Site-specific ground motion models for soil sites with thick sedimentary layers

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Keywords: instrumental site classification, strong-motion database, ground motion prediction model, site-specific seismic action, soil sites with thick sedimentary layers, single station approach

1 ABSTRACT

As so far ground motion prediction equations (GMPE) for soil sites might be misleading if the selection of records is restricted to the uppermost 25 m or 30 m of the subsoil (and the average shear wave velocity \( v_{s,25} \) or \( v_{s,30} \)) and if the whole underlying geological depth profile is ignored. The concept of subsoil and geology-dependent ground classes (recently introduced into German Code DIN 4149: 2005) offers an alternative approach by the explicit consideration of the thickness of sedimentary layers and their effect on the site amplification as well as on the shape of site-specific spectra. As a whole, six respectively seven site-specific subsoil classes are distinguished. Despite the fact that alongside the river Rhine in Western and South-Western Germany, the thickness of the sediments is reaching several hundred metres, site-specific data and corresponding attenuation relationships are missing due to the lack of earthquakes and strong-motion records. The commonly used subsoil class “soft soil” (C) is replaced and differentiated by three classes (C-R, C-T, C-S), where C-R stands for soft soil above rock (with high amplification factor in a small plateau range), C-S for layers with more than 100 m thickness, and C-T for a transition range. Ground class C-S is connected with reduced site soil amplification factors (which can also be derived from site response analysis).

2 INTRODUCTION

Within a series of comprehensive instrumental site studies supported by USGS, Californian strong motion stations are classified with respect to their ground classes considering the characteristics of the uppermost 25 m of the subsoil overlaying the geological depth profile (Lang and Schwarz, 2006). Taking profit from an accompanying study (see Schwarz et al., 2007), as a whole 484 records from Californian “soil site” strong motion stations are considered. From this basic or primary dataset (DS I) spectral attenuation relationships are elaborated with different regression methods; the one with the smallest standard deviation is used.

The attribute of “site-specific” implements two further elements: the deaggregation of Probabilistic Seismic Hazard Assessment (PSHA) for the relevant design hazard level (i.e. \( 10^{-2}/a \) for N.P.P.) and the selection of recorded ground motion for the mean or modal (controlling) magnitude-distance combination. According to these principles, the design ground motion (DGM) is regarded as site-specific if ground motion data for the local depth profile are considered, exclusively, and if the database corresponds with the deaggregated hazard from PSHA results.

In the low seismicity areas of Central Europe and in cases where DGM for very low probability rates of exceedence is required, small magnitude and near field events (often neglected in common GMPE) are of importance. Therefore, further sets of data (DS II) are taken from aftershock records in Turkey during in 1999/2000 (DS II) and – as an innovative element of the whole approach - from seismic instrumentation at a reference site in Germany contributing to a third dataset (DS III).
The key and linking element of the presented procedure is the instrumental subsoil classification making the different datasets comparable and unique. Ongoing studies are related to a further refinement of the selection criteria by comparing not only the peak and amplitude level of H/V-spectra but also the frequency-dependent shape by a cluster analysis of all stations related to the target site and its depth profile.

The whole procedure can be characterized as a modified „single-station“ approach considering records from stations of comparable subsoil profiles under the assumption of similar site amplification effects. The impact of the datasets, their combination and composition on the ground motion prediction models (GMPE) are studied. Besides the realistic description of site-specific ground motion it will be discussed to which extent the procedure is contributing to a reduction in the uncertainty of ground motion models.

3 RESULTS OF INSTRUMENTAL SITE CLASSIFICATION OF RECORDING SITES

3.1 Californian strong motion recording sites (primary dataset DS I)

3.1.1 Overview

One of the world’s largest strong-motion networks, consisting of more than 1,200 accelerographs either installed in the free-field or inside of buildings, is contained within the borders of the state of California. Most of the stations are owned and maintained by the United States Geological Survey (USGS) and the California Strong Motion Instrumentation Program (CSMIP). In contrast to the large amount of high-quality strong-motion data from this network, an elaborated classification of the station’s subsoil conditions into groups that might share similar site amplifications is not available for most of the stations. This is because seismic velocities and geologic logs from borehole measurements or seismic experiments are missing for most of the strong-motion sites.

