

3C Computer Programs Used in the Design and Analysis of Seismic Category I Structures

The information in this appendix of the reference ABWR DCD, including all subsections, is incorporated by reference with the following departure and supplements.

STD DEP Admin

3C.1 Introduction

The list in this subsection is supplemented to include the following site-specific structures.

- (4) Ultimate Heat Sink
- (5) Reactor Service Water Piping Tunnel

3C.5 ANSYS

3C.5.1 Description

ANSYS is a large, finite element program for a broad range of analyses types. The structural analysis capabilities include material and geometric nonlinear analysis, static analysis, and a variety of dynamic analyses.

The element for a concrete cracking analysis allows a full-nonlinear analysis of reinforced concrete with cracking and crushing of concrete.

3C.5.2 Validation

ANSYS, Inc. of Canonsburg, Pennsylvania developed ANSYS. The program validation documentation is available at ANSYS, Inc.

3C.5.3 Extent of Application

This program is used for the containment dynamic analysis of containment loads, for the containment ultimate capacity analyses and for containment seismic margin analysis.

3C.6 ~~Section Design Program 2D (SSDP 2D)~~

3C.6.1 ~~Description~~

~~Section design of Reactor Building Concrete Structures, such as the Reinforced Concrete Containment Vessel (RCGV), shear walls, and slabs is performed using SSDP 2D.~~

~~SSDP 2D computes stresses in a thick concrete element under thermal and/or nonthermal (real) loads, considering effects of concrete cracking. The element represents a section of a concrete shell or slab, and may include two layers of orthogonal reinforcing. It does not include the effect of the orthogonal liner.~~

~~SSDP 2D calculates the stresses considering two dimensional equilibrium conditions of section forces with the existence of thermal loads and concrete cracking. It is assumed in the code that concrete has an anisotropic property and that cracked concrete does not carry tensile forces. Concrete is assumed to have no tensile strength.~~

3C.6.2 **Validation**

~~SSDP 2D is written and maintained by Shimizu Corporation of Tokyo, Japan. Program validation documentation is available at Shimizu Corporation.~~

3C.6.3 **Extent of Application**

~~This program is used for evaluating the Reactor Building (RB) including the RCGV and Control Building (CB).~~

3C.7 **NASTRAN**

3C.7.1 **Description**

~~NASTRAN is a GE in-house version of the MSC/NASTRAN program which is developed by the MacNeal-Swendler Corporation. NASTRAN is a general purpose computer program for finite element analysis; its capabilities include: static response to concentrated and distributed loads, to thermal expansion and to enforced displacements; dynamic response to transient loads, to steady state sinusoidal loads, and to random excitation; and determination of Eigen values for use in vibration analysis.~~

3C.7.2 **Validation**

~~MSC Software Corporation of Santa Ana, California developed NASTRAN. The program validation documentation is available at MSC Software Corporation.~~

3C.7.3 **Extent of Application**

~~This program is used for the static and Eigen value analysis of the concrete containment, RB, and CB. This program is also used for the static and dynamic analysis of the Drywell Head and containment internal structures.~~

3C.8 **A System for Analysis of Soil-Structure Interaction - SASSI²⁰⁰⁰**

3C.8.1 **Description**

SASSI²⁰⁰⁰ is used to solve a wide range of dynamic soil-structure interaction (SSI) problems, including layered soil conditions and embedment conditions, in two or three dimensions. ~~#SASSI~~ was originally developed at the University of California, Berkeley in 1982 under the technical direction of John Lysmer. The program is based on the finite-element method formulated in the frequency domain using a substructuring technique.

3C.8.2 Validation

~~SASSI was obtained from the University of California, Berkeley. Program validation documentation is available at UC Berkeley.~~ SASSI2000 was obtained from ISATIS, LLC, University of California, Berkeley and validated by Simpson Gumpertz and Heger (SGH). The program validation documentation is available at SGH. The program validation was also accepted by Sargent & Lundy (S&L) under S&L's QA Program.

3C.8.3 Extent of Application

SASSI2000 is used to obtain seismic design loads and in-structure floor response spectra for the Seismic Category I buildings accounting for the effects of SSI.

3C.9 Free-Field Site Response Analysis (SHAKE)

3C.9.1 Description

This program is used to perform the free-field site response analysis to generate the design- earthquake-induced strain-compatible free-field soil properties and site response motions required in the seismic SSI analysis. SHAKE is a computer program developed at the University of California, Berkeley, by B. Schnabel, John Lysmer and H. B. Seed in 1972.

3C.9.2 Validation

SHAKE was developed by UC Berkeley. The program validation documents are located at UC Berkeley.

