GOLDER ASSOCIATES

Numerical Modeling Capabilities
to Predict Repository Performance

PO # 8970703
NUMERICAL MODELING CAPABILITIES TO PREDICT REPOSITORY PERFORMANCE

Golder Associates, Inc.
1658 Cole Boulevard
Golden, Colorado 80401

DISCLAIMER
The views and opinions expressed in this report are those of the authors and do not necessarily reflect the position or the policy of the United States Government.

Distribution:
2 copies - Lawrence Livermore Laboratory
2 copies - Golder Associates

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
September 1979
This report presents a summary of current numerical modeling capabilities that are applicable to the design and performance evaluation of underground repositories for the storage of nuclear waste. The report includes codes that are available in-house, within Golder Associates and Lawrence Livermore Laboratories, as well as those that are generally available within the industry and universities.

The first listing of programs are in-house codes in the subject areas of hydrology, solute transport, thermal and mechanical stress analysis, and structural geology.

The second listing of programs are divided by subject into the following categories:

- Site Selection
- Structural Geology
- Mine Structural Design
- Mine Ventilation
- Hydrology
- Mine Design/Construction/Operation

These programs are not specifically designed for use in the design and evaluation of an underground repository for nuclear waste; we expect that several or most of them may be so used.
## LIST OF ACRONYMS USED
### FOR INDEXING COMPUTER CODES

(continued)

<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>

### General Problem Codes (primary acronym)

<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATAN</td>
<td>Statistical Analysis</td>
<td>Standard statistical calculations, regression, and curve fitting.</td>
</tr>
<tr>
<td>VENT</td>
<td>Ventilation</td>
<td>Flow resistance and pressure loss analysis, ventilation networks, and gas emission and dilution.</td>
</tr>
</tbody>
</table>

### Specific Problem Areas (secondary acronym)

<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANAL</td>
<td>Analysis</td>
<td>Analysis of data, information or systems.</td>
</tr>
<tr>
<td>COSTA</td>
<td>Cost Analysis</td>
<td>Cost estimation of unit operations.</td>
</tr>
<tr>
<td>EQUIP</td>
<td>Equipment</td>
<td>Simulation or analysis of equipment functions.</td>
</tr>
<tr>
<td>GENENG</td>
<td>General Engineering</td>
<td>General Engineering Problems Analysis</td>
</tr>
<tr>
<td>GENMIN</td>
<td>General Mining</td>
<td>Traditional mining of any mineral.</td>
</tr>
<tr>
<td>GENUUC</td>
<td>General Underground</td>
<td>Underground mining.</td>
</tr>
<tr>
<td>GEOLOG</td>
<td>Geological</td>
<td>Geological or rock analysis.</td>
</tr>
<tr>
<td>GEOSTA</td>
<td>Geostatistics</td>
<td>Geostatistical analysis of mineral deposits.</td>
</tr>
<tr>
<td>GEOUTL</td>
<td>Geo-Utility</td>
<td>Analysis of natural phenomenon.</td>
</tr>
<tr>
<td>GRAFIC</td>
<td>Graphics</td>
<td>Cartographic analysis and plotting.</td>
</tr>
<tr>
<td>GROUND</td>
<td>Ground Control</td>
<td>Ground reinforcement, and support design.</td>
</tr>
<tr>
<td>MINDEP</td>
<td>Mineral Deposits</td>
<td>Specific or regional mineral deposits.</td>
</tr>
<tr>
<td>SPECAL</td>
<td>Specialized Systems</td>
<td>Mining related or specialized analysis.</td>
</tr>
<tr>
<td>STATAN</td>
<td>Statistical Analysis</td>
<td>Standard statistical analysis.</td>
</tr>
<tr>
<td>COALU</td>
<td>Coal Underground</td>
<td>Underground coal mining operations.</td>
</tr>
<tr>
<td>INDEX</td>
<td>PAGES</td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>CODES AT GOLDER ASSOCIATES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CODES AT L.L.L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTSIDE CODES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Site Selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Structural Geology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Mine Structural Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Mine Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hydrology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Mine Design/Construction/Operation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CODES AT GOLDER ASSOCIATES
A finite element plane stress or plane strain program capable of performing 2-dimensional non-linear stress and displacement analysis. Non-linear soil and rock material behavior are simulated using the initial stress method. An out-of-core solution routine combined with a stiffness matrix bandwidth reduction procedure removes size and complexity limits for most geotechnical problems. The types of finite elements available are:

1. Continuum elements (triangles or quadrilaterals) with linear-elastic orthotropic constant stress elements having a Mohr-Coulomb failure criterion with a tension cut-off.

2. Discontinuum elements that are similar to continuum elements but with one or two ubiquitous joint set directions defined with a limiting friction angle and no tension resistance. After failure continuum elements are treated as discontinuum elements.

(Continued on the Next Page)

INITIAL OPERATIONAL DATE 1973

PROGRAM SIZE

FREQUENCY OF USE Seldom

LANGUAGE

COMPUTER

UNIVAC 1100 Series
Computers with EXEC-8 operating system.
3. Joint elements which are line-elements of zero nominal thickness, do not resist tension, have a limiting friction angle, and can be dilatant.

4. Bar and cable elements which are line elements with defined cross sectioned properties to simulate rock bolts or cable anchors.

Construction and excavation sequences and changes in material properties can be simulated. Stress and displacement boundary conditions can be set and later modified, non-linear analysis iterations can be reduced through use of Aitken acceleration procedures. Results can be contoured and plotted by the STRCON program. A possible use of this program is to model openings in bedded salt including clay or shale bands.
APPLICATION Contour and vector plots of FES2D

DOCUMENTATION TITLE/AUTHOR
Contour and plot Results of FES2D/Golder Associates

SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS
Golder in-house

PROGRAM CAPABILITIES AND METHODOLOGY

Used with FES 2D to plot function contours, nodal displacements, and stress vectors. All contours of functions are generated by following the variations of the functions through the finite element, thus accurately taking into account the effect of problem boundaries, boundary conditions and changes in material properties. General functions which may be contoured include normal and shear stresses on the x & y planes, maximum and minimum principal stresses, maximum shear stress, first, second and third invariant of stress tensors. The friction angle required to maintain action of finite elements and the average normal stress. Vector functions which may be plotted are element principal stress magnitudes and directions, element maximum shear stress magnitudes and direction, nodal displacement magnitudes and direction. Displaced finite elements mesh plots may also be generated (for machine plots only).

INITIAL OPERATIONAL DATE 1973

PROGRAM SIZE

FREQUENCY OF USE Seldom

PROG ID STRCON

LANGUAGE

COMPUTER UNIVAC
1100 Series
CRPSL (CRPLIB) is a two-dimensional, small displacement plain strain finite element package incorporating thermal and creep effects using the initial strain method. Thermal coefficient and creep laws are hardwired into the program, but these can easily be incorporated as part of the data to provide additional flexibility.

A general path dependent creep law is used. It is based on the pillar model tests of Project Salt Vault and extended to general 3D stress field using deviator stresses and stress and creep strain invariants in the theoretical formulation. A general structural analysis can be performed to include roof and floor structural response, near-canister behaviour, and pillar response when associated with shale partings.

A maximum of five different material types may be employed. Materials may be isotropic or transversly isotropic. The time dependent temperature field must be predetermined.
The code has been used to analyze hypothetical ventilated repository room in homogeneous salt and in salt with low strength shale beds. For the bedded shale a six noded line element (joint) was employed.
BEM2D is a program for determining plane stress or plane strain distributions around holes in an infinite elastic plane. It utilizes the boundary integral equation method to solve linearly elastic continuum stress and strain problems. The material property must therefore be homogeneous, isotropic and linearly elastic as well as infinite or closed by a finite external boundary of arbitrary shape. The medium may contain a number of openings of arbitrary shape.

Boundary elements, which are used to discretize openings, may be optionally assigned applied loads. Output consists of an echo of the data input, stresses, and optionally displacements at the centre of each boundary element; stresses, and displacements at grid points generated automatically by the program, and stresses and displacements at additional points specified in the input state.

The efficiency of Boundary Integral Equation Methods may make this method attractive for estimating at the initial stress state around openings.

Initial Operational Date N/A  Prog Id BEM2D.

Program Size

Frequency of Use Frequent

Computer CDC CYBER w/NOS operating system.
PROGRAM CAPABILITIES AND METHODOLOGY

The MSIH3D program is limited to analyzing the effect of mining excavation in a single tabular region that is planar, remote from the ground surface, and has roof and floor materials with identical elastic properties. The problem is modeled as a three dimensional linear elastic rock mass into which discontinuities have been introduced. Solutions incorporate the displacement discontinuity method of numerical stress analysis. The tabular excavation may be inclined at any dip. Any in-situ (primitive) stress field is specified which varies with depth and need not have its principal directions perpendicular to the plane of the tabular orebody; up to 5000 rectangular dislocation pattern elements in a rectangular grid are available to idealize the mining region which can be irregular in the plan view.

The tabular mining region can be assumed to be rigid elastic, elasto-plastic or brittle. Strength/deformation behaviour can be input as a function of proximity to mined areas. Mined areas may be back-filled with compressible material. Areas of interest may be isolated and sealed to provide more detail of stress and displacement distributions.

INITIAL OPERATIONAL DATE

PROG ID MSIH3D

PROGRAM SIZE

LANGUAGE UNIVAC FORTRAN 4

FREQUENCY OF USE Moderate

COMPUTER

CDC CYBER series computer with NOS operating system
APPLICATION Stress and displacements due to tabular openings

DOCUMENTATION TITLE/AUTHOR
Three-Dimensional Seam Scaling/Golder Associates

SURVEY PARTICIPANT/ADDRESS
Golder Associates, Inc. 1658 Cole Boulevard, Golden (Denver) CO 80401

AVAILABILITY COMMENTS
Golder in-house code

PROGRAM CAPABILITIES AND METHODOLOGY
SCAL3D: will modify mine model information files produced by the NSIM 3D program to account for changed material properties and modifications to the mine layout, (sequential room excavations). The code can also be used to refine the displacement discontinuity pattern used in the mine model for more detail of stress variations in a particular area.

INITIAL OPERATIONAL DATE 1974

PROGRAM SIZE

FREQUENCY OF USE Moderate

PROG ID SCAL3D

LANGUAGE

COMPUTER
HFOLD is a three-dimensional displacement discontinuity code in which the rock mass is considered as an elastic body. It is similar to the MSIM 3D Code in methodology but is set up to analyze the stresses and displacement in multiple tabular (or folded) excavations in which the pillars and backfilled portions of the excavations may be assigned nonlinear behaviour. The prime restriction is that tabular seams must strike parallel to each other. An in-situ stress field can be specified which is general in orientation and can vary with depth and plan location. Upto 2500 to 3000 rectangular dislocation pattern elements could be economically used to idealize the mining region. The tabular regions can be assumed to be rigid, compressible or brittle. In addition slip or separation on a seam fault plane can be calculated and accumulated from one mining phase to the next.

Output consists of tabular reports of orebody stress and displacement and a simple summary pictorial report of stresses and displacements on the orebody. This code may have use in modeling excavation of multilevel repository in three dimensions.