A compendium of available P- and S-wave velocity profiles and geologic data at a number of strong-motion sites in California is given by Boore (2003). In total, Boore (2003) summarizes the data of 277 boreholes in California, of which 160 are located in the vicinity of strong-motion stations. Since the assignment of borehole sites to strong-motion stations is solely based on the distance between them, a blind assumption of the geological subsurface properties may lead to misinterpretations of site-specific amplification potential. In addition to this, the drilling depths of most boreholes did not reach geological bedrock. This impedes the classification of the subsoil profile not only according to the consistency of near-surface soil materials (i.e. $v_{s,30}$) but also the total sedimentary thickness $H_{tot}$. In order to allow a more refined classification of subsoil conditions, even at those sites where geological information is missing, a hybrid procedure based on instrumental measurements and analytical investigations (analogy considerations) was developed and applied (see Lang and Schwarz, 2006).

3.1.2 Site classification

During a measurement campaign in spring 2004, instrumental microtremor recordings were conducted at nearly 300 strong-motion sites in the central and southern parts of California, providing the basis for a fast and cost-effective classification including even deep-sediment recording sites. Figure 1 shows the respective region of California with observed strong-motion stations. Primarily, the measurements were carried out between the south coast of San Pablo Bay in the North (north of San Francisco) and Imperial Valley in the South.

In order to allow a consistent site classification even of those Californian strong-motion sites where detailed information on the geological subsoil conditions is missing, a hybrid procedure based on analytical investigations of model soil profiles and instrumental measurements based on noise records was developed. This allows the classification of a site of interest into site-specific subsoil classes of the German seismic code DIN 4149: 2005 (NABau, 2005) simply by the shape of spectral H/V-ratio on micro-tremor data recorded at the site (Lang, 2004; Lang et al., 2004; Lang and Schwarz, 2006). In this respect, the main decisive factor is the location of its predominant peak in the spectral domain being characterized by a distinct and well-defined hump (see Fig. 2).
A site classification considering the uppermost soil layers as well as the depth-extension (total thickness $H_{\text{tot}}$) of sedimentary soil layers is contained in the current earthquake code of Germany DIN 4149: 2005 (Schwarz et al., 1999). Table 1 illustrates the possible combinations of soil condition classes A, B, C, and geological subsoil classes R, T, S. Their corresponding elastic design spectra as specified in the German code DIN 4149: 2005 are elaborated by Schwarz et al. (1999) and can be taken from previous papers (Schwarz et al., 2007). The commonly used subsoil class “soft soil” (C) is replaced and differentiated by three classes (C-R, C-T, C-S), where C-R stands for soft soil above rock (with high amplification factor in a small plateau range), C-S for layers with more than 100 m thickness, and C-T for a transition range (25 to 100 m). Ground class C-S is connected with reduced site soil amplification factors (which can also be derived from site response analysis). Example sites with corresponding and quite distinguished H/V spectral noise ratios and the applied classification scheme are given by Figure 2.

Table 1. Possible combinations of site classes according to the German seismic code DIN 4149: 2005.

<table>
<thead>
<tr>
<th>Soil condition class</th>
<th>Geological subsoil class</th>
<th>Ground classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R: areas pred. characterized by rocks</td>
<td>T: transition zones between R and S</td>
</tr>
<tr>
<td>A: firm to medium-firm soil</td>
<td>$v_{s,25} \geq 800$</td>
<td>A-R</td>
</tr>
<tr>
<td>B: loose soil (gravel to coarse sands, marls)</td>
<td>$350 &lt; v_{s,25} \leq 800$</td>
<td>B-R</td>
</tr>
<tr>
<td>C: fine-grained soil (fine sands, loesses)</td>
<td>$150 &lt; v_{s,25} \leq 350$</td>
<td>C-R</td>
</tr>
</tbody>
</table>

1) Average shear-wave velocity of the uppermost 25 m of subsoil materials [m/sec].
2) As proposed by Schwarz et al. (1999). Combination B-S is not considered in DIN 4149: 2005.
While the number of records in dataset DS I is permanently growing due to the events recorded from Californian stations. The entire earthquake database herein applied consisted of 653 strong-motion records of around 100 near-field events being recorded at 183 stations at time of the first data elaboration and publication of ground motion prediction equations (GMPE) by Schwarz et al. (2007). The recently available number of data can be taken from Table 2.