3C.9.3 Extent of Application

This program is used to provide site response motions input to the SASSI2000 analysis for Reactor Building, Control Building and Ultimate Heat Sink.

3C.10 GT STRUDL

3C.10.1 Description

GT STRUDL (Structural Design Language) is a subsystem of GTICES (The Georgia Tech Integrated Civil Engineering System). It solves structural engineering problems in frame analysis, finite element analysis, static and dynamic analysis, as well as steel and concrete design.

3C.10.2 Validation

GT STRUDL is developed by Georgia Tech Research Corporation (GTRC). The program validation documents are located at GTRC.

3C.10.3 Extent of Application

~~This~~ GT STRUDL is a general purpose program ~~and is extensively used to perform structural analysis for structures on various buildings, such as Turbine Building, Water Treatment Building, etc.~~

3C.11 ~~DATAN~~**3C.11.1 ~~Description~~**

~~The program DATAN (Probabilistic Data Analysis) processes and generates data which are randomly varied with time using Fast Fourier Transform (FFT) algorithm.~~

3C.11.2 ~~Validation~~

~~DATAN was developed by Bechtel. The program validation documents are located in the Data Processing Library at the Bechtel San Francisco office.~~

3C.11.3 ~~Extent of Application~~

~~DATAN is used to process input and response time histories for the seismic SSI analyses.~~

3C.12 ~~BISMQKE~~**3C.12.1 ~~Description~~**

~~This computer program is used to generate spectra compatible time history functions. For given acceleration response spectra of (input) seismic motion, BISMQKE can generate a time history function that will closely match the given spectra.~~

3C.12.2 ~~Validation~~

~~BISMQKE is developed by Bechtel. The program validation documents are located in the Data Processing Library at the Bechtel San Francisco office.~~

3C.12.3 ~~Extent of Application~~

~~BISMQKE is used to generate acceleration time history functions that will closely match a given acceleration response spectra.~~

3C.13 DYNAS**3C.13.1 Description**

DYNAS is used for seismic analysis of structures, including generation of floor response spectra.

3C.13.2 Validation

DYNAS was developed and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.13.3 Extent of Application

This program is used to calculate concrete shear wall stiffnesses and determine forces in shear wall design for shear wall structures.

3C.14 SAFE**3C.14.1 Description**

SAFE is used for the analysis and design of concrete slabs and basemats. It integrates modeling analysis and design of slabs and foundations.

3C.14.2 Validation

SAFE was developed by Computers and Structures, Inc., Berkeley. It was purchased and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.14.3 Extent of Application

SAFE is used to determine required reinforcing for concrete slabs and foundations.

3C.15 RSG**3C.15.1 Description**

RSG is used to generate artificial synthetic time histories for seismic analysis. It also generates response spectrum from an input acceleration time history. It can envelope spectra, combine spectra, and generate a spectrum consistent time history.

3C.15.2 Validation

RSG was developed and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.15.3 Extent of Application

RSG is used to generate response spectra for various percentages of critical damping from a given acceleration time history.

3C.16 TEMCO**3C.16.1 Description**

TEMCO analyzes reinforced concrete beam and plate sections subjected to non-thermal and thermal loads. The program can also perform design for reinforced concrete sections subjected to axial bending or shear forces.

3C.16.2 Validation

TEMCO was developed and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.16.3 Extent of Application

TEMCO is used to analyze reinforced concrete sections subjected to non-thermal and thermal loads.

3C.17 APLAN**3C.17.1 Description**

APLAN is used to analyze rectangular attachment plates mounted on concrete walls or slabs by means of expansion anchors, headed welding studs or wire embedments.

3C.17.2 Validation

APLAN was developed and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.17.3 Extent of Application

APLAN is used to analyze rectangular attachment plates mounted on concrete walls by means of expansion anchors, headed welding studs or wire embedments.

3C.18 SAP2000**3C.18.1 Description**

SAP2000 is a finite element program for analysis and design of structures. It performs both static and dynamic analysis.

3C.18.2 Validation

SAP2000 was developed by Computers and Structures, Inc., Berkeley. It was purchased and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.18.3 Extent of Application

SAP2000 is used to perform general structural analysis for buildings.

3C.19 PCACOLUMN**3C.19.1 Description**

PCACOLUMN is a software program for the design and investigation of reinforced concrete column sections. The column section can be rectangular, round or irregular, with any reinforcement layout or pattern. Slenderness effects can also be considered.

3C.19.2 Validation

PCACOLUMN was developed by Portland Cement Association. It was purchased and validated by Sargent & Lundy. The program validation documentation is available at Sargent & Lundy.

3C.19.3 Extent of Application

PCACOLUMN is used for analysis and design of concrete columns.