INITIAL OPERATIONAL DATE '78

PROGRAM SIZE 30,000

FREQUENCY OF USE MODERATE

PROG ID NFOLD

LANGUAGE

COMPUTER CDC CYBER (IN AUSTRALIA) with NOS operating system
PROGRAM CAPABILITIES AND METHODOLOGY

The analysis of one-dimensional non-linear transient heat flow problems using the finite element method. Phase change of materials can be directly modelled. The thermal regime may be nonhomogeneous with different materials present. The following significant material properties must apply: conductivity constant or piece-wise linear with temperature; capacity (=density x specific heat) is constant or piece-wise linear with temperature, and the latent heat is constant.

Boundary conditions of specified heat flow or specified temperature variations with time can be applied. Unconditionally stable solution algorithm is used which does not require iteration.
The HISTGM program will handle structural geology data obtained from: a) area mapping; b) line surveys; c) drill hole core logging. Apparent core angles obtained from drill hole core logging will be converted to true dip and dip-direction angles. Data obtained from line surveys and core logging may be corrected using the Terzaghi multipliers to account for measurement bias. For all histograms a range of dip and dip-direction angles may be chosen. For spacing histograms up to ten rock types may be selected.
PROGRAM CAPABILITIES AND METHODOLOGY

The STEREO program will handle structural data obtained from area mapping, line surveys, and drill hole core logging. Apparent core angles obtained from drill hole core logging will be converted to true dip and dip-direction angles. Data obtained from line surveys and core logging may be corrected using the Terzaghi multipliers to account for measurements bias. Scatter and contoured equal area (lower hemisphere) projections are printed as 20 cm. diameter plots so that a standard 20 cm equal area net may be used to facilitate interpretations and additional manual constructions.
UGWEDG is designed to analyze wedges formed on the roof and walls of underground openings of rectangular cross-section in a rock mass. Wedges are formed by three planes of weakness and one planar free-face. When using the limiting equilibrium methods of analysis, only translateral movement modes are considered; no attempt is made to consider the rotational effects.
A pipe model in which a network of one dimensional path segments is made to simulate steady state flow and transient nuclide transport in 2 or 3 dimensions. The background heads and gradients in aquifers (before repository excavations) must be known and are assumed to be unaffected by the repository. The model is composed of nodes points defining junctions of flow paths, connections between nodes characterized by their effective area, hydraulic conductivity porosity, dispersion factors and dispersivities; overlying or underlying aquifers receiving units which can be associated with some nodes and represent many waste-disposal rooms, each containing an initial inventory of waste; and waste-packets which are released once the hydraulic flow system is established. The transport of three different groups of radionuclides may be considered by defining separate retardation factors and dispersivities for each group in a connection. The output listing of radionuclides is computed for the aquifers and for all nodal sinks.

The model does not have any means of dealing with reactive chemistry.
Static and Transient groundwater flow, 2-dimensional planar or axisymmetric/Golder Associates.


Golder in-house code.

Two dimensional transient and steady state planar or axisymmetric groundwater flow conditions using the finite element method.
Elements of the flow regime may differ in material properties. The permeability may be linear isotropic or linear anisotropic, the stiffness must be constant, the specific yield must be constant, and the evaportranspiration must be linear with depth (within limits). Boundary conditions of either known flow rates or fluid pressure may be applied. The program can compute the fluid potentials and pressures at nodes throughout the flow regime, element flow rates and directions, and the net inflow/outflow for transient problems.

The code is setup to minimize user involvement in data setup and run control and to minimize computer time required to perform analyses.

Initial Operational Date '70
PROG ID FPM
Program Size 30,000 decimal words of core
LANGUAGE Fortran
FREQUENCY OF USE
COMPUTER CDC
- CDC Cyber Series with NUS Operating System.
PROGRAM CAPABILITIES AND METHODOLOGY

Three-dimensional steady state and transient ground water flow conditions using the finite element method. The flow regime must be approximately geometrically represented as a layered system of confined, unconfined (containing phreatic surface) and leaky aquifers (to simulate rock matrix with joint flow). Each aquifer layer is sub-divided into triangular and rectangular elements which have appropriate material properties assigned. Elements of an aquifer may differ in material properties. The permeability may be linear isotropic or linear anisotropic, the specific storage must be incompressible or constant, the specific yield must be constant and the evapotranspiration must be zero or linear with depth (within limits).

The elements of a layer may vary in thickness and dip to conform to the variable thicknesses and slopes of an aquifer. Boundary conditions of either known flow rates or known head may be applied (and altered at any time for transient problems).

The program can compute the location of the phreatic surface in the top aquifer (unconfined flow), fluid potentials and pressures at nodes throughout the flow regime element flow rates and directions, connected surface stream (Continued on Next Page)

INITIAL OPERATIONAL DATE '75 PROG ID APFM
PROGRAM SIZE 30,000 Decimal Words of Core on CDC
FREQUENCY OF USE: Frequent

LANGUAGE FORTRAN 4
COMPUTER CDC CYBER SERIES
W/NOS operating system
flows and leakage rates between aquifer elements.

This program would be useful in determining the flow net in the repository basin.
The FLOCON code prepares contour plots displaying results of ground water seepage analysis performed by AFPM or FPM, and solute transport performed by SOLTR. It can plot head and fluid pressure as well as flownet for FPM only. With SOLTR, the plots can be made of solute concentration levels, vector velocities of solute transport, and solute mass flux vectors. FLOCON uses the standard FPM/AFPM/SOLTR Program output information file.
SOLUTE TRANSPORT

APPLICATION

DOCUMENTATION TITLE/AUTHOR
Solute Transport Analysis/Golder Associates

SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS
Golder in-house

PROGRAM CAPABILITIES AND METHODOLOGY
SOLTR is a code for the analysis of solute transport in a planar or axisymmetric finite element mesh or through layers of a multi-aquifer finite element mesh corresponding to the flow regimes modeled in the AFPM or FPM programs. The processes of convection, dispersion, diffusion, di/dt, sorption and radioactive decay are simulated. Solute concentrations are presumed to be small so that the fluid density is unaffected by concentration.

Significant element (limit of 30) material transport property relationships are constant dispersion coefficient in the average direction of flow and perpendicular to the average direction of flow, a constant solute retardation factor and constant material porosity.

Initial and boundary conditions are defined by using an initial solute concentration distribution and prescribed concentrations for all recharging flows. Boundary conditions and material properties may be altered at any stage in the analysis to reflect changing conditions of the flow regime.

(Continued on Next Page)

INITIAL OPERATIONAL DATE 77

PROGRAM SIZE

FREQUENCY OF USE Frequent

PROG ID SOLTR

LANGUAGE FORTRAN CDC

COMPUTER CDC CYBER with NOS operating system
The transport model for multi-layer aquifer (AFPM) is limited by the fact that inner layer leakage is assumed to have no time lag.

Program output includes nodal concentrations, element fluxes and nodal solute discharge rates.

This program may be applicable to radionuclides transport modeling in the resaturated regime of the repository and flow regime of the repository basin.
A finite element code for linear and non-linear, static and
dynamic analysis in two-dimensional plane stress or plane strain or in
three dimensions. Five types of elements are available as follows:
Stress elements, plane stress and plane strain elements, axisymmetric
shell or solid elements, three-dimensional solid or thick shell element:
or three-dimensional beam elements. The following 2-D and 3-D material
models are available: isotropic linear elastic, orthotropic linear
elastic, isotropic thermo-elastic, curve description, concrete,
Drucker-Prager (not in 3-D), isothermal elastic-plastic (isotropic
hardening), isothermal elastic plastic (kinematic hardening), thermo-
elastic plastic and creep (isotropic hardening), thermo-elastic
plastic and creep (kinematic hardening), Mooney-Rivlin (not 3-D),
or user supplied. The curve description model is based on volumetric
strain and is suitable for many geologic materials. It can also be used
to simulate either tension cut-off yielding or tensile failure
(cracking). Besides material nonlinearities, nonlinearities may be
due to large displacements and large strains.

Continued on next page
ADINA uses an out-of-core solution of equilibrium equations to obtain maximum program capacity. Finite elements are processed on blocks according to their type and whether they are linear or non-linear elements. The finite element system response is calculated using an incremented solution of the equations of equilibrium.
APPLICATION

DOCUMENTATION TITLE/AUTHOR  A Finite Element Program for Automatic Dynamic Incremental Nonlinear Analysis of Temperature (ADINAT)/ Klaus-Jurgen Bathe

SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS

PROGRAM CAPABILITIES AND METHODOLOGY  ADINAT is a compatible heat transfer analysis program to the stress analysis program ADINA. It can be used for general linear and nonlinear steady-state and transient transfer analysis. It employs the finite element method and incremental heat flow equations. For transient analysis a numerical time integration scheme is employed. Material models available are anisotropic constant conductivity, orthotropic constant conductivity. Boundary conditions of surface (of element) convection, radiation or heat flow input may be specified. ADINAT is an out-of-core solver and allocates storage dynamically during the different phases of solution.

INITIAL OPERATIONAL DATE

PROGRAM SIZE

FREQUENCY OF USE

PROG ID ADINANT

LANGUAGE

COMPUTER IBM, CDC, or UNIVAC Versions
APPLICATION Nonlinear, transient fluid flow

DOCUMENTATION TITLE/AUTHOR
Federal Information Processing Software Summary/J. Parliagrico

SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS
At L.L.L.
L.L.L. PUB. UCRL -14754

PROGRAM CAPABILITIES AND METHODOLOGY

Heat transfer or fluid flow capabilities. Finite difference code. Incompatible with finite element. Arbitrary geometries, 2D, 3D. Anisotropic, Non-Linear.

TRUMP has been used to solve for the 3-D unsteady state temperature profiles within a unit cell of a deep geological waste repository.

Problem parameters may vary. Spatial position and sources and/or boundary conditions may vary with time.

INITIAL OPERATIONAL DATE

PROGRAM SIZE Large

FREQUENCY OF USE Large general use.

OTHER USERS DOE and NRC waste management
APPLICATION Fluid flow through porous media and mass transport

DOCUMENTATION TITLE/AUTHOR N/A

SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS
At L.L.L. available to public

PROGRAM CAPABILITIES AND METHODOLOGY

OGRE can be used for time simulation of fluid flow and mass transport through porous media in one or two dimensions. Using an implicit (Backward Euler) finite difference scheme specifically, OGRE can and has been used to simulate the time dependant flow of ground water into or out of underground openings and the mass transport of radionuclides under the influence of pressure gradient.

Parameters may be either time and space dependent or fixed in either time or space. Initial and boundary conditions may also vary with time and space. Zoning of the grid must be constant in both directions, but zoning is dynamic and set at execution time.

Output includes a time dependent pressure and velocity graphics file.

INITIAL OPERATIONAL DATE N/A
PROG ID OGRE
PROGRAM SIZE N/A
LANGUAGE L.L.L. FORTRAN
FREQUENCY OF USE
COMPUTER CDC 7600
A finite element, two-dimensional, seepage code where flow is governed by Darcy's Equation. Pressures, equipotentials and flow velocities are determined for both plane and axisymmetric problems under the conditions of saturated, steady state flow. Different material properties may be assigned to zones of the flow regime. Free surface (unconfined flow) problems are solvable by the program which systematically varies the free surface until free surface boundary conditions are met (flow =0, pressure =0). User must specify the initial mesh including the free surface boundary if there is one. The program will regenerate the mesh for free surface problems, and generally requires 5 - 20 iterations to solve the problem. Known flow rates and pressures may be used as boundary conditions.