As it was already addressed, a subsoil classification of the recording sites was conducted on the basis of instrumental micro-tremor measurements (Lang and Schwarz, 2006) allowing a subdivision of the entire dataset into site-specific subsoil classes of the German seismic code DIN 4149: 2005. As it becomes obvious from Figure 3 showing the magnitude-distance relationship of applied earthquake events depending on DIN 4149: 2005 site classes, site class C-S holds the majority of earthquake records, while site classes C-R and C-T show only a few records.

**Table 2. Number of records within the different Site and Data Categories (SDC)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Soil Classification</th>
<th>No. of records for the resp. DIN 4149 site classes</th>
<th>Site and Data Category (SDC)</th>
<th>No. of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>data combinations and site-specific (^1) (DIN 4149: 2005)</td>
<td></td>
<td></td>
<td>653</td>
</tr>
<tr>
<td></td>
<td>A-R</td>
<td>B-R</td>
<td>B-T</td>
<td>C-R</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>10</td>
<td>61</td>
<td>41</td>
</tr>
<tr>
<td>II</td>
<td>site-specific (^1) (DIN 4149: 2005)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A-R</td>
<td>C-R</td>
<td>C-T</td>
<td>C-S</td>
</tr>
</tbody>
</table>

**Annotations:**

1. Points (●) indicate the DIN 4149: 2005 site class for which the regression analysis is performed.
2. Number of records onto which the regression analysis rests upon (shaded area).
3. Representing the conventional site classes (rock, stiff soil, soft soil) as defined by Ambraseys et al. (1996).
4. Representing the critical site class E (Eurocode 8).
As it becomes obvious from Figure 3, showing the magnitude-distance relationship of applied earthquake events depending on DIN 4149: 2005, soft soil site classes, class C-S holds the majority of earthquake records, while site classes C-R and C-T show only a few records. In Schwarz et al. (2007) the applied database is broken down into specified types of magnitudes and computable types of distances. Basically, moment magnitudes $M_W$ and local magnitudes $M_L$ were available, while a transition between both types of magnitudes happens around magnitude 5 to 6. In general, moment magnitudes $M_W$ are used for regression analysis; in case of lacking information local magnitudes $M_L$ are taken (assuming $M_W = M_L$). For larger magnitude events where information about the spatial dimension of the rupture area is available, the Joyner-Boore-distance $r_{JB}$ is calculated, while the epicentral distances $r_e$ are assigned to the smaller magnitude records.

3.2 Aftershocks records form German TaskForce and field missions to Turkey (dataset DS II)

3.2.1 Overview and database

The temporary strong-motion network of the German TaskForce for Earthquakes which was installed immediately after the 1998 Adana and the 1999 Kocaeli and Duezce (Turkey) earthquakes provides a unique database of aftershocks for which the efficiency of a subsoil- and geology-dependent classification scheme could be tested. In a series of parameter studies concerning the future directions in strong-motion instrumentation (Schwarz et al., 2005) it was emphasized that starting from the whole (site-independent) database and the differentiation or sampling of data, precedence has to be given to the sub-classification of site conditions. Dataset DS II is taken from recordings in Turkey where site classification was performed at the sites of strong-motion stations (see Lang et al., 2004; Schwarz et al., 2005).
4 GROUND MOTION PREDICTION EQUATION FOR THE HORIZONTAL COMPONENT AND RESULTANT

4.1 Data elaboration and regression types

In order to emphasize the influence of near-surface geology and total thickness of sedimentary materials on the results of ground-motion prediction equations, different concepts of soil classification can be regarded (see Lang & Schwarz, 2006). Table 2 gives an overview of these analyzed datasets being composed of those records classified into the six (seven) different site classes of DIN 4149: 2005. While Regression type I is restricted to one single data group, Type II distinguishes between the six (+1) site classes of Table 1. In addition, different compositions of the DIN 4149 site classes according to conventional (e.g., Ambraseys et al., 1996) or other site-specific classification concepts (e.g., disregarding the classes for stiff soil layers above bedrock) are generated in type “soil1” to “soil4” to illustrate the impact of classification limits.

Generally, two different types of regression analyses are elaborated differing in the applied regression model (equation (1) and (2)) and in the size of the dataset to rest upon (see Table 2).

