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1 SEISM 1.1 MODIFICATIONS

The probability that future seismic events will adversely affect the performance of the proposed Yucca Mountain (YM) repository has been identified as one of the five Key Technical Subissues in the Structural Deformation and Seismicity (SDS) Key Technical Issue (KTI). A fundamental task of the SDS KTI is determining the hazard associated with earthquake activity at or near the proposed repository site. The future prediction of seismic events relies on an understanding of the timing, location, and character of past seismic events in the **YM** region. The modified SEISM 1.2 code can be used to evaluate the probability of future seismic events in the YM region.

This report does not detail the original character of the SEISM code as acquired from Lawrence Livermore National Laboratory (LLNL) by CNWRA. The code had been used by Nuclear Regulatory Commission (NRC) for some time prior to original changes accomplished by CNWRA (Hofmann and Menchaca, 1995). The seismic hazard code was modified by the CNWRA to work for western locations in the United States and was identified as SEISM Version 1.1. However, since the original modifications by ~~Hofmann~~ and Menchaca (1995), significant time and the ensuing retirement of Hofmann have necessitated a change in internal CNWRA responsibility for the code. As a result, CNWRA determined it to be necessary to (i) re-create results originally published by Hofmann and Menchaca (1995) to verify that the SEISM 1.1 code functions appropriately and to baseline its status and output, (ii) modify the baselined SEISM 1.1 code to incorporate FORTRAN libraries designed to make the operation easier for the user, (iii) amend the newly-modified SEISM 1.1 code appropriately to make it portable to platforms other than the Cray or **SUN** IPX, particularly to SUN workstations which reside at the CNWRA and at the **NRC**, and (iv) generate the code SEISM version 1.2 for the Software Configuration Control System (SCCS) and future use.

1.1 VERIFICATION OF RESULTS FROM SEISM 1.1 CODE

The function of SEISM 1.1 is to provide the user with a convenient and efficient means to evaluate seismic and fault displacement hazards using data from the YM region. Input data necessary for defining a SEISM 1.1 run is provided by elicitation of experts or by compiling published information ("pseudo-participants") to establish seismic source zones, earthquake recurrence, and vibratory-ground-motion functions for the area of interest. Additional expert opinions are required for a self-appraisal of the likelihood that the estimates or alternate estimates are correct. One test conducted by Hofmann and Menchaca (1995) used data from an east coast reactor shifted 35 degrees of longitude to the west, while a second test used data from the YM area to test the functionality of the code with western United States seismic attenuation functions and narrow source zones designed to approximate faults. Published interpretations or opinions (rather than a formal elicitation of experts) of paleofault offsets were used as the bases for long-term seismicity in the test analysis of the YM area in lieu of non-existent, historical earthquake records for the required extended base period (now 10,000 years).

To verify that the archived SEISM 1.1 code was operating as designed, input data files and source files used to generate the SEISM 1.1 results of Hofmann and Menchaca (1995) were identified. A new directory (/usr3/seism) was created and all known files necessary to run SEISM 1.1 were copied into this new directory. The pre-modification files found in /usr2/pinafore and /usr3/pinafore were backed up to magnetic tape prior to current modifications. These unmodified files can be restored to replace files that are inadvertently lost or corrupted in subsequent code updates. The SEISM 1.1 code was run in the

/usr3/seism directory. Results of that run were the same as those obtained by Hofmann and Menchaca (1995) verifying the integrity of the code.

SEISM 1.1 output is a hazard curve that depicts the annual probabilities of exceedence of ground accelerations anticipated at a site based on the nature, occurrence, and distribution of seismic sources. Probabilistic design spectra may also be expressed in hazard curve form by using alternative attenuation functions.

