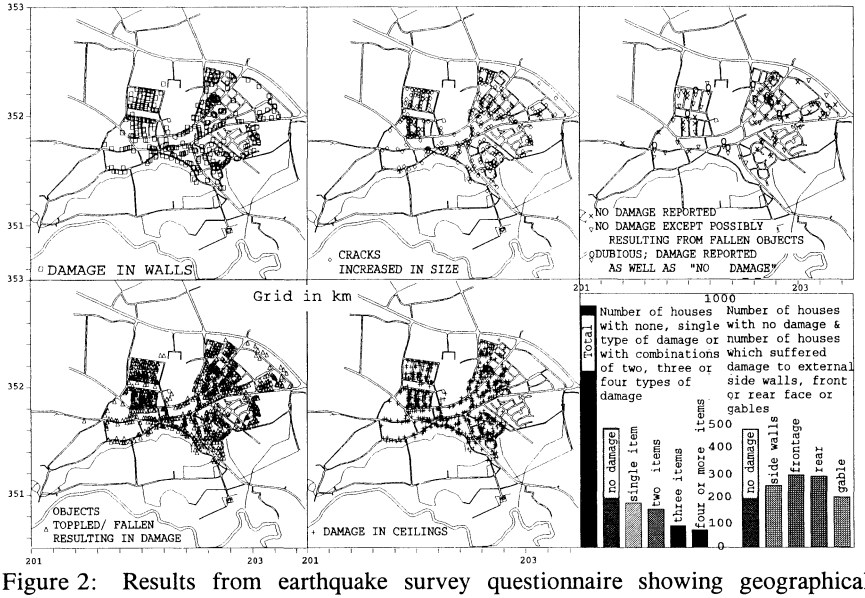


Figure 2: Results from earthquake survey questionnaire showing geographical distribution of various types of damage.

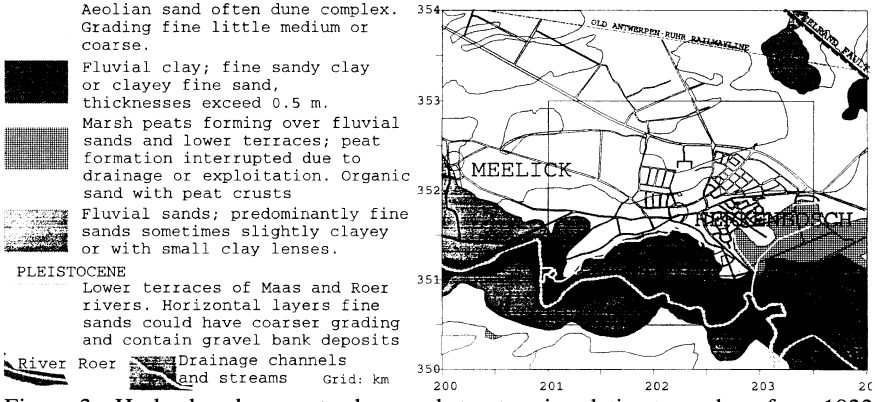


Figure 3: Herkenbosch present urban road structure in relation to geology from 1933 map[2]

## 4. GIS presentation

Presently the digitizing facility of the GIS programme ILWIS has been used to enter data from maps; the 1:10000 topographical map 58G Zuid[3] covering Herkenbosch, the municipality map[4] and the geological map[2]. All three maps use not only different scales but also different projections. The maps were combined to conform to the topographical map[3] Amersfoort coordinate system. Examples of geographical and statistical distribution of types of damage based on database selection criteria are given in Fig. 2. The geology map in Fig. 3 depicts the same geographical features as the thematic maps so as to enable comparisons with the type of information presented in Fig. 2.