Output information includes nodal point pressures and equipotential values, element flow rates at the center of each element and printout of each mesh correction for free surface problems.
Program Capabilities and Methodology

Two-dimensional transient flow code for saturated-unsaturated porous media. Numerical implementation is by a finite-element grid, Galerkin spatial discretization and Gaussian elimination. The flow regime may be non-homogeneous with anisotropic permeability. In saturated regions conductivity and medium compressibility are needed for each formation. In the unsaturated regions curves of conductivity vs. pressure, and of water content vs. pressure, for each soil type are required. The code is set up to include constant rainfall seepage. Output includes flow information, pressure heads, total heads, water contents, and Darcy velocity distributions.

Plotting of data requires an auxiliary program.
APPLICATION Solute Transport


SURVEY PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS At L.L.L.

PROGRAM CAPABILITIES AND METHODOLOGY A two-dimensional transient model for flow of a dissolved constituent through porous media has been developed. Mechanisms for advective transport, hydrodynamic dispersion, chemical absorption, and radioactive decay are included in the mathematical formulation. Implementations of quadrilateral finite elements, bilinear spatial interpolation and Gaussian elimination are used in the numerical formulation. The program is completely compatible with the OAKFLOW/saturated-unsaturated flow through porous media code. Material properties to be input to the code include the longitudinal and transverse dispersivity, bulk density of the solid material within an element, element porosity, modified coefficient of compressability, and the radioactive decay constant.

Output information includes concentrations and fluxes.

INITIAL OPERATIONAL DATE

PROGRAM SIZE

FREQUENCY OF USE

PROG ID MATTRAN

LANGUAGE Fortran IV

COMPUTER
PROGRAM CAPABILITIES AND METHODOLOGY

The code solves a very general pair of coupled time-dependent non-linear, partial differential equations. The code can solve any subset of the coupled equations such as the 3-D transient heat equation or the 3D groundwater flow equation and the solute transport equations simultaneously. The basic method of solution is the Galerkin finite element method for spatial discretization and any combination of explicit euler, implicit euler or trapezoid rule for time integration.

Output consists of nodal histories. Program is not as yet optimized for CDC computers.

A program of this type may be needed for coupling field phenomena i.e temperature field flow and radionuclides transport.
OUTSIDE CODES
SITE SELECTION
APPLICATION Mineral Resources Information Processing


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from Geological Survey Circulars, under the above title, Accession Number CIRC. 681.

PROGRAM CAPABILITIES AND METHODOLOGY "CRIB consists of a set of variable-length records containing the basic information needed to characterize one or more mineral commodities, a mineral deposit, or several related deposits. The information consists of text, numeric data, and codes. Some topics covered are: name, location, commodity information, geology, production, reserves, potential resources, and references. The data are processed by the GIPSY program, which performs all the processing tasks needed to build, operate, and maintain the CRIB file. The sophisticated retrieval program allows the user to make highly selective searches of the file for words, parts of words, phrases, numeric data, word ranges, numeric ranges, and others, and to interrelate variables by logic statements to any degree of refinement desired. Three print options are available, or the retrieved data can be passed to another program for further processing."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
PROGRAM CAPABILITIES AND METHODOLOGY. The above document abstracts a number of programs that USGS has operational. Some of these we judged to have application in mining practice. The following are some of the programs that deal with data bases and retrieval systems:

1. RASS - geochem analyses, sample location, minerals, organics, rock type, geologic formation.
2. CRIB - commodities information, reserves, mineral resources data, geology, occurrences, deposits, mines, references.
3. NCDS - geochemical analyses, coal resources, locations with geologic descriptions.
4. MINREF - bibliographic information, location, geologic formation, rock type, various analyses, crystallographic data, X-ray data.
APPLICATION Rock Analysis Storage

DOCUMENTATION TITLE/AUTHOR Rock Analysis Storage System (RASS-II)
United States Geological Survey

SURVEY PARTICIPANT/ADDRESS United States Geological Survey/Geological Division, United States Geological Survey, Denver, CO

AVAILABILITY COMMENTS Contact George Van Tramp, telephone number (303) 234-2758 or Raoul Mendes, telephone number (303) 234-2438

PROGRAM CAPABILITIES AND METHODOLOGY "The Rock Analysis Storage System (RASS) is designed for the storage and retrieval of analytical data and sample identification and location. RASS is designed to accept data not only from rocks but also unconsolidated sediments, minerals, soils, water, plants, organic fuels, and miscellaneous substances. RASS is for data storage and retrieval only; STATPAC (Statistical Package) is a series of computer programs for the manipulation of data."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID RASS-II

LANGUAGE Fortran

COMPUTER Dec 10
APPLICATION Rock Analysis


AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-206-736.

PROGRAM CAPABILITIES AND METHODOLOGY A user oriented command language is developed to provide direct control over the computation and output of the standard CIPW Norm computation. Once the oxide values have been read by the computer, these values may be manipulated by the user and the "norm" recalculated on the basis of the manipulated or "adjusted" values. Up to 99 rock analysis cards may be processed on a group, which consists of weight per cents of oxides. The program has twelve subroutines. The output provides tabular listings, X-Y plots and ternary diagrams.
APPLICATION Drill Core Data Storage

DOCUMENTATION TITLE/AUTHOR "Computerized Data as an Aid to Kaolin Exploration"/Harland E. Cofer, Jr., Chairman, Division of Science and Mathematics, Georgia Southwestern College, Americus, Georgia, Office of Mineral Resources, United States Geological Survey, Grant Number 14-08-1110-G-173

AVAILABILITY COMMENTS Society of Mining Engineers of AIME, 540 Arapena Drive, Salt Lake City, Utah 84108, under the above title, preprint number 77-H-20. This paper was presented at the 1977 AIME Annual Meeting-Atlanta, Georgia - March 6-10, 1977.

PROGRAM CAPABILITIES AND METHODOLOGY
The GRASP file was created by Nancy A. Wright of the U. S. Geological Survey, Reston, Virginia, and was used for storage and retrieval of drill core data. "(GRASP is an acronym for the Geological Retrieval and Synopsis Program of the U. S. Geological Survey. A portable data-retrieval system requiring minimal user training)"

INITIAL OPERATIONAL DATE NA
PROGRAM SIZE NA
FREQUENCY OF USE NA
OTHER USERS NA
DOCUMENTATION TITLE/AUTHOR "COREMAP-A Data System for Drill Cores and Bore Holes"/Tom K. Ekstrom, Ake Wirstam, Lars-Elve Larsson.

AVAILABILITY COMMENTS Reference to program published in Economic Geology, March-April, 1975 issue, Volume 70, number 2, pp. 359-368.

PROGRAM CAPABILITIES AND METHODOLOGY "COREMAP produces de-coded lists, lists of any specified parameter or parameters, and simplified description of the core on a line-printer. COREMAP plots the deviation of boreholes, data locations on chosen levels, and vertical sections parallel to the x-or y-axes. Furthermore, COREMAP plots the length of each analyzed interval together with one optional chemical element. All boreholes running through a defined slice of rock are projected on a given plane. The scale of the plot is determined by the user, and it is also possible to correct the error of strike and dip during the projection."
APPLICATION Drill Hole Data Analysis


AVAILABILITY COMMENTS Reference to program published in Economic Geology, September-October, 1972 issue, volume 67, number 6, pp. 796-813.

PROGRAM CAPABILITIES AND METHODOLOGY "In this program the assay or geological values are plotted in three dimensions as averages weighted with respect to the distance from plotting point to data points in drill holes. The symbols printed on the plan effectively contour the data. Data summaries for these plans list tons of each category within each bench and the reliability of that estimate. Analysis of these data might, for example, be a guide to zoning classification or an important consideration in mining or pit design."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Geostatistics

DOCUMENTATION TITLE/AUTHOR "Computerized Determination of Mine Planning Data from Boreholes"/Christopher Haycocks, Assistant Professor of Mining Engineering, J. Richard Lucas, Head, Division of Minerals Engineering Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Mining Engineering, April, 1973 issue, volume 25, number 4, pp. 52-56.

PROGRAM CAPABILITIES AND METHODOLOGY The basic purpose of this program is to provide accurate estimates of mineable tonnage based on the geological structure. The program also calculates ore body dimensions, pillar dimensions, heading widths, roof-bolt spacing and length, subsidence data, and plot subsidence and strain curves as well as a "traverse plot or contoured coal thickness."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 156K

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID RAMPLAN

LANGUAGE Fortran IV

LEVEL G

COMPUTER IBM 370/155 ASP
APPLICATION Predict Mineral Occurrences

DOCUMENTATION TITLE/AUTHOR "First Interim Report on Digital Geographic Data Handling Activities in the USGS"/Ray Batson, Western, Flagstaff Field Center


AVAILABILITY COMMENTS Report is internal

PROGRAM CAPABILITIES AND METHODOLOGY LANDSAT "can significantly help detect and predict mineral resource occurrences and provide information relevant to mineral exploration that may not be acquired by other methods. Enhancement techniques are employed."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 28K words each

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID LANDSAT

LANGUAGE NA

COMPUTER PDP/11 (11/45 & 11/20 central processor)
APPLICATION Computer-Drawn Maps of Geological Data


AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-255-497.

PROGRAM CAPABILITIES AND METHODOLOGY The computer is used to draw the following kinds of geologic maps for mining areas:

1) structure contour maps
2) coal isopach maps
3) overburden isopach maps
4) maps showing ratio of sandstone types
5) percent sandstone or shale maps
6) environmental ratio maps
7) lithologic frequency maps
8) and various other contour maps. Any type of geologic map can be drawn as long as some unit can be contoured.
PROGRAM CAPABILITIES AND METHODOLOGY The Division of ADP has implemented three map projection programs used principally to provide Mylar map overlays demonstrating aspects of the minerals industry. The projections available are Mercator, Lambert, Conformal Conic, and Albers. Each is stand-alone program, accepting as input a tape file or disk file of selected data, usually in the Minerals Industry Location System format, and a few necessary parameters—such as map scale, map delimiters, title, and "cluster radius".
APPLICATION Mapping and Plotting

DOCUMENTATION TITLE/AUTHOR "Software"/United States Geological Survey, Reston, Virginia 22092

SURVEY PARTICIPANT/ADDRESS Nancy Sage/Technical Information Section, Branch of Computer Information, Computer Center Division, USGS National Center, Stop 804, Reston, Virginia 22092

AVAILABILITY COMMENTS
Contact Nancy Sage at above address.

PROGRAM CAPABILITIES AND METHODOLOGY The above document abstracts a large number of programs that USGS has operational. Some of these we judged to have application in mining practice, especially the ones dealing with mapping and plotting. The following are some of the programs that deal with mapping, data reduction, and plotting:

1. Calcomp Basic - set of subroutines that provide all functions for controlling and driving Calcomp Plotting Systems.
2. Calcomp DRAFTING - five subroutines that performs general graphical details.
3. Calcomp GENERAL - plots various functions.
4. Calcomp Plotting Software (Benson-Lehner) - produces plots by incorporating a conversion deck with the applications program.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE Varies

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID NA

LANGUAGE Varies

COMPUTER Varies
APPLICATION Underground Mining Systems


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-237-053

PROGRAM CAPABILITIES AND METHODOLOGY The volume includes three of seven sections: Section 1 - Summary Report, Section 2 - COST-SCHED Program, Section 3 - RAILSIM Program. "Computerized simulation, coal mining, mine haulage, mine ventilation, coal handling, power supply circuits. Two computer programs developed for use in the operation and design in underground mining systems supporting primary face operations are discussed. Each program is described in detail for analysis of problems, data procurement, and implementation."
APPLICATION Cost and Scheduling Analysis of Mine Development

DOCUMENTATION TITLE/AUTHOR Computer Applications in Underground Mining Systems, Seven Volumes/Division of Minerals Engineering Virginia Polytechnic Institute and State University, Blacksburg, Virginia, R & D Report No. 37, Interim Report, OCR, Department of the Interior, Washington, D.C.

