Identification of the Subsoil Profile Characteristics at the Coyote Creek Outdoor Classroom (CCOC), San José, from Microtremor Measurements - A Contribution to the CCOC Blind Comparison Experiment

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1 INTRODUCTION

In spring 2004 instrumental measurements on ambient seismic noise (microtremors) were conducted at the Coyote Creek Outdoor Classroom (CCOC) in San José, California.

As can be seen from the roadmap in Figure 1, the outdoor classroom is located in the eastern part of San José, approximately one mile west of Hwy101/I280-junction close to William Street Park.

A small stream, so-called Coyote Creek runs alongside the premises of the outdoor classroom and right through William Street Park in north-south direction.

Surface topography of the regarded area can be described as flat, although a very slight slope towards the course of Coyote Creek can be stated.

Figure 1. Roadmap of the eastern San José area indicating the three different recording sites.

Table 1. Overview of investigated recording sites.

Station	Index	Latitude	Longitude	Surface topography, geology
Coyote Creek Outdoor Classroom	CCOC	37.3369°N	121.8692°W	flat, gravels
William Street Park - west	WSPw	37.3350°N	121.8688°W	slight slope, gravelly soil
William Street Park - east	WSPe	37.3362°N	121.8655°W	flat, loamy soil

2 INSTRUMENTAL MEASUREMENTS

In order to increase reliability of measurement results, two sites located inside of William Street Park (WSPw and WSPe) were observed in addition to the CCOC site. The three stations almost describe an isosceles triangle having side lengths between 220 m (720 ft) and 330 m (1080 ft); cf. Figure 1. The coordinates as well as visually examined geological conditions at the ground surface are given in Table 1.

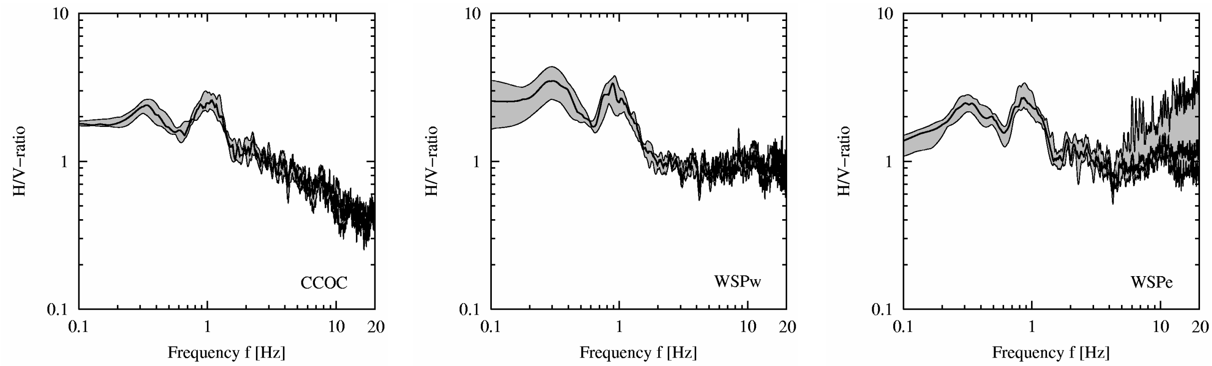
The instrumental measurements were conducted during the daytime using a RefTek data acquisition system of the 72A series and a triaxial seismometer of type Lennartz LE3D/5sec.

At each site microtremors were recorded for approximately 30 minutes with a sampling rate of 100 Hz, while care was taken in order to keep the recording free from very local noise sources, like e.g. passing pedestrians or vehicles. Meteorological disturbances, e.g. rainfall or gusty wind, did not occur during the instrumental observations.

Data of the overall recording duration was divided into several time windows each having a length of 81.92 seconds (8,192 samples). Fast Fourier spectra (FFT) were calculated for each time window of the vertical and both horizontal components. After smoothing the curves of the FFT-spectra, horizontal-to-vertical ratios were generated for each respective time window. Figure 2 illustrates the analysis results for station CCOC, WSPw, and WSPe. The bold lines represent the arithmetic mean value of spectral H/V-ratios for all time windows, the gray-shaded area marks the range of the 16% and 84% percentiles, respectively.