Additional information from the Disaster Fund and municipal archives on specific building damage, valuation of damage, building design details and specific ground conditions will make such

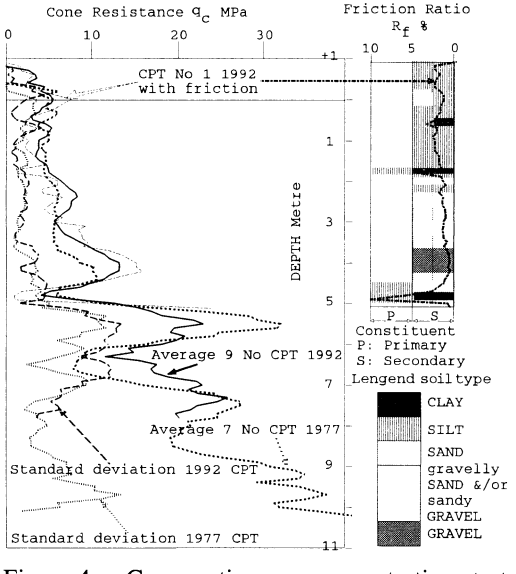


Figure 4: Comparative cone penetration tests (CPT) logs at site A (see Fig. 5), 1977 and July 1992. Note increase densities in sandy/ gravelly zones. Soil type based on $q_c$ - $R_f$ values taken from Searle's chart[13]

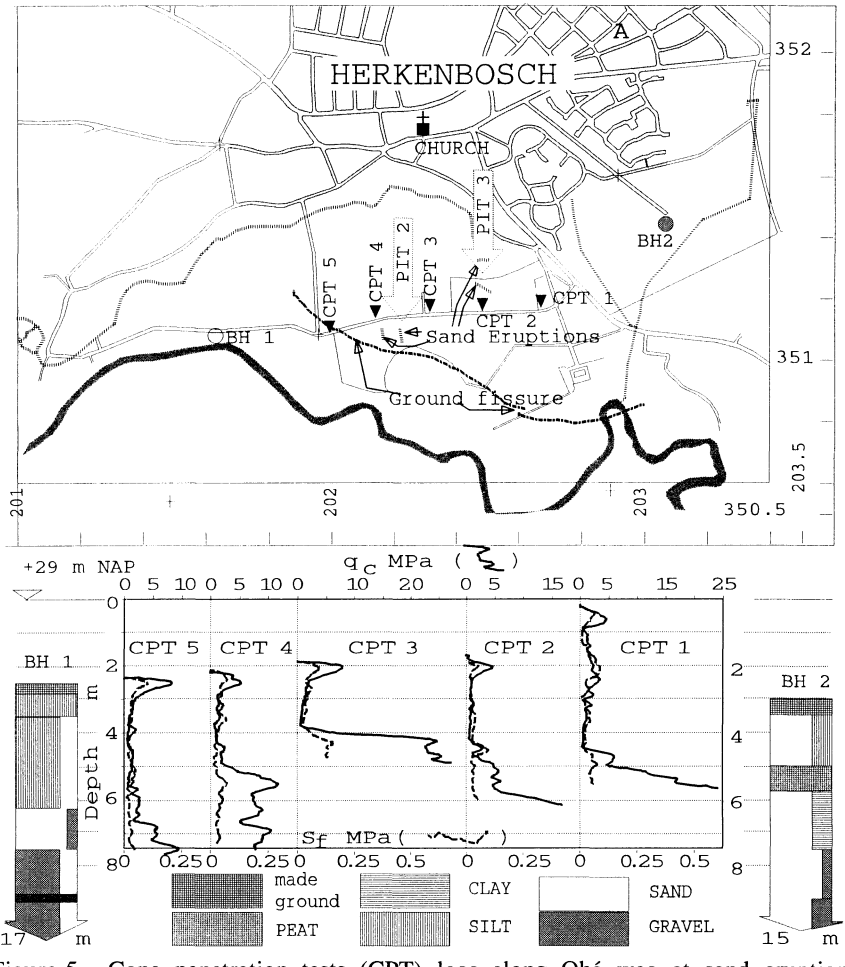


Figure 5: Cone penetration tests (CPT) logs along Ohé weg at sand eruptions (dewatering injection structures) locations and borehole soil constituent profiles indicating variation soil profiles southern flank of Herkenbosch.

correlations more pertinent. An example of ground condition analyses is given in Fig. 4 which shows the results from a site investigation in 1977 and a subsequent site investigation after the earthquake event in July 1992.