SURVEY PARTICIPANT/ADDRESS Department of Mining and Minerals Engineering Virginia Polytechnic Institute & State University, Blacksburg, Virginia 24061

AVAILABILITY COMMENTS 
National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22151

PROGRAM CAPABILITIES AND METHODOLOGY "COST-SCHED" economically schedules mine development and projects the cost of mining. The scheduling can be done separately or in conjunction with cost projections for up to 24 time periods, usually months. Such costs as labor, supply, general inside and outside, plant, supervision and overhead cost are accumulated as mining advances. Also supplies may be designated recoverable or non-recoverable for later reuse as a section retreats. Monthly costs are outputted for such items as labor, supplies, and other costs. Final output summarizes days worked, tons mined, and various cost categories.

INITIAL OPERATIONAL DATE Sept. 1968

PROGRAM SIZE 200K

FREQUENCY OF USE On demand

OTHER USERS Both foreign and U.S.A. mining companies, various universities and research groups.
PROGRAM CAPABILITIES AND METHODOLOGY

The following is a list of programs that IBM has operational. The list consists of the program name, followed by the program number if given:

1. Surface Techniques, Annotation and Mapping Programs for Exploration Development and Engineering (STAMPEDE) - 360D-17.4.001.
2. Calgary Seismic Package
3. Scientific Subroutin Package (OS/PLI) - 360A-CM-07X.
6. Graphic Analysis of Three-Dimensional Data - 5734-SXZ.

(CONTINUED ON FOLLOWING PAGE)
7. Subroutine Library - MATH (SL-MATH) - 5736-XM7.
10. Economic Analysis of Petroleum Project Programs - 1130-MP-01X.
11. Casing Design Program - 1130-MP-02X.
12. Decline Curve Analysis Program 1130-MP-03X.
13. Tarner Material Balance Program 1130-MP-04X.
14. Schilthuis Material Balance Program 1130-MP-05X.
15. Two-Dimensional Water Flooding Program - 1130-MP-06X.
16. Gas Deliverability Program - 1130-MP-07X.
17. Velocity Functions from Time Depth Data Program - 1130-MP-09X.
18. Wave-Front Ray-Path Determination Program - 1130-MP-10X.
19. Synthetic Seismogram Program - 1130-MP-11X.
20. Gravity and Magnetics Continuous Derivatives and Residuals - 1130-MP-12X.
21. Theoretical Gravity of a 3-D Mass Program - 1130-MP-13X.
22. Quantitative Log Analysis Program - 1130-MP-14X.
23. Dipmeter Program - 1130-MP-15X.
24. Statistical System - 1130-MP-16X.
25. Numerical Surface Techniques and Contour Map Plotting - 1130-CX-11-.38X.
26. Scientific Subroutine Package - 1130-CM-02X.
27. Least Squares Curve Fit for a Time-Depth Chart - 1620-MP-03X.
28. Wave-Front Ray-Path Chart for Geophysical Seismic Interpretations - 1620-MP-04X.
29. Integration Template Plotting - 1620-MP-05X.
30. Normal Move-Out Chart 1620-MP-06X.
31. Synthetic Seismogram - 1620-MP-07X.
32. Grid Value Determination - 1620-MP-08X.
33. Analysis of Magnetic or Gravity Anomalies - 1620-MP-10X.
34. Data Point Plotting Program - 1620-MP-11X.
35. Calculation of Intercepts and Velocities From Observed Seismic First Arrivals - 1620-MP-12X.
36. Refraction Interpretation and Velocity Determination - 1620-MP-13X.
37. Contouring by Triangulation - 1620-MP-21X.
38. Velocity Determination by Delta-T Analysis (Card) - 1620-MP-24X.
39. Gas Deliverability (Card) - 1620-MP-25X.
40. Tarner Material Balance (Card) - 1620-MP-27X.
41. Prediction of Water Cut vs. Recovery (Card) - 1620-MP-28X.
42. Sand Volume Determination (Card) - 1620-MP-30X.
43. Filter Analysis Routine (Card) - 1620-MP-31X.
44. CVL or Sonic Log Adjustment to Check-Shot Data (Card) - 1620-MP-32X.
45. Two Dimensional Waterflooding (Card) - 1620-MP-33X.
46. Calculation of Mineral Unit Cell Contents - 1620-MP-34X.
47. A Program to Index Crystals - 1620-MP-35X.
STRUCTURAL GEOLOGY
APPLICATION Seismic Refraction Modeling

DOCUMENTATION TITLE/AUTHOR "Seismic Refraction Modeling by Computer"/James H. Scott, United States Bureau of Mines, Denver, Colorado 80225

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Geophysics, April, 1973 issue, Volume 38, number 2, pp. 271-289

PROGRAM CAPABILITIES AND METHODOLOGY "A computer program has been developed by the U. S. Bureau of Mines for designing a two-dimensional, layered earth model as an aid in interpreting seismic refraction field measurements. The program requires input data consisting of shotpoint and geophone locations, refraction traveltimes, and identification of the refraction layer associated with each traveltime. In the program, a first approximation model is generated by a computer adaptation of the delaytime method, followed by a series of improved approximations that are made by use of a ray-tracing procedure. The final result of the program is a model designed to minimize the discrepancy between field-measured traveltimes and computed traveltimes of rays traced through the model.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Seismic Data Analysis


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Engineering and Mining Journal, February, 1970 issue, volume 171, number 2, pp. 93-96.

PROGRAM CAPABILITIES AND METHODOLOGY By analysis of seismic data the "program provides the structure angle and cross-sectional thickness of the fault plane or mineralized zone. This analysis also provides information necessary to calculate strike and dip of the detected anomalies. In effect, the computer analysis of the collected data reconstructs a three-dimensional representation of the structures which had to have existed to produce the particular pattern of data collected."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID NA

LANGUAGE Fortran

COMPUTER Univac 1108
APPLICATION Stress Wave Analysis


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-214-236

PROGRAM CAPABILITIES AND METHODOLOGY The program provides a one-dimensional stress wave analysis in a generalized, linear viscoelastic rock. Numerical results calculated by this technique are free of spurious oscillations that occur in certain other methods of numerical calculations. WAVE generates results that are most accurate near the wave front. WAVE is a powerful tool for analyzing the propagation of stress waves in not only time-dependent inelastic rocks but also in any viscoelastic material whose properties are defined by a Prony series fitted to its compliance curve.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 20K core storage

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Seismic Refraction interpreter-interactive

DOCUMENTATION TITLE/AUTHOR SIPT - A seismic refraction inverse modeling program for timeshare terminal computer systems/ James H. Scott (USGS Open File Report 77-365)

SURVEY PARTICIPANT/ADDRESS J. E. Scott/U.S. Geological Survey Box 25046 Denver Federal Center MS 964, Denver, Colorado 80225

AVAILABILITY COMMENTS Documents available at USGS libraries at Denver, Colorado, Menlo Park, California, and Reston, Virginia. Program available from J. H. Scott by request.

PROGRAM CAPABILITIES AND METHODOLOGY Creates layered earth model consistent with input locations of shotpoints and geophones and refraction arrival times for up to 5 in-line spreads with up to 7 shotpoints and 48 geophones each, and up to 5 velocity layers. Input is by terminal (disc file) - Output is to terminal and/or line printer.

INITIAL OPERATIONAL DATE July 1977

PROGRAM SIZE 30K words

FREQUENCY OF USE On demand

OTHER USERS Utah International, USBM, Newmont Exploration, Ltd., Geo-Recon Div. Shannon & Wilson, etc.

PROG ID SIPT

LANGUAGE Fortran

COMPUTER DEC-10, Honeywell Multics, Burroughs, IBM, CDC Univac
SOURCE OF INFORMATION SUBMIT APPLICATION CODE ROCSOL

APPLICATION Seismic refraction interp.-batch

DOCUMENTATION TITLE/AUTHOR SIPB - A seismic refraction inverse modeling program for batch computer systems/James H. Scott (USGS Open File Report 77-366)

SURVEY PARTICIPANT/ADDRESS J. H. Scott/U.S. Geological Survey, Box 25046 Denver Federal Center MS 964, Denver, Colorado 80225

AVAILABILITY COMMENTS Documentation available at USGS libraries in Denver, Colorado, Menlo Park, California, and Reston, VA program available from J. H. Scott on request

PROGRAM CAPABILITIES AND METHODOLOGY Creates layered earth model consistent with inputted locations of shotpoints and geophones and refraction arrival times for up to 5 in-line spreads with up to 7 shotpoints and 48 geophones each, and up to 5 velocity layers. Input is by cards, output on line printer.

INITIAL OPERATIONAL DATE July 1977

PROGRAM SIZE 25K words

FREQUENCY OF USE On demand

OTHER USERS USBM, USBR, Fugro, Inc., Newmont Exploration Ltd., UCLA, etc.

PROG ID SIPB

LANGUAGE Fortran

COMPUTER Dec-10, Honeywell Multics, Burroughs, IBM, CDC, Univac
APPLICATION Analysis of Point Clusters


AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-240-685

PROGRAM CAPABILITIES AND METHODOLOGY "The report presents a computer code that has been developed for isolating naturally occurring clusters of data plotted on the unit hemisphere and testing these clusters against a probability distribution which admits elliptical symmetry about its mean. A listing of the computer code is provided along with an example output illustrating the delineation and analysis of clusters in fracture orientations measured in a porphyry copper deposit."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 1,818

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Clustering Data Points on the Sphere


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-231-285

PROGRAM CAPABILITIES AND METHODOLOGY "The computer program, HYBMODE, has been developed to meet the need for a fast and economical method for clustering data points on the sphere. The algorithm used in this development is an extension of D. Wishart's one-level mode analysis. The program can be used to cluster either vectorial or axial data; it is currently being used by the Bureau of Mines to cluster fracture orientations."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 75,600 words max.

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Fracture Orientation Analysis


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-212-696

PROGRAM CAPABILITIES AND METHODOLOGY This computer program analyzes the orientations of fractures in rock, identifies clusters or groupings among fracture orientations, calculates the mean orientation of the fractures within each cluster, and calculates the dispersion among these fracture orientations. The program also initiates a polar plot of point concentrations for a cluster mean to be situated at the pole.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Simulation of Spacing Between Planar Discontinuities

DOCUMENTATION TITLE/AUTHOR M. Monicov

SURVEY PARTICIPANT/ADDRESS Professor H.H. Einstein/Department of Civil Engineering, Room 1-330, MIT Cambridge, Massachusetts 02139

AVAILABILITY COMMENTS Listing available from Professor Einstein at above address. User manual not available.

PROGRAM CAPABILITIES AND METHODOLOGY Input includes orientation and the coordinates of a point on the discontinuity, as well as the orientation and end points of the reference line along which the spacings are desired. The program will then compute the distance separating adjacent discontinuities and the results can be compared to a user supplied probability distribution.

