SIMSAR

V. 1.0

Simulation of Silica Aggregate Reaction in Concrete

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ABSTRACT

SIMSAR is a Windows-based program for the simulation of silica aggregate reaction in concrete. It simulates the concurrent ion diffusion from the cement paste into the aggregate, and then the gel formation and its diffusion into the cement paste. SIMSAR is coupled with the MERLIN finite element code for stress analysis because gel diffusion is a function of the stress state.

Analysis of the silica aggregate reaction in concrete is facilitated by the PARSIFAL code, which can generate a finite difference grid and a finite difference mesh for heterogeneous materials.

There are two solution procedures to SIMSAR: The first is based on a numerical solution for ion and gel diffusion around arbitrarily shaped aggregates; and the second is based on a two-dimensional analytical solution around circular aggregates.

Table of Contents

List of Figures

1 Introduction

SIMSAR is a window-based application program that is used for performing the Alkali-Silica Reaction (ASR) analysis in the dam in order to determine the expansion coefficients of the RVE (should spell out RVE before using the acronym) due to the gel formation around inclusions.

There are four menu options:

- **`File`**: Gives options for analysis controls.
- **`Analysis`**: Provides options for preparing input information for either ion diffusion analysis, or coupled diffusion-stress analysis. This menu option also launches and stops the analysis.
- **`View Analysis Results`**: This option allows for viewing of the analysis results.
- **`View`**: Presents options for controlling the model view.

The procedure for analyzing ASR problems using SIMSAR can be summarized in the following sections.

2 Run SIMSAR

Run **`SIMSAR.exe`** (if this is a pre-defined executable, it may need to stay in lowercase). An interface of the program is shown in Figure 1.

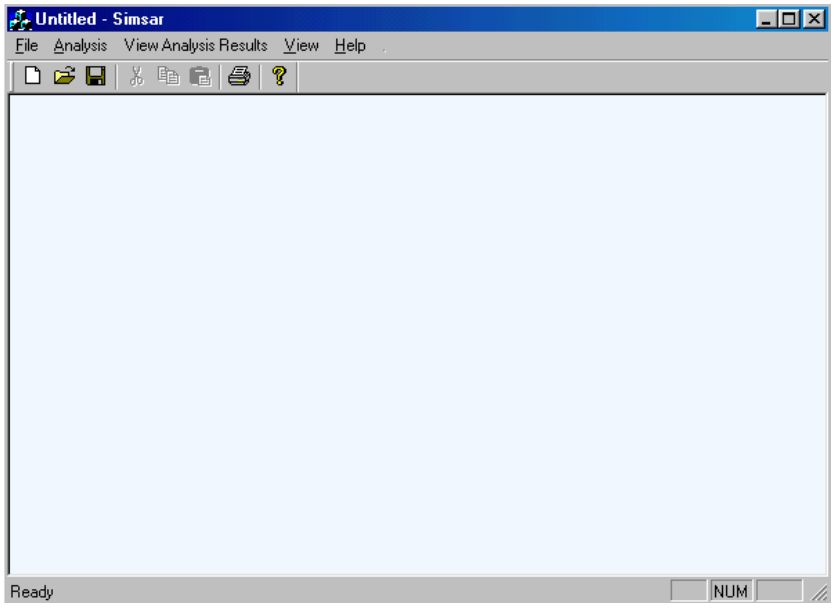

Figure 1: Graphical User Interface of SIMSAR

Open the input files. There are two types of input files needed in the analysis: an input file of RVE definition generated by the PARSIFAL program, and an input file of finite element definition generated by the Kumonosu (should this be capitalized?) program. The first input file has an "**`.arg`**" extension, whereas the latter has an "**`.inp`**" extension. To open the

PARSIFAL input file, click on the "**File**" menu and select "**Open .arg file**". For the Kumonosu input file, select "**Open .inp file**". The menus are shown in Figure 2.