Additional investigation by boreholes and cone-penetration tests (CPT) are necessary to study those areas with insufficient information. A number of CPT's were performed along the Ohé weg, Herkenbosch, to determine the soil profiles at the location of the sand eruptions[5], Fig. 5.

## 5. Discussion

The aim of our study is to correlate damage to building with local ground

conditions. Even though no buildings collapsed, there is still room for design improvement. Our results will enable various disciplines to make use of the results; architects to design safer houses, planners to determine areas having less vulnerable subsurfaces and insurance assessors to determine premiums for various grades of earthquake damage for buildings and for soil conditions.

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## References

1. Abeki, N., T. Enomoto & H.O. Murakami 1991 Distribution of the seismic intensities for the Loma Prieta earthquake in San Francisco city by a questionnaire survey/ (ed R.D. Borcherdt) Vol.3 pp 311-318 *Proceedings of the 4th Int. Conf. Seismic Zonation,* Standford, 1991, Earthquake Engineering Research Institute, Oakland, California
2. Anon, Geologische kaart van Nederland 1:50000 Nr. 58 Roermond Kaartblad IV- Rijks Geologische Dienst, Haarlem, 1933
3. Anon, Topografische Kaart 1:10000 58 G zuid: Herkenbosch- Topografische Dienst, Emmen, 1987
4. Anon, Straatnaam Kaart, Kern Herkenbosch 1:2500- Dienst Openbare Werken Roerstreek, Gemeente Herkenbosch, 1985
5. Davenport, C.A., L.J.M. Lap, P.M. Maurenbrecher & D.G. Price 1993 Ground liquefaction and dewatering injection structures at Herkenbosch: field investigations of the effects of the Roermond 1992 earthquake- in Geol. & Mijnbouw **2-4,** 1994
6. Haak, H.W., L. Ahorner, P. Hoang-Trong, M. Meidow, R.W. Musson, Z. Schenkova & R. Verbeiren, Macroseismic observations for the Roermond earthquake- Geol. Mijnbouw **2-4**, 1994
7. Herbschleb, J., Ingeobase, design and implementation of an engineering geological database- Memoirs Centre Eng. Geol. Netherlands, Fac. Mining Petr. Eng. TU Delft **77**, 1990
8. Houtgast, G., Catalogus aardbevingen in Nederland-KNMI Publ. **179**, de Bilt, the Netherlands, 1992
9. Kronieger, R.R., Development of engineering-geological maps on construction materials in South-Limburg- TU Delft Prog. Rep. **13** 237-253
10. Lap, J.M.J., Earthquake-induced liquefaction potential in the area south of Eindhoven, The Netherlands- Memoir Centre Eng. Geol. Netherlands, Fac. Mining Petr. Eng. TU Delft **47** 1987

11. Outer, A. den, P.M. Maurenbrecher & G.T. de Vries Earthquake hazard mapping with questionnaires in the Roermond area, The Netherlands-(ed. R. Oliveira, L.F. Rodrigues, A.G. Coelho & A.P. Cunha) *Proc. 7th Congress Int. Ass. of Eng. Geol.*, Lisbon, Portugal, 1994, pp 2087-2094 A.A. Balkema, Rotterdam 1994
12. Pappin, J.W., A.R. Coburn & C.R. Pratt, Observations of damage ratios to buildings in epicentral region of Roermond, the Netherlands, earthquake of April 13, 1992- Geol. Mijnbouw **2-4**, 1994
13. Searle, I.W., The interpretation of the Begemann friction jacket cone results to give soil type and design parameter- *The measurement, selection and use of design parameters in Geotechnical Engineering- Proc. 7th Eur. Conf. Soil Mech.*, Brighton, 2: 265-270, 1979, British Geotechnical Society, London, 1979
14. Vries, G.T, Engineering geological thematic computer mapping fro Herkenbosch- the geotechnical component of SEIS- Memoir Centre Engng. Geol. Netherlands, Fac. Mining Petr. Eng., TU Delft, **115**, to be published 1995
15. Winkoop, A. van, Ingenieursgeologische atlas van Venray- Memoirs Centre Eng. Geol. Netherlands, Fac. Mining Petr. Eng., TU Delft, **7**: 37 pp, 1981