SEISMIC HAZARD ANALYSIS FOR THE NETHERLANDS

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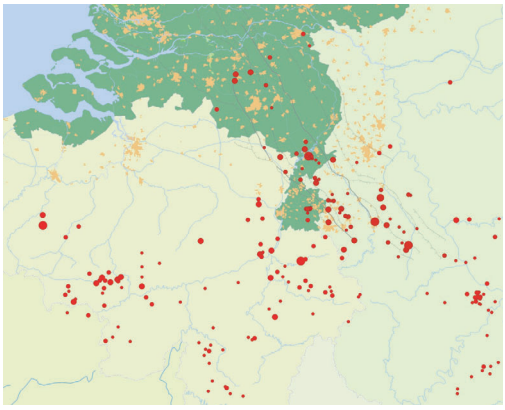
Seismic Hazard becomes more and more an issue of importance in earthquake engineering, politics and public interest. The last hazard analysis for the southern part of the Netherlands was carried out in 1996. Since then a lot more information is available and the requests coming from engineering companies and the government are becoming more specific. Therefore we are performing an update of that hazard analysis.

Data

260 events in the Netherlands, Belgium and Germany from 1750 - 2007 are used in this study. The magnitude of the events ranges from 2.5 to 6.0, the depth from 5 - 20 kilometres.



Seismicity in and around the southern part of the Netherlands from 1750 - 2007.

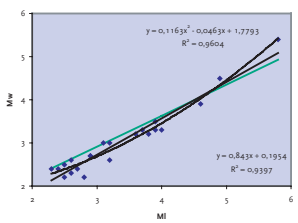
Logic tree

To analyse the influence of the different input parameters and to explore the ranges of the output of the hazard analysis, a logic tree approach is used. The input parameters of this approach are:

- Seismic zonation:
  1. Old KNMI 1996 zones
  2. Zonation used by Hinzen (Bensberg, GE)
  3. Zonation used by Leynaud (Liege, B)
- Attenuation relation:
  1. Ambraseys 1996
  2. Campbell 1997, 2003
  3. Berge-Thierry 2003
  4. Dost 2003
- Magnitude-Frequency relation:
  1. Same b-value for all sources
  2. Difference b-value in and outside Roer Valley Graben
- Maximum magnitude
  1. Ml = 6.4
  2. Different Ml - Mw conversions
  3. Including paleoseismicity:
     Mw = 6.1-6.6 (vd Berg et al. 2002)

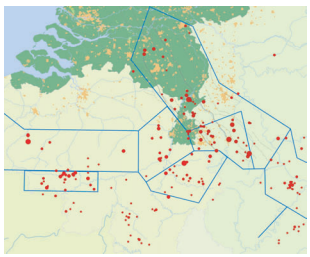
M_W versus M_L

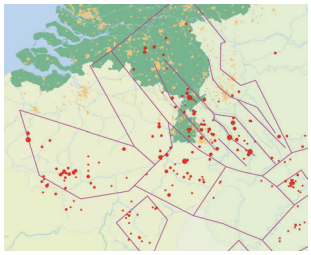
The magnitude of the events in the Netherlands is determined in Ml, but in the hazard analysis Mw will be used. The relation between Ml and Mw for the southern part of the Netherlands is determined based on 20 events for which both Ml and Mw is calculated.

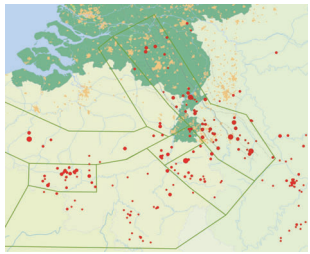


M_W as a function of M_L. Both a linear fit and a quadratic fit are determined. The green line represents the relation of Reamer and Hinzen (2004).

Zonation





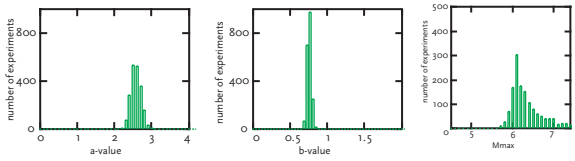


Maps with the three different zonations. Blue is the zonation used by the KNMI in 1996, purple is the zonation used by Hinzen when determining the hazard in the western part of Germany, green is the zonation used by Leynaud in 2000 for the hazard in Belgium.

Monte Carlo simulation

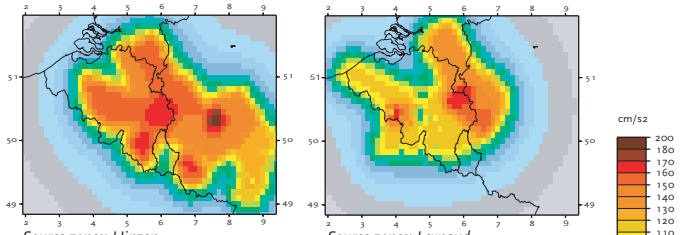
In a simulation of 2000 experiments the a- and b-values and the maximum magnitude were determined. The simulation calculates the best fit of a truncated exponential function to the data. In each experiment the data were randomly perturbed. The outcome shows the distribution of the parameters.

a = 2.66±0.14
b = 0.77±0.03
Mmax = 6.2±0.2



Seismic Hazard

Some examples of calculated seismic hazard with 3 different source zones and 2 different attenuation models. Mmax = Ml = 6.4 and the b-value is 0.77 for each zone.



Source zones: Hinzen
Attenuation relation: Ambraseys 1996

Source zones: Leynaud
Att relation: Ambraseys 1996

Source zones: KNMI
Att relation: Ambraseys 1996

Source zones: KNMI
Att relation: Campbell 2003

Conclusions

As can be seen in the hazard plots the influence of the zonation and the attenuation relation is significant. We are aiming at an in-depth variability analysis to determine the hazard uncertainties and the major factors influencing these uncertainties.

In addition to updating the hazard map a main goal of this study is to compare our results with the hazard studies done in Belgium and Germany and to achieve a well fitting map at the borders of the countries. This last issue is important for a relevant application of the Eurocode 8 in the border regions.

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