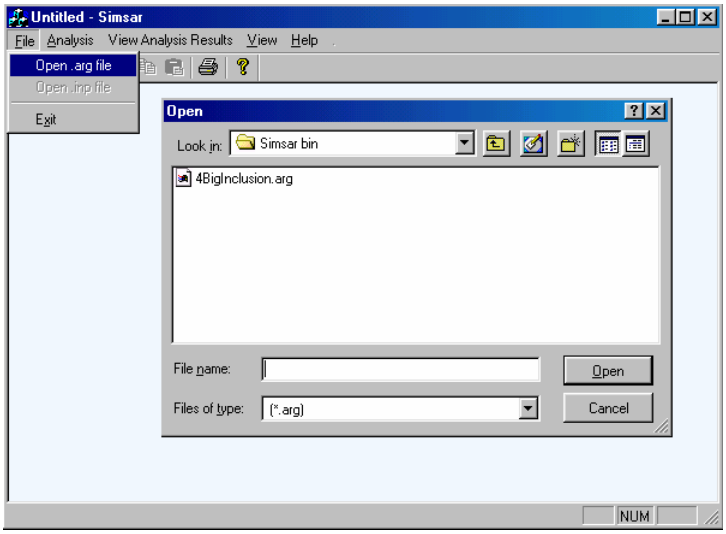

Figure 2: Selection of Input File

In this example, open "**4BigInclusion.arg**" and "**4bigInclusion1inc.inp**". After opening these two files, the view of the program is as shown in Figure 3.

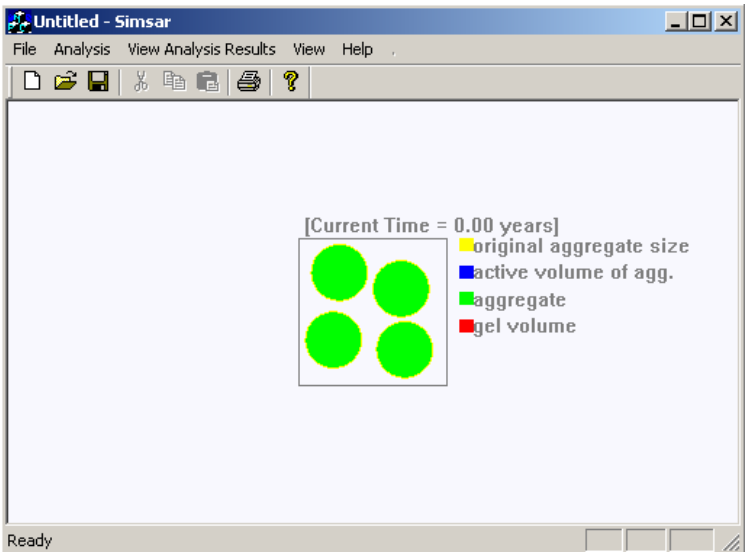

Figure 3: GUI After the Two Input Files have been Opened

3 Input Data Selection

Prepare the input information for the problem. To enter the input data, click on the "**Analysis**" menu and then select the preferred analysis model. This launches the input dialog for the selected analysis model. There are two models the user can select. The first model is an ion diffusion analysis, and the second one is a coupled diffusion-stress analysis. The ion diffusion analysis is

used to determine the time that the gel diffusion starts. The coupled diffusion-stress analysis is used to perform the full analysis of ASR problem where it involves ion diffusion, gel diffusion and stress analysis. (The stress analysis can be done by using MERLIN program.) For the case of the coupled diffusion–stress analysis, the input dialog is shown in Figures 4-6.

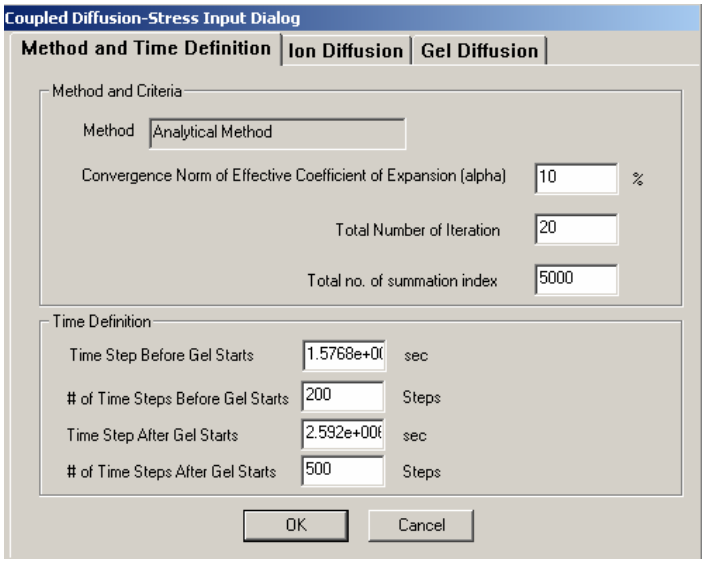

Figure 4: Solution Procedure and Time Increment Definition for Coupled Diffusion-Stress Analysis