INITIAL OPERATIONAL DATE 4/77
PROGRAM SIZE 450K bytes
FREQUENCY OF USE Occasional
OTHER USERS NA

PROGRAM CODE ROCSOL
ANAL
MINE STRUCTURAL DESIGN
PROGRAM CAPABILITIES AND METHODOLOGY. A 3D or 2D finite element structural analysis program with broad capabilities obtained by allowing the user to select from three comprehensive libraries for elements, materials and structural procedures. The three libraries contain over 50 element geometries, 35 material models and 15 structural procedures that steer the program through its various modules in order to simulate a particular physical phenomenon such as temperature cycling, viscoplasticity, etc. Elastic-plastic and large displacement analysis is effected in a series of piece-wise linear increments. Creep and thermal effects which cause initial strains are analyzed as a series of steps in which an increment of initial strain occurs at the start of each step. This initial strain can be a function of nuclear irradiation as well as of temperature. An automatic load control for creep selects the time step for each increment so that the resulting stress and strain changes remain within a specified limit. A higher order step by step integration in time, known as the residual load correction, may be specified for creep and other non-linear problems. Additional program features include a three-dimensional search generator with an integrated plotting feature which eliminates hidden lines.

INITIAL OPERATIONAL DATE
NA

PROGRAM SIZE Variable

FREQUENCY OF USE On demand

OTHER USERS NA
SOURCE OF INFORMATION: SUBMIT
APPLICATION CODE ROCSOL
ANAL

APPLICATION Structural Analysis and Design

DOCUMENTATION TITLE/AUTHOR "GTICES STRUDL, GTICES STRUDL-II

SURVEY PARTICIPANT/ADDRESS Dr. Leroy Z. Emkin/GTICES Project,
School of Civil Engineering, Georgia Institute of Technology,
Atlanta, Georgia 30332

AVAILABILITY COMMENTS Available for a lease and maintenance fee.
Write Dr. Emkin or call (404) 894-2204. Note, source not available.

PROGRAM CAPABILITIES AND METHODOLOGY GTICES STRUDL-II operates
as a subsystem of the GTICES system on CDC computers. Both are
proprietary to the Georgia Tech Research Institute of Technology,
Atlanta, Georgia.
GTICES STRUDL-II provides the engineer with the ability to specify
characteristics of structural problems, perform analyses, reduce
and combine results, perform design, and output any part, or all
of the information stored in the structural problem data base
on a selective basis.
Analytic procedures apply to any combination of framed structures
and continuum mechanics problems of arbitrary configuration and
composition. Framed structures consist of an assemblage of one-
dimensional member elements, which can be represented by properties
along a centroidal axis.

INITIAL OPERATIONAL DATE 10/77
PROGRAM SIZE 200,000 source statements
FREQUENCY OF USE On demand
OTHER USERS NA

PROG ID GTSTRUDL
USAGE Ices Icetran & CDL
COMPUTER CDC and IBM
APPLICATION Analysis of structures in Jointed Rock


SURVEY PARTICIPANT/ADDRESS Dr. F.E. Heuze/2448 Brainwood Drive, Boulder, Colorado 80303

AVAILABILITY COMMENTS Program for CDC 6400 and 6600 available with a surcharge in object form. Contact Dr. Heuze at (303) 499-7841.

PROGRAM CAPABILITIES AND METHODOLOGY Finite element program with joint elements. Two-dimensional (plane strain, plane stress). Can model strain-softening both in the joint/faults and in the solids. Can model sequential construction or excavation - has a restart option. Has plotting facilities. Well suited to the analysis of rock structures with or without reinforcement.

INITIAL OPERATIONAL DATE 1975
PROGRAM SIZE 120,000
FREQUENCY OF USE On demand
OTHER USERS Engineering Consultant.
APPLICATION Mine Pillar Systems Analysis

DOCUMENTATION TITLE/AUTHOR "How High-Speed Computers Advance Design of Practical Mine Pillar Systems"/A.M. Starfield, Assistant Professor, C. Fairhurst, Professor and Associate Head, School of Mineral and Metallurgical Engineering, University of Minnesota, Minneapolis.

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Engineering and Mining Journal, May, 1968 issue, volume 169, number 5, pp. 78-87

PROGRAM CAPABILITIES AND METHODOLOGY "This paper presented an approach to the calculation of pillar loads and convergences in flat-lying tabular deposits. These calculations can be made with the aid of either a resistance analog or digital computer. The digital computer method is of a general nature and can, in principle, be applied to any pattern or system of mining. Problems that have not been discussed in the paper but which have been solved by an extension of the digital computer method include:

1) the calculation of loads and displacements resulting from extraction of two or more levels.
2) the calculation of loads and shear stresses in a dipping ore body.
3) the calculation of time-dependent deformations in a non-elastic ore body."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
PROGRAM CAPABILITIES AND METHODOLOGY: This volume of the final report describes the roof support subsystem of the Master Design Simulator. This model is based on popular roof support practices for different geological environments with related restrictions imposed by the Coal Mine Health and Safety Act of 1969. From geological sections, the model determines the anchor horizon for roof bolts and the density of roof support necessary. The roof support subsystem is tied to both the geology and reserves subsystem and the production subsystem of the Master Design Simulator, but can also operate as a free standing model. Several case studies are presented showing the application of the model. A detailed user's manual, including a program listing is presented in the appendices.
APPLICATION Physical Property Testing of Rocks

DOCUMENTATION TITLE/AUTHOR Two Dimensional Finite Element Simulation of Brazilian Test/J. Basas, R.W. Heins

SURVEY PARTICIPANT/ADDRESS R.W. Heins/U. of Wisconsin, Dept. of Met. & Min. Engineering, 1509 University Ave., Madison, WI 53706

AVAILABILITY COMMENTS NA

PROGRAM CAPABILITIES AND METHODOLOGY Program is based upon isoparametric finite elements which may be either isotropic or non-homogeneous and a failure criterion in which a fixed percentage of the stiffness of the failed elements is subtracted from the total stiffness during each loading cycle.

INITIAL OPERATIONAL DATE Sept. 1972

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROGRAM ID NA

LANGUAGE Fortran IV

COMPUTER Univac 1108
SOURCE OF INFORMATION JOUR

APPLICATION CODE ROCSOL COALU

APPLICATION Coal Mine Roof Monitoring

DOCUMENTATION TITLE/AUTHOR "How Computerized Instrumentation Monitors Coal Mine Roofs"/James R. McVey, Maynard O. Serbousek, USBM Spokane Research Center, East 318 Montgomery Ave., Spokane, WA 99207

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Mining Engineering, September, 1976 issue, volume 28, number 9, pp. 40-43

PROGRAM CAPABILITIES AND METHODOLOGY "The Spokane Mining Research Center of the U.S. Bureau of Mines has developed a computerized instrumentation system that can examine the structural behavior of roof supports in a coal mine. It can instantaneously compute and plot the load, load rates, deformation, stress, opening, closures, etc., in an actual production operation carried out by such conventional mining techniques as room-and-pillar."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID NA

LANGUAGE NA

COMPUTER NA

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to programs published in Mining Engineering, February, 1970 issue, volume 22, number 2, pp. 74-76.

PROGRAM CAPABILITIES AND METHODOLOGY The numerical technique of finite element analysis has enabled the development of models devised for open-pit, room-and-pillar, and longwall mining.
SOURCE OF INFORMATION JOUR
APPLICATION Rock Mechanics

APPLICATION CODE ROCSOL
GENMIN

DOCUMENTATION TITLE/AUTHOR "Two-Dimensional Analysis of Near-Surface Single-Seam Extraction"/S.L. Crouch, University of Minnesota, Minneapolis, MN

SURVEY PARTICIPANT/ADDRESS None


PROGRAM CAPABILITIES AND METODOLOGY "This paper describes a digital computer method for calculating the stresses and displacements induced by underground excavations in a single flat-lying seam that is arbitrarily near to the surface of the earth. The method is developed by superposition from solutions previously given for a displacement discontinuity, or dislocation, in an otherwise continuous, linearly elastic, infinite rock mass. The new solution can be applied to complicated extraction patterns in the plane of a seam in a semi-infinite mass, the surface of which can be subjected to arbitrary prescribed tractions. The method can be used to study a wider class of problems than has previously been possible, and is not limited to mining applications.

INITIAL OPERATIONAL DATE NA
PROGRAM SIZE NA
FREQUENCY OF USE NA
OTHER USERS NA

PROG ID NA
LANGUAGE NA
COMPUTER NA
APPLICATION Design of Underground Excavation

DOCUMENTATION TITLE/AUTHOR S.L. Crouch

SURVEY PARTICIPANT/ADDRESS S.L. Crouch/Department of Civil and Mineral Engineering, University of Minnesota, Minneapolis, MN 55455


PROGRAM CAPABILITIES AND METHODOLOGY
The program is intended for the calculation of stresses and displacements around an underground excavation (cavity) or a seam type mining pattern. The program is based on the Displacement Discontinuity Method. It is two-dimensional (plane strain) and includes treatment of faults and seam materials displaying nonlinear behavior.

INITIAL OPERATIONAL DATE 1976
PROGRAM SIZE 130,000 octal
FREQUENCY OF USE On demand
OTHER USERS NA
PROGRAM CAPABILITIES AND METHODOLOGY

"This report describes a combined analog-digital computer system for solving problems that are impractical when either device is used separately. This method applied to the important class of mining problems involving excavations to tubular seam or vein-type deposits. The Hybrid computer has many implications for rational planning of underground excavations, since it allows practically any type of inelastic seam behavior or artificial support characteristics to be simulated. The Hybrid computer shows considerable potential as a design tool for coal mine layout. It is ideally suited to investigations of effects of design changes due to the speed with which parameter changes can be implemented."
APPLICATION Geomechanical Problems in Mining


SURVEY PARTICIPANT/ADDRESS Spokane Mining Research Center/ E. 315 Montgomery, Spokane, Washington 99207

AVAILABILITY COMMENTS Latest Version of Code Available from Agbabian Associates, 250 North Nash Street, El Segundo, California 90245

PROGRAM CAPABILITIES AND METHODOLOGY Capability: Static, linear and nonlinear material properties, two-and three-dimensional representations, applied external forces and pressures, displacements, gravity loading; sequence of construction (i.e., addition or removal of elements). Modeling of slip surfaces (faults). Both structural and continuum elements available. Sophisticated mesh generation capability for ease of mesh description. Quite efficient. Restartable from tape. User oriented.

Method: Finite-element method.

Input: Basic structural configurations, loads, material definitions sequence of element removal and insertion.

Output: Displacement, stresses, strains. Mesh plots.