Regression type I: The dataset is restricted to records on those site classes for which the ground motion prediction is worked out. Since not all of DIN 4149: 2005 site classes are well-represented by a certain number of records (see Table 2, Figure 3), a regression analysis for some of these site classes (e.g. C-T) may not be representative and is omitted. The general form of the regression is given by equation (1). The regression model to be used for Regression type I is given by equation (2). Since both types of regression are based exactly on that type of data (narrowed dataset) for which a prediction is elaborated, no site coefficients are incorporated:

$$\log (y) = C_1 + C_2 M + C_3 \log (r) + \sigma P$$  \hspace{1cm} (1)

In order to predict ground motion parameters (horizontal PGA and spectral acceleration) the same regression model is used as proposed by Ambraseys et al. (1996). Merely a refinement is introduced by substituting the conventional site classes (rock, stiff soil, soft soil) for the site-specific subsoil classes of DIN 4149: 2005 (see Table 1).

Regression type II: Irrespective of the DIN 4149: 2005 site classes (for which the ground motion prediction is to be elaborated) the regression analysis is based on the entire dataset covering all events recorded at all types of subsoil. Based on pure rock-type soil conditions, coefficients are determined for the respective site class according to the classification concept of DIN 4149: 2005. A ground motion prediction for a specific site class (i-j; i-soil class, j-geological class) is performed by setting/adjusting the respective “Dummy” variable $S_{(i,j)} = 1$ while all others to 0, thus solely determining the respective coefficient $C_k$. Consequently, a calibration of the results for the particular site classes is ensured. The general form of the regression model is represented by equation (2):

$$\log (y) = C_1 + C_2 M + C_3 \log (r) + C_4 S_{(B,R)} + C_5 S_{(C,R)} + C_6 S_{(B,T)} + C_7 S_{(C,T)} + C_8 S_{(B,S)} + C_9 S_{(C,S)} + \sigma P$$  \hspace{1cm} (2)

with $y$ the ground motion parameter in g (PGA or $S_a$), $M$ the magnitude ($M_w$), $r$ a function of the distance measure ($r = \sqrt{d^2 + h^2}$), while $d$ is the distance (either epicentral $r_e$ or fault distance $r_{fb}$) and $h$ the source depth, and $P$ the uncertainty in the GMPE. For further analysis the resultant of both horizontal components will be utilized following vector sum approach of SDOF-responses proposed by Schwarz and Ahorner (1995).

4.2 Horizontal peak ground acceleration depending on the composition of dataset

Adopting the “site-specific” regression analysis to the entire dataset and thus deriving site coefficients $C_k$ for horizontal peak ground acceleration $PGA$, for dataset DS I equation (2) transforms into:

$$\log (PGA) = -1.3593 + 0.50699 M - 1.17702 \log (d^2 + h^2)^{0.5} + 0.23781 S_{(B,R)} + 0.16351 S_{(C,R)}$$
$$- 0.02792 S_{(B,T)} + 0.09793 S_{(C,T)} + 0.08513 S_{(B,S)} + 0.12414 S_{(C,S)} + 0.289 P$$  \hspace{1cm} (3)
7

(a) Comparison with “soft soil” PGA according to GMPE for the component derived by Ambraseys et al. (1996) and Ambraseys et al. (2005)

(b) Results for different combinations of the datasets elaborated for this study (for DS III see sect. 5); using GMPE given by Table 3

Figure 5. Attenuation of the resultant of the horizontal ground acceleration components for SDC “soft 1”

For dataset DS II equation (2) is predicted as follows:

\[
\log (PGA) = -0.67121 + 0.52502 M - 1.59205 \log (d^2 + h^2)^{0.5} + 0.36212 S_{(B-R)} - 0.03126 \left(1 - - 0.21383 S_{(B-T)} + 0.41319 S_{(C-T)} - 0.00227 S_{(B-S)} + 0.02178 S_{(C-S)} + 0.39686 P \right)
\]

To receive an impression about the level of PGA values derived by equation (3), Figure 5(a) correlates the attenuation curves of this study with the results of the ground motion prediction models published by Ambraseys et al. (1996) and Ambraseys et al. (2005). Results for the different combinations of the datasets DS elaborated for this study are compared in Figure 5(b). DS III implies the results of a site-specific instrumentation programme for a low seismicity site in Germany, presented in section 5, subsequently.