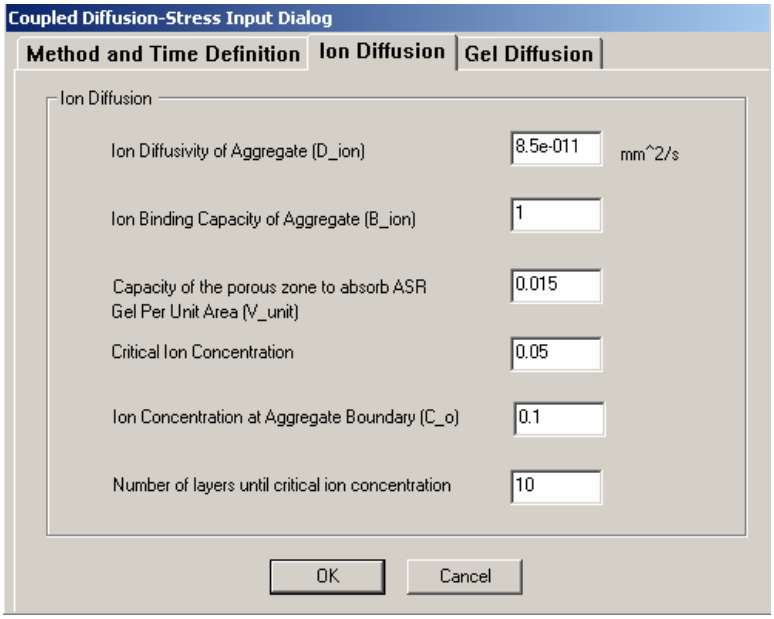

Figure 5: Ion Diffusion Input Image for Coupled Diffusion-Stress Analysis

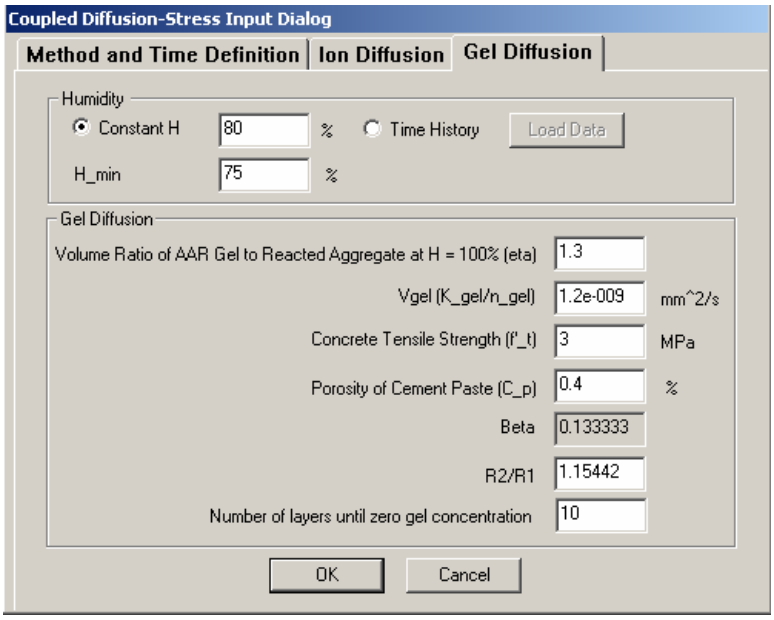

Figure 6: Gel Diffusion Input Page for Coupled Diffusion-Stress Analysis

4 Analysis

Perform the analysis by clicking on the "**Analysis**" menu and then selecting "**Run Analysis**". The program will commence from ion diffusion until the gel diffusion starts, then it will proceed through the coupled process among ion diffusion, gel diffusion and stress analysis. In the stress analysis, the MERLIN program is called by SIMSAR. The SIMSAR program during the coupled analysis process is shown in Figure 7. The analysis process will stop after the analysis is done, or it can be stopped at any time by clicking on the "Analysis" menu and then selecting "**Stop Analysis**".