INITIAL OPERATIONAL DATE 1972

PROGRAM SIZE Source Decic 12,000

FREQUENCY OF USE Daily/Qualified Users may access Code on Univ. of CA. CDC

OTHER USERS 7600 at Berkeley, CA

University of Illinois, ERDA at Sandia, Bureau of Reclamation at Denver, C.S.I.R.O. at Victoria, Australia. Lawrence Berkely Laboratory, Berkeley, California

PROG ID BuMINES

LANGUAGE Fortran

COMPUTER CDC 3200, 6600, 7600

IBm 360-66
APPLICATION Nonlinear Structural Response Analysis

DOCUMENTATION TITLE/AUTHOR "ANSR-1...General Purpose Program for Analysis of Nonlinear Structural Response"/D.P. Mondkar and G.H. Powell, Department of Civil Engineering, University of California, Berkeley, California  94720

SURVEY PARTICIPANT/ADDRESS K.K. Wong/Associate Development Engineer, Earthquake Engineering Research Center, Computer Applications, Davis Hall, University of California, Berkeley, California 94720

AVAILABILITY COMMENTS
Write for catalog which contains program description, and program documentation prices to: NISEE/Computer Applications, Davis Hall, University of CA, Berkeley, CA 94720 (415) 642-5113.

PROGRAM CAPABILITIES AND METHODOLOGY
"ANSR is a general purpose computer program for static and dynamic analysis of nonlinear structures. In it, a structure is idealized as an assemblage of discrete finite elements. Each node may possess up to six degrees of freedom. The structure mass is assumed to be lumped at the nodes. Viscous damping effects may be included, or damping proportional to mass, initial elastic stiffness and/or tangent stiffness can be specified. Static loads are applied in a series of load increments, each load increment being specified as a linear combination of static force patterns. This feature permits nonproportional loads to be applied. Dynamic loading may consist of earthquake ground accelerations, time-dependent nodal loads, or prescribed initial values of nodal velocities and accelerations.

INITIAL OPERATIONAL DATE 12/75
PROGRAM SIZE NA
FREQUENCY OF USE NA
OTHER USERS NA

PROG ID ANSR-1
LANGUAGE Fortran IV
COMPUTER CDC 6400
DOCUMENTATION TITLE/AUTHOR "SAP IV...A Structural Analysis Program for Static and Dynamic Response of Linear Systems"/ K.J. Bathe, E.L. Wilson, and F.E. Peterson, Department of Civil Engineering, University of California, Berkeley, CA 94720

SURVEY PARTICIPANT/ADDRESS Edward L. Wilson/Department of Civil Engineering, University of California, Berkeley, California 94720

AVAILABILITY COMMENTS
Write for catalog which contains program description, and program documentation prices to: NISEE/Computer Applications, Davis Hall, University of California, Berkeley, CA 94720 (415) 642-5113

PROGRAM CAPABILITIES AND METHODOLOGY
"SAP IV is finite element structural program for the static and dynamic response of linear three dimensional systems. The program is written to analyze structures which are idealized by combinations of structural element types. The capacity of the problem depends mainly on the number of finite element nodal points in the system. There is practically no restriction on the number of elements, the number of loadcases and the number or bandwidth of the equations to be solved. In a dynamic analysis the options are (1) frequency calculations only, (2) frequency calculations followed by response history analysis, (3) frequency calculations followed by response spectrum analysis, and (4) response history analysis using step-by-step direct integration. Despite large system capacity, no loss in efficiency is encountered in solving smaller problems.

INITIAL OPERATIONAL DATE 6/73 revised 4/74

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Nonlinear Structural Analysis

DOCUMENTATION TITLE/AUTHOR "NONSAP...A Structural Analysis Program for Static and Dynamic Response of Nonlinear Systems"/K.J. Bathe, E.L. Wilson, and R.H. Iding, Department of Civil Engineering, University of California, Berkeley, CA 94720

SURVEY PARTICIPANT/ADDRESS Edward L Wilson/Department of Civil Engineering, University of California, Berkeley, California 94720

AVAILABILITY COMMENTS
Write for catalog which contains program description, and program documentation prices to: EE/Computer Applications, Davis Hall, University of California, Berkeley, CA (415) 642-5113

PROGRAM CAPABILITIES AND METHODOLOGY
"NONSAP is a finite element structural analysis program for the static and dynamic response of nonlinear systems. The program is an in-core solver. The capacity of the program is essentially determined by the total number of degrees of freedom in the system. However, all structure matrices are stored in compacted form, i.e. only nonzero elements are processed. The system response is calculated using an incremental solution of the equations of equilibrium with the Wilson or Newmark time integration scheme. Before the time integration is carried out, the constant structure matrices, namely the linear effective stiffness matrix, the linear stiffness, mass and damping matrices, whichever applicable and the load vectors are assembled and stored on low-speed storage. During the step-by-step solution the linear effective stiffness matrix is updated for the nonlinearities in the system. Therefore, only the nonlinearities are dealt with in the time integration."

INITIAL OPERATIONAL DATE 2/74

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID NONSAP

LANGUAGE NA

COMPUTER CDC 6400

IBM 370/158
**APPLICATION**  Three Dimensional Static Analysis

**DOCUMENTATION TITLE/AUTHOR** "SOLID SAP...Static Analysis Program for Three Dimensional Solid Structures"/E.L. Wilson, Department of Civil Engineering, University of California, Berkeley, CA

**SURVEY PARTICIPANT/ADDRESS** Edward L. Wilson/Department of Civil Engineering, University of California, Berkeley, California

**AVAILABILITY COMMENTS** Write for catalog which contains program description, and program documentation prices to: NISEE/Computer Applications, Davis Hall, University of California, Berkeley, CA

**PROGRAM CAPABILITIES AND METHODOLOGY**

"SOLID SAP or SSAP is designed to perform static, linear, elastic analyses of three dimensional structural systems. The program had flexibility of application to structures which contain combinations of structural element types. The capacity of the program depends mainly on the number of joints in the system. There is practically no restriction on the number of elements, number of load cases, or the "bandwidth" of the equations to be solved. Despite large system capacity, no efficiency loss is encountered in solving smaller problems. The report contains a discussion of the use of incompatible displacement nodes with solid elements and the use of the static condensation algorithm. A brief discussion of each element type is also given. SSAP is machine independent and coded in FORTRAN IV."

**INITIAL OPERATIONAL DATE** 9/71 revised 12/72

**PROGRAM SIZE** NA

**FREQUENCY OF USE** NA

**OTHER USERS** NA
This program calculates the amount of heat to be extracted for ground consolidation by means of forming an ice wall around shaft excavation. Input data includes physical, mechanical, and thermal properties for single and multiple rock formations.
SOURCE OF INFORMATION SUBMIT

APPLICATION Code ROCSOL

GROUND

APPLICATION Design of Shaft Linings

DOCUMENTATION TITLE/AUTHOR Witold Ostrowski—Author

SURVEY PARTICIPANT/ADDRESS Larry S. Jaycox, Mining Engineer/
S.A. Scott & Company, Inc., 12567 West Cedar Drive, Lakewood,
CO 80228

AVAILABILITY COMMENTS By special arrangement.

PROGRAM CAPABILITIES AND METHODOLOGY This program calculates
stress around shaft openings for rock in the elasto-plastic
and elasto-elastic state of equilibrium.

INITIAL OPERATIONAL DATE 7/75

PROGRAM SIZE NA

FREQUENCY OF USE On Engineer Demand

OTHER USERS None

PROG ID ELASTO-PC

LANGUAGE Fortran IV

COMPUTER IBM 360/40
APPLICATION Calculation of Stresses on Concrete Shaft Linings

DOCUMENTATION TITLE/AUTHOR Larry S. Jaycox—Author

SURVEY PARTICIPANT/ADDRESS Larry S. Jaycox, Mining Engineer/ S.A. Scott & Company, Inc., 12567 West Cedar Drive, Lakewood, CO 80228

AVAILABILITY COMMENTS By special arrangement

PROGRAM CAPABILITIES AND METHODOLOGY This program calculates stresses on concrete shaft linings for uniform and combined uniform and nonuniform loadings.

INITIAL OPERATIONAL DATE 12/4/75
PROG ID STRESCON
PROGRAM SIZE NA
LANGUAGE Fortran IV
FREQUENCY OF USE On Engineer Demand
COMPUTER IBM 360/40
OTHER USERS None
APPLICATION Stabilizing Pressures

DOCUMENTATION TITLE/AUTHOR USBM RI 8128 "A Method for Computing Stabilization Pressures for Excavations in Incompetent Rock, with Computer User Information"/J.D. Dixon, M.A. Mahtab, Denver Mining Research Center, United States Bureau of Mines, Denver, CO

SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-252-902

PROGRAM CAPABILITIES AND METHODOLOGY The purpose is to compute stabilization pressures for excavations in incompetent rock by means of a confining pressure analysis (CPA) and a failure evaluation analysis (FEA). The CPA evaluates concentrated nodal point forces to confine elements wherein shear stress along the critical failure plane exceeds Mohr-Coulomb strength criteria. The FEA evaluates the stress condition at the centroid of a finite element. When run in conjunction with the CPA, indication of its confining forces resulting in an overall stable element will be given. When FEA is run alone, overstressed shear and tensile zones will be given. The program code is a by-product of this research and its development has not been oriented for general use. The USBM assumes no responsibility for its operation. This program is experimental, it compiles for syntax but is not tested for accuracy.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID STABIL

LANGUAGE NA

COMPUTER Cyber 74-28
APPLICATION Space-Frame Protective Canopies


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-210-166

PROGRAM CAPABILITIES AND METHODOLOGY Computer program performs a structural analysis of space-frame protective canopies used in underground mines to protect equipment operators from falls of roof, face and rib. Rapid calculation of the elastic strength of a canopy for a variety of loading conditions is done. Output also includes identification of all members that have commenced yielding weight of the canopy, total loads on the canopy and maximum loads the canopy can sustain elastically.

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 40K core storage

FREQUENCY OF USE NA

OTHER USERS NA

PROG ID CANOPY

LANGUAGE Fortran IV

COMPUTER CDC 6500
SOURCE OF INFORMATION SUBDOC

APPLICATION Subsidence

DOCUMENTATION TITLE/AUTHOR Final Report "A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining Volume V - Subsidence Susystem"/C.B. Manula, B. Mozumdar, D.K. Jeng, The Pennsylvania State University, University Park, PA 16802, USBH, Grant Number G0111808

SURVEY PARTICIPANT/ADDRESS Department of Mineral Engineering/ The College of Earth and Mineral Sciences, The Pennsylvania State University, University Park, PA 16802

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS) under the above title, Accession Number PB-255-425

PROGRAM CAPABILITIES AND METHODOLOGY "This volume of the final report describes the subsidence subsystem of the Master Design Simulator. This subsystem uses the finite element method to simulate ground movement caused by an advancing mining face in an underground coal mine. The model is structured around the concept that the ground mass is a layered media of different thicknesses and material properties. Gob areas are considered to be unfilled with broken rock at the beginning of mining. After mining starts, the gob areas are filled with broken materials which provides resistance to the lowering of the overlying strata. The model is tied to the geology and reserves subsystem, but it can also operate as a free standing routine. A case study is presented illustrating the application of the model. A detailed user's manual, including a program listing, is included in the appendices."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA

APPLICATION CODE ROCSOL

COALU

LANGUAGE Fortran IV

COMPUTER IBM 370/168
APPLICATION Nonlinear Regression


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title. Accession Number PB-237-036

PROGRAM CAPABILITIES AND METHODOLOGY "This program will solve nonlinear regression problems. The program is written in a general form so that, regardless of the functional relationship assumed, the unknown parameters may be evaluated by the Newton-Raphson method of iteration. Variances and co-variances of the parameters are derived, based on the propagation of errors. A creep function is established from shale test data as are examples of program utility. Program accuracy is compared to the accuracies of other programs in present day use."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE 16K core memory Mac 900 data points, 30 parameters

FREQUENCY OF USE NA

OTHER USERS NA

LANGUAGE Fortran IV

COMPUTER CDC 6400

PROG ID REGRESS
APPLICATION Prediction of Surface Subsidence

DOCUMENTATION TITLE/AUTHOR Mining Subsidence/Naiem S. Tanious

SURVEY PARTICIPANT/ADDRESS U.S. Steel Research Center/B. Street, Pittsburgh, PA 15235

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-252-455.