1.2 INCORPORATION OF NEW FORTRAN LIBRARIES INTO SEISM 1.1

The libraries IMSL, TVSOLIB, and DIGLIB were copied from Lawrence Livermore to SwRI. These libraries were expanded and un-tarred. A new FORTRAN source library was then built for selected IMSL, TVSOLIB, and DIGLIB routines. An object library was similarly created for the routines. The new routines were linked to the SEISM programs and the SUNOS environment was modified for the directories. *Goshc* (*shc* is a pre-processor which interactively generates the files necessary to run SEISM 1.1) was moved to the SEISM directory.

1.3 AMEND AND PORT CODE TO SUN WORKSTATIONS

The revised SEISM 1.1 code, including the amended libraries, was successfully installed and run on two CNWRA SUN platforms: (i) Pinafore which is a SUN IPX (4/50) running SUNOS 4.1.3 and (ii) Skippy which is a SPARCstation 20 running SUNOS 4.1.3_U1 Version B. No additional modifications were necessary.

The following are the steps required to run the SEISM 1.2 code on any UNIX system like the SUN workstations:

- Prepare, in advance, answers for shc input file (SEISM 1.2).
- Verify that data in input files ax(i), c(j)sis, and c(j)altz is appropriate for the current geographic site of interest (e.g. Yucca Mountain). Modify, if needed.
- Go to the directory in which seism resides (e.g. /usr3/seism/).
- Go to results directory and delete "command" file if one already exists from a previous run (e.g. /usr3/seism/hzrd/results/970401).
- Go to the SEISM 1.2 directory that contains the file goshc (e.g. /usr3/seism/hzcds/). Run goshc ("go Seismic hazard code") which starts the interactive input program shc.
- After finishing input to shc, go to the results directory (e.g. /usr3/seism/hzrd/results/970401) and edit the new command for the correct number of experts (use vi or other editor). The command file runs SEISM 1.2 with the usr-supplied inputs.

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- Run the file *command*. If all goes well there should be no run-time error messages and the seismic hazard code will be run.
- Go to the results directory (e.g. /usr3/seism/hzrd/results/) and print the dig.ps* files using the *qp* command.
- If additional runs are to be made, either delete the datafiles in results directory or move them to a different directory.

1.4 GENERATE SEISM 1.2 VERSION FOR SOFTWARE CONFIGURATION CONTROL

The verified and portable SEISM 1.1 code was recompiled and relinked with the modified libraries to make an official benchmark run of SEISM 1.2. The results of the SEISM 1.2 benchmark run were consistent with the earlier SEISM 1.1 runs. After transferring all files to /usr3/seism, SEISM 1.2 was run once more to verify that all appropriate files had been transferred to /usr3/seism and that it was running properly. SEISM 1.2 ran successfully, reproducing the earlier results. Following this verification, the SEISM 1.2 code was deemed ready for porting to other SUN platforms or UNIX-based systems. The new data structure of SEISM 1.2 was stored in the SCCS. SEISM 1.2 will be the starting point for any future programming tasks and will be used for computations of seismic hazard.

In order to improve utilization of SEISM 1.2, several aids have been created. These include: (i) readme files which have been placed in the directories under /usr3/seism and describe file contents in each directory and what the files are for; (ii) detailed instructions for using SEISM 1.2 are also included in the readme files; (iii) instructions for porting SEISM 1.2 to other UNIX-based systems which are found in Attachment B of Bowman et al. (1996); and (iv) a description of the format of the input files ax(i), c(j)sis, and c(j)altz which are located in Attachment C of Bowman et al. (1996). The required scientific notebook (No. 059) containing descriptions of the progress made on the various subtasks as they were accomplished was also completed. Copies of output results are included in the scientific notebook.

2 REFERENCES

Bowman, P., M. Menchaca, and C. Scherer. 1996. *SEZSM 1.1: Portability* Tusk *Summary*. Report to Center for Nuclear Waste Regulatory Analyses.

Hofmann, R.B. and M. Menchaca. 1995. *SEZSM 1.1 Test Analysis, Rev. 1*. Center for Nuclear Waste Regulatory Analyses. CNWRA 94-014, Rev. 1. April.