As shown in Figure 3, site class C-S has the highest number of available records in dataset DS I; site class C-T is dominating in DS II (see Figure 4). Due to methodical reasons all site and data categories (SDC) have been analyzed. The respective coefficients for the prediction of peak ground acceleration according to equation (2) are given in Table 3. From the preliminary results it can concluded that the uncertainty (expressed by the error term \(\sigma\) “Sigma”) is increasing if different datasets are combined. Nevertheless, it should be noticed that in this study, a refined definition of the source parameter is not the primary intention and a topic of further refinement. This is especially true for the strong-motion data from dataset DS II.

With regard to the possible and relevant magnitude and distance pairs it can be stated that combinations \(M = 5.0\) and \(d \leq 25\) km (see Figure 6) can be regarded as being significant for structural design in Central European earthquake regions. It is located (except for site class A-R) in the “inner” data range for dataset DS I; and for DS II at data border, where no recordings are available. Higher magnitudes and far events (not significant for Central European design practice) lies at the “outer” border of the dataset DS I.

Table 3. Regression coefficients for Regression type I (equation (1)) and soft soil site classes.

<table>
<thead>
<tr>
<th>Dataset DS</th>
<th>Site class</th>
<th>(C_1)</th>
<th>(C_2)</th>
<th>(C_3)</th>
<th>(\sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Soft 1</td>
<td>-1.2683</td>
<td>0.5083</td>
<td>-1.1720</td>
<td>0.2877</td>
</tr>
<tr>
<td></td>
<td>Soft 2</td>
<td>-1.2489</td>
<td>0.5020</td>
<td>-1.1633</td>
<td>0.2866</td>
</tr>
<tr>
<td></td>
<td>Soft 3</td>
<td>-1.2626</td>
<td>0.5009</td>
<td>-1.1486</td>
<td>0.2889</td>
</tr>
<tr>
<td></td>
<td>Soft 4</td>
<td>-1.4987</td>
<td>0.4989</td>
<td>-0.9649</td>
<td>0.3154</td>
</tr>
<tr>
<td>I + II</td>
<td>Soft 1</td>
<td>-1.1928</td>
<td>0.5185</td>
<td>-1.2489</td>
<td>0.2990</td>
</tr>
<tr>
<td></td>
<td>Soft 2</td>
<td>-0.0712</td>
<td>0.4398</td>
<td>-1.6318</td>
<td>0.3593</td>
</tr>
<tr>
<td></td>
<td>Soft 3</td>
<td>-0.0628</td>
<td>0.4388</td>
<td>-1.6298</td>
<td>0.3645</td>
</tr>
<tr>
<td></td>
<td>Soft 4</td>
<td>-0.0675</td>
<td>0.4537</td>
<td>-1.7930</td>
<td>0.3916</td>
</tr>
<tr>
<td>I + II + III</td>
<td>Soft 1</td>
<td>-1.2585</td>
<td>0.6064</td>
<td>-1.5095</td>
<td>0.3532</td>
</tr>
</tbody>
</table>
Based on predicted spectral accelerations for discrete magnitude-distance-combinations the influence of covered data on the results is checked. A comparison between predicted spectral accelerations using regression type I and Eq. (1) illustrates the circumstance, that site class C-S obviously holds the majority of the applied database DS I. The prediction curves of Regression type I which can be regarded as site-independent (“all soils”) clearly reflect the similarities to spectral curves for site class C-S derived with regression type II (cf. Schwarz et al., 2007). Figure 6 illustrates the influence of a stepwise enlargement of the different datasets on the predicted spectral accelerations and compares them with the results of Regression type II and Eq. (2). The differences in predicted spectral accelerations between the same site classes but resting upon different SDC (e.g., A-R and rock 1, C-S and soft 1) strongly depend on the number of records available for the respective site class.

The influence of a dataset enlargement by additional datasets from other regions as for DS II (shown here in Figure 7) can result lead to surprising results if their amount is large in comparison to the “starting” dataset. The dominant presence of records for rock and soft soil (C-T) sites in DS II (Turkey) contributes to slightly deviating results; this effect is overlapped by the consequences if GMPE are extrapolated from lower magnitudes (of the existing data, see Figure 4) to higher ones (not covered by the data), and by the uncertain distance definition for DS II recordings (assuming a point source instead the more reliable fault line solution, leading in this study to unrealistic high spectral and ground motion predictions). It is a task of ongoing studies to refine the originally, immediately after the Task Force missions determined parameters. In order to extent the database for those site classes where only a small number of records is available, additional earthquake data from recently completed instrumental site investigation in Greece can to implemented.