PROGRAM CAPABILITIES AND METHODOLOGY The program predicts surface subsidence caused by multiple mining of flat seam type deposits. The numerical method in the program is based on a traversely inisotropic, elastic solution given by means of a mathematical method in the Theory of Elasticity called the displacement discontinuity method. To describe the rock mass behavior, elastic constants are needed which can be obtained by a back calculation procedure. The program data input consists of specifying number of seams in the problem under consideration, elastic constants of the rock mass, depth and thickness of seams, mining pattern in the seams and whether it has been mined and caved.

INITIAL OPERATIONAL DATE 1/75

PROGRAM SIZE CM 145,000

FREQUENCY OF USE Unlimited

OTHER USERS Department of Civil and Mineral Engineering, University of Minnesota, Minneapolis, MN
MINE VENTILATION
APPLICATION Mine Ventilation Network Analysis


SURVEY PARTICIPANT/ADDRESS Peabody Coal Company/301 N. Memorial Drive, St. Louis, Missouri 63102 ATTENTION: EDP Department

AVAILABILITY COMMENTS Contact U.S. Bureau of Mines, Ventilation Group, Pittsburgh, PA or authors of documentation at Penn State U., Department of Mineral Engineering.

PROGRAM CAPABILITIES AND METHODOLOGY: Program input defines all airways in ventilation network by specifying each branch in terms of nodes, resistance or friction factor and airway dimensions, air quantity or NVP pressures, # of entries, fan number if one exists, and type of airway (fixed, NVP, fan, leak or general). Additional input defines fan curve characteristics (Q vs H, and efficiency) for each fan. Constraints on iterative methods of network computation are also variably input (maximum iterations, allowable error). To compute Q (air quantity) and H (head loss) in each airway, program utilized Gauss-Seidel form of iteration, Hardy Cross Correction factor, Kirchhoff's law for networks and Atkinson's law for pressure drop.

INITIAL OPERATIONAL DATE Nov. 1973

PROGRAM SIZE 95,000 by'es

FREQUENCY OF USE On Demand, at Division Engineers request

OTHER USERS None
PROGRAM CAPABILITIES AND METHODOLOGY

"This volume of the final report describes the ventilation subsystem of the Master Design Simulator. The ventilation subsystem has the capabilities to handle: (1) branches in parallel or series, (2) fans in parallel or series, (3) multiple fans, (4) methane, compressed air, or other injections into the system, (5) leakages and fixed quantities, and (6) calculations of absolute pressure at nodes. The program uses the Kirchhoff's Junction and mesh laws, and the Hardy-Cross iterative technique to converge to the desired accuracy in solving for the head quantity. A case study is included in the report illustrating the use of the model. The appendices of the report constitute a user's manual for the ventilation subsystem, and include program listing."
PROGRAM CAPABILITIES AND METHODOLOGY "The underground mining industry is presently using the fluid network analyzer and digital computer to analyze ventilation systems. The availability of the digital computer and ventilation programs to mining companies has escalated its use permitting the design and modification of new or existing mine systems to be projected completely and throughly with consistent precision. Furthermore, the analog computer has been analyzing ventilation systems accurately for many years, and a comparison of the analog and digital methods was warranted. The report summarizes a detailed comparison for one mine and illustrates the paralleled analysis between the computers."
APPLICATION Ventilation Simulator


SURVEY PARTICIPANT/ADDRESS Department of Mining and Minerals Engineering/Virginia Polytechnic Institute & State University, Blacksburg, VA 24061

AVAILABILITY COMMENTS National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22151.

PROGRAM CAPABILITIES AND METHODOLOGY "VENTSIM" utilizes one or a combination of three options: (1) measured pressure drops and volumes; (2) friction factor calculation; and (3) friction factor definition, to calculate the resistance of mine airways. From this and other input dealing with the flow network, fans, regulators, and airways, the program calculates volumes, pressure drops, flow rates, horsepower requirements and flow distributions. It can be used to model, predict, and solve a number of problems dealing with ventilation networks.

INITIAL OPERATIONAL DATE Sept. 1968

PROGRAM SIZE App. 150K

FREQUENCY OF USE On demand

OTHER USERS Both foreign and U.S.A. mining companies, various universities and research groups.
APPLICATION Ventilation Planning

DOCUMENTATION TITLE/AUTHOR Interactive Ventilation Planning System/R.A. Turpin

SURVEY PARTICIPANT/ADDRESS W.D. Bender/Bethlehem Steel Corporation, Research Department, Bethlehem, PA 18016

AVAILABILITY COMMENTS Program or listing not available but may negotiate.

PROGRAM CAPABILITIES AND METHODOLOGY The INVENT ventilation planning package contains interactive computer programs to perform the complex and lengthy calculations required in solving ventilation problems. These programs primarily compute: (1) airway resistances from air survey data, (2) air flow rates and pressures in a ventilation system, and (3) optimum fan blade settings and fan speed adjustments for single and multiple fan mines. The package also contains extensive user accommodations that simplify the work required to enter air-survey data into the computer, constructs ventilation system models, and selectively displays the results of a ventilation analysis.

INITIAL OPERATIONAL DATE 7/23/75
PROGRAM SIZE 3000 stmts
FREQUENCY OF USE On demand
OTHER USERS NA
APPLICATION Ventilation

DOCUMENTATION TITLE/AUTHOR Computer program for Mine Ventilation Network Analysis/Y.J. Wang


PROGRAM CAPABILITIES AND METHODOLOGY Data input includes nodal points of airways, airway resistance (or friction factor, height, width and length of airway), fan characteristics, natural ventilation pressures, and if desired, air quantities for regulated airways. The solution to mine ventilation network is obtained by applying Hardy Cross iteration technique. Program output includes air quantity and pressure drop for each airway, cumulative pressure drop for each mode, operating points of fans, and pressures to be adjusted for regulated airways.

INITIAL OPERATIONAL DATE Oct. 1975

PROGRAM SIZE 120 K bytes

FREQUENCY OF USE On demand

OTHER USERS NA
APPLICATION Solute Waste Isolation Flow and Transport (SWIFT)

DOCUMENTATION TITLE/AUTHOR
Risk Methodology for Radioactive Waste Disposal in Geologic Media (Draft) Chapter C - Sandia Laboratories and the USGS

PARTICIPANT/ADDRESS

AVAILABILITY COMMENTS
Contact Sandia Laboratories

PROGRAM CAPABILITIES AND METHODOLOGY

Three dimensional finite difference code that solves the combined effects of the differential equations of continuity combined with Darcy's Law (single phase flow), energy balance (heat transfer), solute concentration equation for material present in sufficient quantity to cause a density or viscosity effect, and a material transport equation for radionuclides which includes decay chains.

The code is comprehensive enough to include the effects of hydrodynamic dispersion in both the temperature and compositional mixing between resident and injected fluids. Convective flow modeling uses second-order correct space and time approximations minimizing the numerical dispersion problem.

Fluid and material properties to be input include radionuclide data, thermal properties of the fluid, thermal properties of porous media in each direction, rock density, reference temperatures and pressures, well properties, concentration viscosity tables, hydraulic conductivity, porosity, longitudinal and transverse

INITIAL OPERATIONAL DATE

PROGRAM SIZE VERY LARGE

FREQUENCY OF USE

OTHER USERS
USGS
dispersivity and molecular dispersivity.

To establish initial conditions the relevant state includes solute concentrations (salt in water etc.), initial velocities of resident fluid, and initial concentration of the radionuclides. Source value of radionuclides may be varied.

The code has been developed for the specific purpose of modeling radionuclide transport considering many physical phenomena and appears to be the most complete code for the task. The code has been verified hydrologically by comparison with an USGS geohydrology code and has also been used for a number of thermal calculations.
APPLICATION Water Flow


USBM, Grant Number G0111808

SURVEY PARTICIPANT/ADDRESS Department of Mineral Engineering/
The College of Earth and Mineral Sciences, The Pennsylvania State University, University Park, PA 16802

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS) under the above title, Accession Number PB-255-429

PROGRAM CAPABILITIES AND METHODOLOGY "The Water Generator (WATGEN) represents one part of the total system entitled "A Master Environmental Control and Mine Systems Design Simulator for Underground Coal Mining", and is applied to predict mine drainage quantity. The development of WATGEN as outlined in the report is based on a finite difference approximation coupled with a finite element analysis. The main differences between this model and its predecessors is the ability to consider such processes as precipitation, infiltration, runoff, evaporation, evapotranspiration and interflow. The second difference that characterizes the model is the consideration given to the unsaturated zone which allows application to a continuous water shed. Although WATGEN can be readily tied to the Geology and Reserves subsystem as a part of MDS, it is free standing and operates as an event-oriented routine."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Mine Drainage Estimation


SURVEY PARTICIPANT/ADDRESS Angelus S.C. Owili-Eger/CONOCO, P. O. Box 1267, Ponca City, Oklahoma 74601

AVAILABILITY COMMENTS NA

PROGRAM CAPABILITIES AND METHODOLOGY Two-phase (water-air/gas) flow model. Solution procedure combines finite difference approximation with finite element method. Input data requirements includes geologic, fluid properties, meteorologic and miscellaneous (book-keeping) data. These data are input for each block or element.

INITIAL OPERATIONAL DATE 1975

PROGRAM SIZE 280K

FREQUENCY OF USE On demand

OTHER USERS USBM, Underground coal mines
APPLICATION In Situ Leaching Fluid Hydrology Analysis

DOCUMENTATION TITLE/AUTHOR U.S. Bureau of Mines Report of Investigation by Donald I. Kurth and Robert D. Schmidt

SURVEY PARTICIPANT/ADDRESS Robert D. Schmidt/Twin Cities Mining Research Center, Twin Cities, MN 55111

AVAILABILITY COMMENTS Program listing and documentation available upon request.

PROGRAM CAPABILITIES AND METHODOLOGY. Computer model simulates aquifer hydrology associated with in situ leaching (of uranium). The model simulates a 5-spot pattern on input and output wells. Leaky and non-leaky aquifers are modeled using closed form solutions of the partial differential equations describing the change in fluid head as the leaching is carried out. User input consists of aquifer, well and leachant flow characteristics. Numeric and graphic output such as iso pressure, iso velocity and iso time contours are available.

INITIAL OPERATIONAL DATE 2/77  PROG ID 5-SISL
PROGRAM SIZE 11,300 words  LANGUAGE Fortran
FREQUENCY OF USE On demand  COMPUTER CDC 6600
OTHER USERS NA
Chemical Reactions in Natural Waters


**SURVEY PARTICIPANT/ADDRESS** None

**AVAILABILITY COMMENTS** Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-251 668.

**PROGRAM CAPABILITIES AND METHODOLOGY** "MIX2 is a Fortran IV computer program that utilizes an aqueous model and the constraints of mass balance and electrical balance to compute the pH and equilibrium distribution of inorganic species as a result of net reaction progress in the closed system: CaO-MgO-Na₂O-K₂O-CO₂-H₂SO₄. The program considers three general classes of problems involving net reaction progress: (1) mixing of two solutions in fixed volume, (2) titration of one solution into another (variable volume), and (3) the addition or subtraction of a net stoichiometric reaction to or from an aqueous solution. In addition MIX2 will follow one phase boundary through any of the above classes of problems. This report presents the theory and method of calculation used by MIX2, describes the input to the program, presents results of two test cases, and provides a program listing."