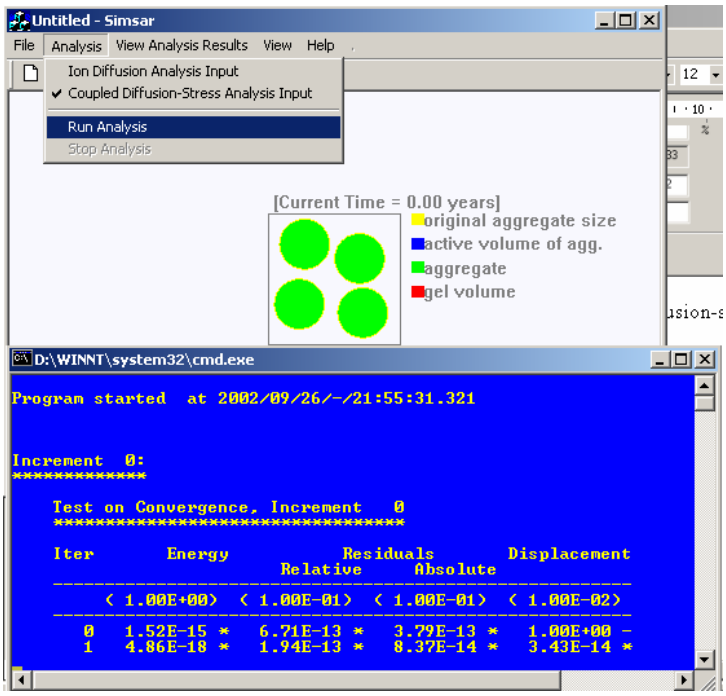

Figure 7: Graphical Display During Coupled Diffusion-Stress Analysis

5 Results

To display the analysis results after the analysis is done or when the user interrupts the process, the user can select the following:

- Displacements and expansion coefficients of RVE, i.e., u_x, u_y, ε_x and ε_y

  These results can be plotted or shown in the data file by clicking on "**`View Analysis Results`**", selecting "**`RVE`**" and then choosing the desired data type. An example of a plot of u_x versus time can be shown in Figure 8.

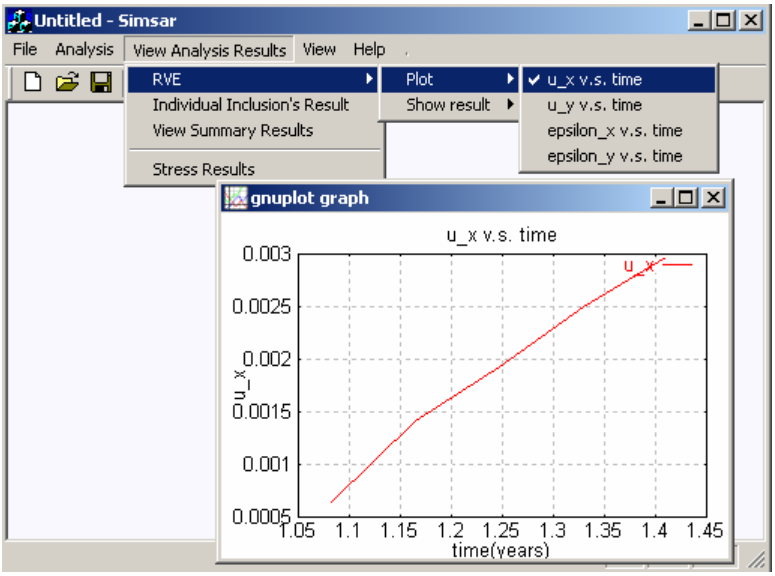

Figure 8: Grphical Plot of u_x of RVE versus Time

- Interface pressure and expansion coefficient of each inclusion

  These results can be plotted or shown in the data file by clicking on "**`View Analysis Results`**" and then selecting "Individual Inclusion's Result". "**`Inclusion Result Dialog`**" is then loaded. In this dialog box, the user can select whether to plot or to show detailed results of any inclusion. An example of a plot of Interface pressure around Inclusion 1 versus time is shown in Figure 9.