Figure 6. Comparison of predicted spectral accelerations for dataset DS I and different levels of categorization (SDC) in order to illustrate the influence of record number the regression rests upon

(a) rock; $M = 5.0, d = 25$ km  (b) soft soil, $M = 5.0, d = 25$ km  (c) soft soil, $M = 6.0; d = 80$ km

Figure 7. Comparison of predicted spectral accelerations for dataset DS I + DS II for different levels of categorization (SDC)

(a) rock; $M = 5.0, d = 25$ km  (b) soft soil, $M = 5.0, d = 25$ km  (c) soft soil, $M = 6.0; d = 80$ km
5 APPLICATION TO A LOW SEISMICITY REFERENCE SITE

In the low seismicity areas of Central Europe and in cases where design ground motion for very low mean annual exceedance frequency is required, small magnitude and near field events (often neglected in common GMPE) are of importance. Therefore, the supplementation of the dataset with smaller magnitude records will be of the most importance such that a more homogeneous database is composed. In order to acquire more data, at a N.P.P low seismicity reference site sensitive seismographs having a recording capability for micro-earthquakes have been installed and operated. Within a three year lasting monitoring period several tectonic and mining induced earthquakes (in general far distant) occurred having very low amplitudes, i.e. they are not recorded by the permanent seismic instrumentation.

![Figure 8](image1.png) ![Figure 9](image2.png)

**Figure 8.** Earthquakes (tectonic and mining induced) in target site vicinity from 01/2006 to 12/2008

**Figure 9.** Database of the reference site with thick sedimentary layers (including DS III)

From Figure 8 it becomes quite evident that a much longer (at least several years in continuation) operating time of seismic instrumentation is necessary to obtain meaningful data. Nevertheless, within this short test period several earthquakes could be identified being elaborated as database DS III. For the GMPE, only records with magnitudes $M \geq 2.0$ and distance $d \leq 200$ km are considered (see Figure 9).

During a different measurement campaigns, instrumental micro-tremor recordings were conducted at different sites within the N.P.P, providing the basis for the site classification and the calibration of the depth profile. A large set of H/V spectral noise ratios (including measurements at day and night time, in the week, over the weekend) supported the quite stable quality of the elaborated basis data for the site classification; according to the scheme of Figure 2(a) clearly indicating a (C-S) soft soil site, underlain by very thick layers of sediments reaching several hundreds of meters (Lang, 2004). Within one initial period of test measurements, a series of small earthquakes (with magnitudes $M_L = 1.9$ and 2.0 in distances of 12 to 14 km) could be recorded in June 2002; the data points are included in Figure 9. The H/V spectral noise ratios for the length of the earthquake and the pre-event noise are given by Figure 10.

Attenuation relationships (GMPE) should be compatible with the reference site condition, and should be consistent with the attenuation characteristics of the region of interest. Making use of the site-specific ground motion data, dataset DS III can be combined with those previously presented for the same site and data category. As a first outcome of this procedure, Figure 5(b) shows the PGA for all datasets (see also Table 3.)

![Figure 10](image3.png)

**Figure 10.** H/V-spectral ratio from weak near-field earthquakes and pre-event noise measurements
6 CONCLUSIONS

On the basis of a database composed of uniformly elaborated sub-datasets and records which are site-specific with respect to the depth profile and their site classification different GMPE can be derived depending on the conditions of the target site. The instrumental site classification and corresponding characterization of the recordings enables a site-dependent selection of those data which are most appropriate for the hazard level (and the deaggregation of magnitude and distance parameters) as well as for the refinement of site characterization. The dataset for the required site-specific GMPE can be qualified by records from the target (reference) site. The advantage of the approach is quite evident: The equations can be used as input parameters for PSHA, directly. Additional uncertainties resulting from the site response analysis can be avoided. The data reflect the local amplification particularities for the spatial ground conditions. Results are realistic and more reliable than those from hypothetically site response studies.

Datasets with a different level of ground motion amplitude can combined if they are similar with respect to the H/V spectral ratio. The proposed concept might be considered as practical implication of a single-station approach if the quality of H/V spectra is used to identify the recording sites best fitting the depth profile of the reference site. Next steps of the presented (still ongoing) studies are focussed on the implementation to PSHA (including lower bound motion filter) and further site amplification considerations.

REFERENCES