**INITIAL OPERATIONAL DATE** NA

**PROGRAM SIZE** NA

**FREQUENCY OF USE** NA

**OTHER USERS** NA
APPLICATION Chemical Equilibria of Natural Waters

DOCUMENTATION TITLE/AUTHOR "WATEQ, A Computer Program for Calculating Chemical Equilibria of Natural Waters"/Alfred H. Truesdell, Blair F. Jones, USGS, Washington, DC.

AVAILABILITY COMMENTS Available from National Technical Information Service (NTIS), under the above title, Accession Number PB-220-464.

PROGRAM CAPABILITIES AND METHODOLOGY "The computer program, WATEQ, calculates the equilibrium distribution of inorganic aqueous species of major and important minor elements in natural waters using the chemical analysis and in situ measurements of temperature, pH and redox potential. From this model, the states of reaction of the water with solid and gaseous phases are calculated. Thermodynamic stabilities of aqueous species, minerals and gases have been selected from a careful consideration of all available experimental data."

INITIAL OPERATIONAL DATE NA
PROGRAM SIZE NA
FREQUENCY OF USE NA
OTHER USERS NA

PROGRAM ID WATEQ
LANGUAGE PL-1
COMPUTER IBM 360
APPLICATION Inorganic Aqueous Equilibrium Distribution

DOCUMENTATION TITLE/AUTHOR "SOLMNEQ: Solution-Mineral Equilibrium Computations"/Yousif K. Kharaka, Ivan Barnes Department of Geology and Geophysics, California University, Berkeley, CA

SURVEY PARTICIPANT/ADDRESS. None

AVAILABILITY COMMENTS Available from National Technical Information Service, under the above title, Accession Number PB-215 899.

PROGRAM CAPABILITIES AND METHODOLOGY "SOLMNEQ computes the equilibrium distribution of 162 inorganic aqueous species generally present in natural waters over the temperature range of 0 to 350° from the reported chemical analyses, temperature, pH, and Eh (optional). Interpolated dissociation constants of the aqueous complexes and the computed activity coefficients are also used in these computations. States of reactions of the aqueous solutions with respect to 158 solid phases (minerals) are computed from the distribution of aqueous species and an internally consistent set of thermodynamic data. Ionic proportions and subsurface temperature estimates are computed."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPICATION Tunnel Cost Estimated Risk Analysis

DOCUMENTATION TITLE/AUTHOR "Tunnel Cost Model User's Manual/ Saturnino Suarez-Heynoso and David J. Gray

SURVEY PARTICIPANT/ADDRESS Michael J. Markow/Massachusetts Institute of Technology, Room 1-170, Cambridge, Massachusetts 02139

AVAILABILITY COMMENTS Contact Mr. Markow. Prior request of descriptive reports is strongly advised before obtaining program.

PROGRAM CAPABILITIES AND METHODOLOGY The Tunnel Cost Model (TCM) is a simulation model of tunnel construction. It includes probabilistic descriptions of anticipated geology, construction productivity and equipment reliability to enable users to gauge risk in project cost and schedule estimates. The model provides owners and engineers a rapid way of analyzing alternative tunnel locations to seek the most favorable geologic environment. It allows owners, engineers and contractors to test different construction options to seek the most rapid and economical construction program. The TCM may also be used by owners and contractors during construction to update and revise the construction plan. The model operates at various levels of detail, and is therefore suited to estimates ranging from preliminary to final.

INITIAL OPERATIONAL DATE 4/74 PROG ID Tunnel Cost Model (TCM)

PROGRAM SIZE 300-600K bytes LANGUAGE PL/1

FREQUENCY OF USE On demand COMPUTER IBM 370/168

OTHER USERS Program has been used in case studies in conjunction with Periul Corporation, United Engineers and Construction, Inc., and Morrison-Knudsen, Inc. Intended for owners, design engineers, contractors, CM's, cost estimators involved in underground construction.
A computer performs all logic and computations customarily done by hand in preparation of engineer's estimates or contractor's bids on tunnel-shaft systems. The program described is based on construction methods, work forces, and equipment selections corresponding to the current state of the art of tunneling. The program contains logic to permit the estimate of costs of complicated tunnel-shaft systems. In any estimate, the program will accommodate a large number of values or changes in the values of the factors that affect costs, such as tunnel shape and size, shaft depth, rock characteristics, and construction method. To provide great flexibility, the user of the program is provided with the option of selecting lining type and thickness, profit and overhead margins, and other input data. Suggestions for selecting an appropriate value for these inputs are contained in the report.
APPLICATION Drilling and Blasting


SURVEY PARTICIPANT/ADDRESS Bonner & Moore Associates, Inc./500 Jefferson, Suite 1124, Houston, Texas 77002


PROGRAM CAPABILITIES AND METHODOLOGY

The DAB (Drilling and Blasting) model was designed for evaluation of rotary and auger drills (from the data files) for drilling either coal or overburden. The model determines equipment requirements and costs for blasting agents. It can determine spacing and burden for specified drills and powder factors, or evaluate drills for user-set burden and spacing.

INITIAL OPERATIONAL DATE March 1977

PROGRAM SIZE 16K

FREQUENCY OF USE NA

OTHER USERS NA
PROGRAM CAPABILITIES AND METHODOLOGY

SKIP I determines the dynamic load interaction between shaft conveyances and guides. Input variables include conveyance mass, location of center of gravity with respect to geometric center, guide material, size and shape, button spacing, conveyance velocity, guide misalignment, and variations in spring constant of guide rollers. Output includes forces normal to the guides, guide displacement; conveyance displacement, lateral accelerations. Program may be used as a design tool for guide and cage/skip specifications or may be used to evaluate the structural stability of particular shaft designs subject to vibrational loads.
PROGRAM CAPABILITIES AND METHODOLOGY  Mine hoist sizing program
prints out the rope speed, drum size, rope size, skip load,
skip weight, rms h.p., peak h.p., tread pressure, T1/T2 ratio
for various mine hoisting applications. Input data consists
of capacity requirements (TPH) or (LOADS), rope safety factor
required, type of rope to be used, type of drive system, duty cycle
data, drum dia. to rope dia. ratio, skip weights or cage weights
and number of ropes. Programs are available for double drum
hoists, single drum hoists, friction hoists and vertical or
inclined shafts.

INITIAL OPERATIONAL DATE 1967  PROG ID NA
PROGRAM SIZE NA  LANGUAGE Fortran
FREQUENCY OF USE NA  COMPUTER NA
OTHER USERS Mining companies, consulting firms, electrical drive
suppliers.
PROGRAM CAPABILITIES AND METHODOLOGY "RAMPLAN" provides a first order estimate of tonnages based on an assessment of structural evaluation problems. The program input gridded data from VPI & SU's "CONTUR" and "RESERV-COAL" along with dimensional data, subsidence data, and roof and floor data. From this it obtains and outputs panel and barrier pillar dimensions, unsupported roof spans, safety factors (both roof and floor), roof bolt length and capacity, bolts set, set spacing, and vertical subsidence dimensions. All calculations are done using design equations currently in use by industry.
PROGRAM CAPABILITIES AND METHODOLOGY

"PUMPSIM" analyzes a network of up to 20 pumps, 50 regulators, and 200 total line segments. It is a steady-state network analysis and shows whether a system design is feasible and illustrates the under-designed portions of the system. Data can be obtained from handbooks, schematics, and manufacturer's data. Output includes information on pumps, regulators, lines, fittings, quantities delivered, operating pressures, and water horsepower. Other output includes volumes, pressure losses and frictional factors.
CODES AT GOLDEN ASSOCIATES
APPLICATION Mine Evacuation Simulation

DOCUMENTATION TITLE/AUTHOR "Development of Emergency Escape Systems Guidelines for Underground Metal and Non-Metal Mines"/ (PTO)

SURVEY PARTICIPANT/ADDRESS Ashok B.Boghani/Program Manager, Foster-Miller Associates, Inc., 135 Second Avenue, Waltham, Massachusetts 02154

AVAILABILITY COMMENTS Card deck, listing, documentation available from USBM, Spokane. Foster-Miller will negotiate application assistance.

PROGRAM CAPABILITIES AND METHODOLOGY
The simulation input variables include characteristics of the mine, expressed in form of a network of passages, properties of hoists, and hoisting strategies, initial miner positions, ventilation and compressed air velocities, stench warning system and self rescuer capabilities. The simulation can be carried out for cases in which there is no fire or for cases in which there is a fire at any arbitrary location. The simulation output includes the evacuation time for each miner, movement of the hoists, propagation of smoke through the mine passages and smoke exposure of the miners.

INITIAL OPERATIONAL DATE 5/75
PROGRAM SIZE 130,000 words
FREQUENCY OF USE On demand
OTHER USERS NA
APPLICATION Geological Hazard Detection With Radar


SURVEY PARTICIPANT/ADDRESS None

AVAILABILITY COMMENTS Reference to program published in Coal Age, March, 1976 issue, volume 81, number 3, p. 196.

PROGRAM CAPABILITIES AND METHODOLOGY "A subsurface-probing radar system has been used to successfully detect and map underground features. The computerized-radar technique could reveal the location of potentially hazardous geological features in hard rock. In the method, radar signals transmitted and received in hard rock are combined with advanced computer-based signal processing techniques. The equipment would operate from small bore-holes to provide accurate information on the size and location of weathered zones, faults, water pockets, cavities, and other potentially hazardous conditions."

INITIAL OPERATIONAL DATE NA

PROGRAM SIZE NA

FREQUENCY OF USE NA

OTHER USERS NA
APPLICATION Power Simulator

PROGRAM CAPABILITIES AND METHODOLOGY
"POWERSIM" determines the adequacy of a power system with either AC or DC power, and containing up to 10 voltage sources, 75 loads, 300 total segments, and up to 9 levels of voltage. Most of the input data may be determined from handbooks, manufacturers data and schematic diagrams. Output includes currents, voltages, percent of rated voltage, watts, vars, volt-amps available, and the power factors for the loads and sources. Similar output including voltage-drop and power-consumed are provided for the lines.

AVAILABILITY COMMENTS Available from National Technical Information Service under the above title, Accession Number AD-A-001-602.

PROGRAM CAPABILITIES AND METHODOLOGY "The report describes a computer program that can model the behavior of assemblages of rock blocks, and visually display this behavior on the screen of a Cathode Ray Tube (CRT). There is no restriction on block shapes and no limits to the magnitudes of displacements and rotations that are allowed. The rock geometry is specified by the user, who "draws" lines on the CRT screen, which is connected to a mini-computer. The program then interprets each closed area between lines as a discrete block, and allows the blocks to move relative to one another, under the action of gravity and forces specified by the user. Joint properties may be specified, and blocks may be "excavated", fixed and released or "reinforced".

INITIAL OPERATIONAL DATE NA
PROGRAM SIZE NA
FREQUENCY OF USE NA
OTHER USERS NA