Office of Health, Safety and Security
Operating Experience Level 3

OE-3: 2011-02 **August 2011**

SASSI Software Problem

PURPOSE

This Operating Experience Level 3 (OE-3) report is issued to provide information on a software technical problem related to the use of the subtraction method in the System for Analysis of Soil-Structure Interaction (SASSI) computer code.

BACKGROUND

SASSI is a computer code for performing finite element analyses of soil-structure interaction to evaluate the effect of seismic ground motion on structures. The code is widely used in the nuclear industry and in the Department of Energy (DOE). SASSI was first developed in 1981 at the University of California (UC) at Berkeley and several modified proprietary versions are being used by the SASSI analysts. In the early years, SASSI was commonly executed with a flexible volume method, also known as the direct method, in which every finite element node within and on the perimeter boundary of the excavated soil volume is treated as an interaction node that couples the free-field soil system and the excavated soil volume. In 1998, a more computationally efficient method known as the subtraction method was developed for SASSI execution. In the subtraction method, only the nodes on the outer perimeter boundary are treated as interaction nodes. The most recent user's manual for the SASSI2000 version of the code from UC Berkeley states that the subtraction method is the preferred method of analysis.

DISCUSSION

In 2010, analyses revealed that the subtraction method, under some conditions, provides results that deviate significantly from those of the direct method. The inconsistent results are found to generally occur at ground motion frequencies above that of the first mode natural frequency of the excavated soil volume. The subtraction method has been found to both overestimate and underestimate the seismic response, depending on the frequency of interest.

ANALYSIS

DOE's review indicates that under some site conditions and excavation geometries, the subtraction method yields ground motion transfer functions with unacceptable deviations compared with the more reliable direct method results. This technical problem appears to be common to all variations of the SASSI code derived from SASSI2000. DOE has found that, in general, the direct and subtraction methods diverge when three conditions coincide:

1) the structures are embedded;
2) the structures have wide, shallow foundations; and
3) the structural response frequencies are close to, or higher than, the first mode frequency of the excavated soil volume.

DOE has evaluated a modified subtraction method and its efficacy at avoiding the shortcomings of the subtraction method. Several test cases were evaluated to illustrate conditions where the subtraction method can yield incorrect results. DOE compiled these test cases into a technical report (see reference) which provides background on the subtraction method problem, examples showing improved accuracy provided by the modified subtraction method, recommendations for reviewing past SASSI subtraction method analyses, and guidance for avoiding subtraction method errors in future analyses.

Since many variations (i.e., modified versions) of the original SASSI software are currently in use, the report also recommends proper verification

and validation of the software in accordance with an approved quality assurance program.

RECOMMENDATION

SASSI users are advised to review the technical report entitled, *U.S. Department of Energy Soil-Structure Interaction Report,* July 2011 which provides background on the subtraction method problem, recommendations for reviewing past SASSI subtraction method analyses, and advice on avoiding subtraction method errors in future analyses.

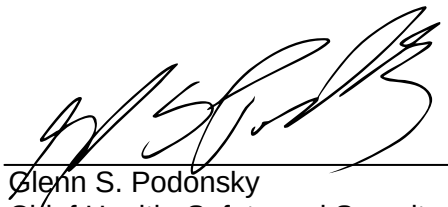
REFERENCE

U.S. Department of Energy Soil-Structure Interaction Report, July 2011, (http://www.hss.energy.gov/deprep/2011)

ADDITIONAL SOURCES OF INFORMATION

Questions about the referenced report should be directed to either Brent Gutierrez at brent.gutierrez@srs.gov or Stephen McDuffie at stephen.mcduffie@rl.doe.gov. Questions related to this OE-3 report should be directed to Subir Sen at subir.sen@hq.doe.gov.

No follow-up report is required to this OE-3 report.



Glenn S. Podonsky
Chief Health, Safety and Security Officer
Office of Health, Safety and Security