If we take it for granted that spectral H/V ratios on microtremor data (HVSR) recorded at the ground surface represent the quasi-transfer function of S-waves of the underlying soil profile, transfer characteristics at all three investigated sites are nearly comparable. To substantiate this, Figure 3 compares the mean curves of HVSR at the three different sites. It can be seen that only minor deviations between the three functions exist.

Microtremor measurements at the CCOC site were already conducted by another scientific group two years before (ASTEN, 2002). A comparison between the spectral H/V-ratios on microtremors calculated by ASTEN with own investigation results is illustrated in Figure 4. Clear agreements exist between both curves particularly regarding spectral peaks in the frequency range below 1 Hz. The consistency of both investigations based upon unequal instrumental equipment and different ways of analysis may substantiate reliability of the results.



(a) *(b)* *(c)*

Figure 2. Spectral H/V-ratios on microtremor data recorded at the three different sites (bold line: arithmetic mean value, gray-shaded area: mean value +/− standard deviation).

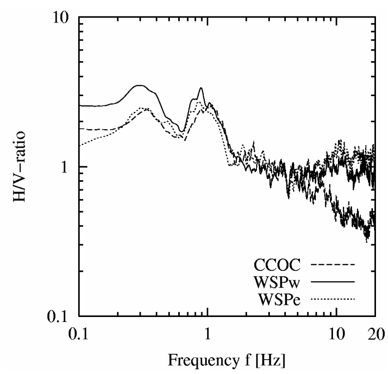


Figure 3. Comparison between arithmetic mean curves of spectral H/V-ratios on microtremors at the different recording sites.

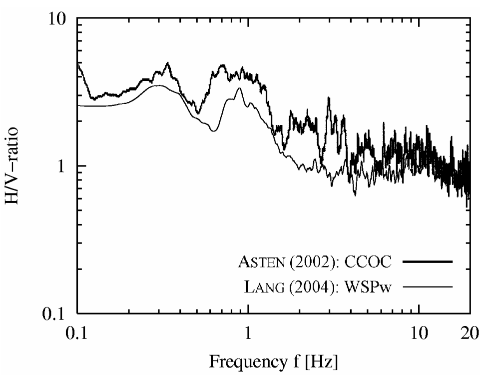
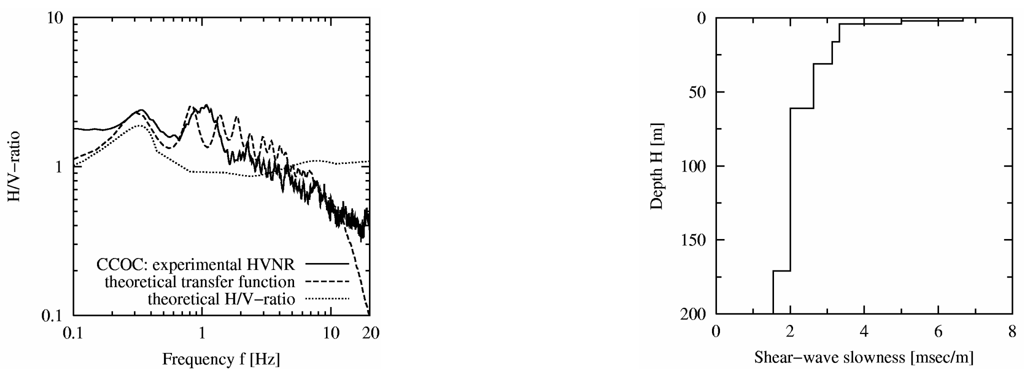


Figure 4. Spectral H/V-ratio on microtremors determined by LANG (2004; site WSPw) compared with that derived by ASTEN (2002; site CCOC).

3 GENERATION OF A SUBSOIL PROFILE

For the generation of a representative subsoil profile at site CCOC an approximation of its theoretical transfer function TF_{theo} to the experimentally appointed transfer function TF_{quasi} (i.e. the spectral H/V-ratio) is performed. This was done following the procedure suggested by LANG *et al.* (2004). Since each individual peak of spectral H/V-ratio refers to a certain layer of the underlying subsoil profile, a model profile for site CCOC could be generated (cf. Figure 5a). The spectral H/V-ratio on microtremors is superimposed to the corresponding theoretical transfer function of vertically propagating shear waves as well as theoretical H/V-ratio (dispersion function of Rayleigh waves) in Figure 5a. The latter being calculated using the algorithm described by ENDE (2000). Table 2 describes the stratigraphy of the derived model profile down to geological bedrock by specifying the mechanical and dynamic parameters of the single subsoil layers.