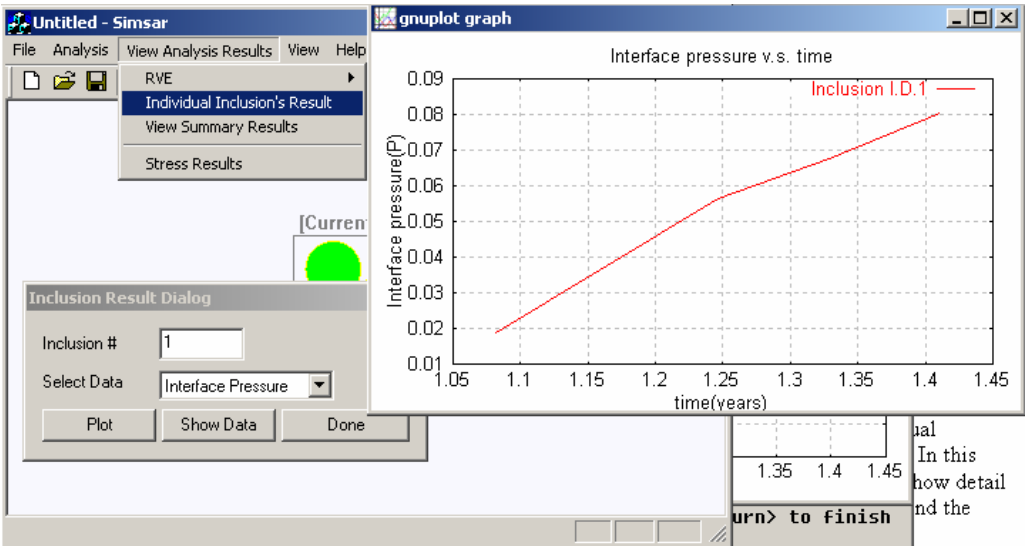

Figure 9: Plot of Interface Pressure Around Inclusion 1 With Time

- Stress results

The resulting stress can be viewed with the SPIDER program. To call SPIDER, click on "**View Analysis Results**" and then select "**Stress Results**". An example of stress results viewed by the SPIDER program is shown in Figure 10.

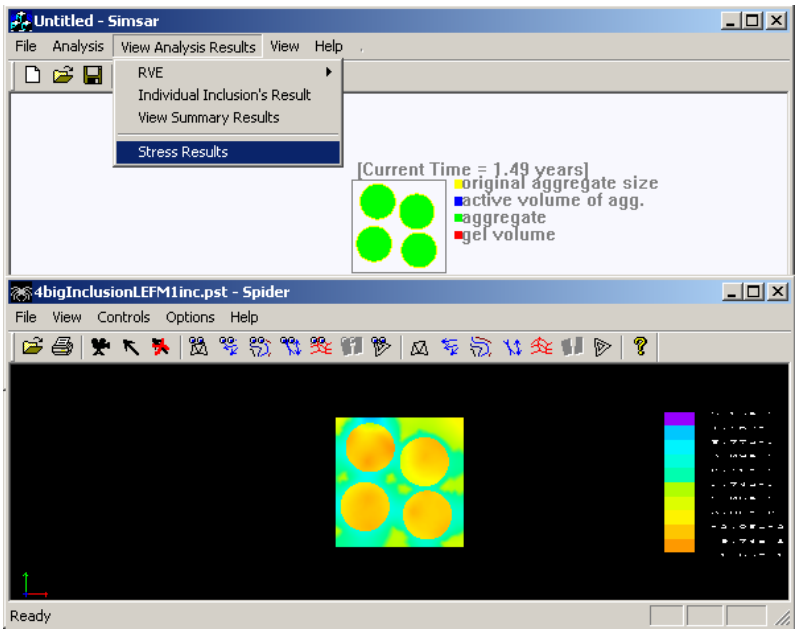

Figure 10: Stress Results Displayed with SPIDER

6 Exit

To exit the program, click on the "**File**" menu and then select "**Exit**".