(a) *(b)*

Figure 5. (a) Comparison between experimental transfer function (HVSR) and theoretical transfer functions of the derived subsoil profile, (b) corresponding shear-wave slowness model of the uppermost 200 m.

Table 2. Parameters of the derived subsoil profile at site CCOC.

Layer	Depth H [m]	Thickness h [m]	Density ρ [tons/m³]	Damping ξ [%]	S-velocity v_s [m/sec]	S-slowness [msec/m]	P-velocity v_p [m/sec]
1	2	2	1.65	8.0	150	6.67	180
2	4	2	1.70	8.0	200	5.00	250
3	16	12	1.70	7.0	300	3.33	500
4	31	15	1.75	7.0	320	3.13	650
5	61	30	1.75	6.0	380	2.63	800
6	171	110	1.80	3.0	500	2.00	1300
7	521	350	1.80	1.5	650	1.54	1300
8	-	∞	2.00	0.5	1300	0.77	2252

4 CONCLUSIONS

Herein, instrumental microtremor recordings at the ground surface and the application of the spectral H/V-ratio technique establish the main basis for the generation of a representative subsoil profile at the site CCOC.
In order to reach this goal, a hybrid procedure of an experimental seismic site assessment (LANG 2004; LANG *et al.*, 2004) was applied, which intrinsically was developed for a fast and convenient site classification.

With regard to the geological map of California (cf. Figure 6; JENNINGS, 1977), the city of San José and consequently the site of Coyote Creek Outdoor Classroom (CCOC) is located right within an alluvial basin south of San Francisco Bay. For this reason, Holocene sediments with total thicknesses of several hundred meters should be expected here.

The derived subsoil profile for site CCOC exhibits a total thickness of sedimentary subsoil layers (v_s < 800 m/sec) of more than 500 m. Shear-wave velocity of the uppermost 30 m can be estimated to $v_{s,30}$ = 280 m/sec. According to the NEHRP classification concept (BSSC, 2001) this would come up to site class D (stiff soils with 180 < $v_{s,30}$ < 360 m/sec). A more refined classification of the NEHRP scheme was proposed by BRAY & RODRÍGUEZ-MAREK (1997) subdividing site classes A to F according to the predominant site frequency f_s. Thus, class D-3 (very deep stiff soil with soil depth H > 200 m) being characterized by site frequencies $f_s \geq 0.5$ Hz could be assigned to site CCOC.

Figure 6. Cutout of the Geological Map of California indicating the San Francisco Bay area (JENNINGS, 1977).

ACKNOWLEDGMENTS

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REFERENCES

ASTEN, M.W. (2002). An assessment of information on the shear-velocity profile at Coyote Creek, San José, from SPAC processing of microtremor array data. Extract of an unpublished report, Monash University Melbourne, 2002.

BUILDING SEISMIC SAFETY COUNCIL (BSSC) (2001): NEHRP recommended provisions for seismic regulations for new buildings and other structures, 2000 Edition, Part 1: Provisions, prepared by the Building Seismic Safety Council for the Federal Emergency Management Agency (Report FEMA 386), Washington, D.C.

BRAY, J.D. & A. RODRÍGUEZ-MAREK (1997): Geotechnical site categories. Proceedings of the First PEER-PG&E Workshop on Seismic Reliability of Utility Lifelines, San Francisco/CA, 1997.

ENDE, C. (2000): Development of a program for ground response analysis with respect to SASW and the Nakamura method. Project work 00:1, Division of Soil and Rock Mechanics, Dept. of Civil and Environmental Eng., Royal Institute of Technology, Stockholm/Sweden, 2000.

JENNINGS, C.W. (1977): Geological map of California. Compilation by Charles W. Jennings with assistance from R.G. Strand and T.H. Rogers (1969-1973). State of California, Divison of Mines and Geology, 1977 (Fifth printing, 2000).

LANG, D.H., J. SCHWARZ & C. ENDE (2004): Subsoil classification of strong-motion recording sites in Turkish earthquake regions. Schriftenreihe der Bauhaus-Universität Weimar 116, 2004.

LANG, D.H. (2004). Damage potential of seismic ground motion considering local site effects. Scientific technical reports 1, (ISBN 3-86068-227-X). Earthquake Damage Analysis Center, Bauhaus-University Weimar, 2004.