



Soft Spot

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Itasca's Software Newsletter

August 1996

UDEC Version 3.0 to be Released in October

A major update of *UDEC* is scheduled for release in October and contains several features (e.g., *FISH*, *SOLVE* and *DAMP local*) previously developed and tested for Itasca's popular *FLAC* program. Features in the new *UDEC* include:

- ***FISH*, Built-In Programming Language** — The powerful Itasca programming language, *FISH*, is now available. *FISH* enables users to define new variables and functions to customize a numerical model to suit their particular needs.
- **New User's Manual** — The manual has been extensively revised and expanded. New examples have been added, and many data files have been modified to take advantage of *FISH*.
- **Enhancements to Joint and Block Material Models** — Joint material models and properties can now be associated with individual contacts by using the new *JOINT* command. A tensile-failure model with associative plastic flow has been added to plasticity models.
- **Graphics Enhancements** — Several improvements (including faster screen plotting) have been added to the graphics facility. PCX and DXF output modes have been added.
- **Enhancements to the Structural-Element Model** — A new inelastic material model is now available for structural elements created with the *STRUCT* command. The model simulates behavior typical of surface lining materials, such as fiber-reinforced shotcrete.
- **New Calculation Control Feature** — The *SOLVE* command has been added. This command permits automatic detection of the equilibrium state for static mechanical analysis.
- **New Mechanical Damping Option** — Local damping (*DAMP local*) provides improved damping for most static analyses.
- **New Utility Features** — The processing speed for the *SAVE/RESTORE* operation has been increased considerably. The *SYSTEM* command has been rewritten to spawn a full DOS session while keeping *UDEC* in the background.

Itasca Software Training Seminar in Germany, October 1996

Itasca will hold a basic-to-intermediate level software training seminar at the Freiberg University of Mining and Technology in Freiberg, Saxonia, Germany. The training will focus on practical applications and problem-solving methodology, but will also include some theoretical background and information on new developments. The seminar will be conducted by Dr. Peter Cundall (USA), Pedro Varona (Spain) and Dr. Heinz Konietzky (Germany). Seminar languages will be English, Spanish and German. One computer will be available for each participant.

Itasca staff will be available to answer questions on all Itasca software products (i.e., *FLAC*, *VisualFLAC*, *FLAC^{3D}*, *UDEC*, *3DEC* and *PFC*) as well as *FISH*. The amount of lecture time devoted to each code will depend on participant interest.

The cost is 1.800 DM (including lunches and training materials). For more information, contact Dr. Heinz Konietzky via telephone/telefax (+49 209167-1380) or e-mail (100413.326@compuserve.com).

Workshops and Training Courses

This year has seen an increase in the size and frequency of workshops and training courses offered by Itasca. Training courses instruct users in proper and efficient use of the codes, while workshops allow more experienced users to benefit from Itasca's experience in practical applications. Listed below are some recently completed and upcoming events.

Vancouver *FLAC* Soils Workshop — This workshop was held on the campus of University of British Columbia (UBC) in May. The workshop focused on solution of static and dynamic soils problems using *FLAC*. The workshop was conducted by Peter Cundall and Loren Lorig. Dr. Peter Byrne was instrumental in organizing the workshop and made a special presentation describing the UBC sand model, which has been implemented as a *FISH* constitutive model. The workshop was attended by 38 participants from North America, Taiwan, Hong Kong and South Korea.

Johannesburg Slopes Workshop — Following the Reno Slopes Workshop held in January, a similar

— Workshops, continued on page 3

Time Scales In Coupled Mechanical-Flow Analysis

Coupled analyses can involve responses with widely different time scales. The times scales include:

- (1) mechanical response (e.g., milliseconds, seconds);
- (2) flow-field response under constant boundary conditions (e.g., minutes, hours); and
- (3) consolidation response (e.g., days, weeks, months).

The following *FLAC* analysis illustrates the various time scales. In the first part of the problem, the weight of an embankment (simulated by an applied surcharge) is suddenly applied to a 40-m wide by 10-m thick soil foundation. The groundwater surface is coincident with the soil surface. The data file below creates the state immediately after embankment placement (Fig. 1),

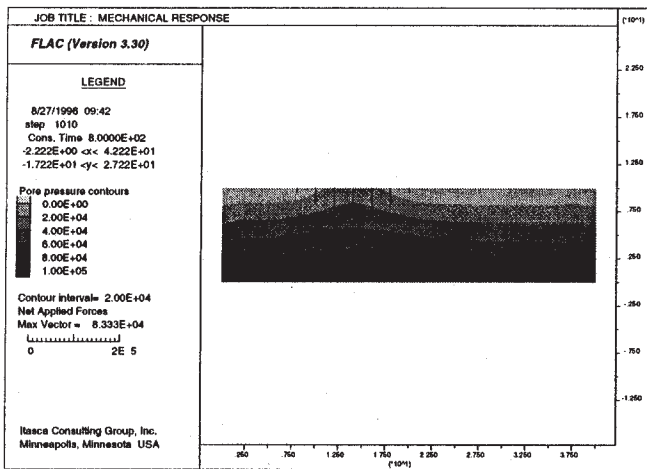


Figure 1. Pore pressure contours immediately after embankment placement.

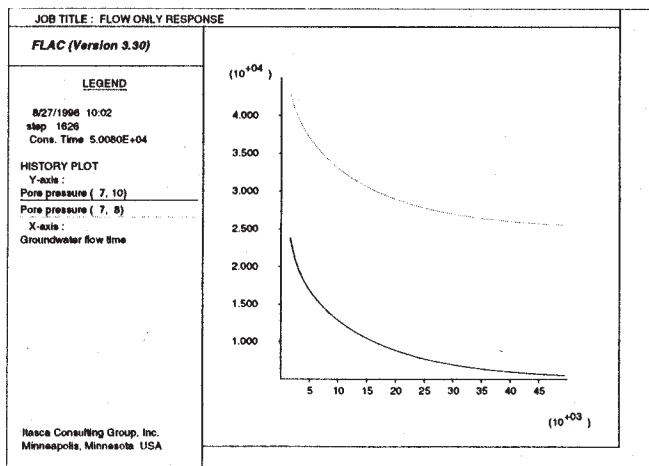


Figure 2. Pore pressures versus time for flow only response.

before any flow has occurred. In reality, the pore pressure changes would occur over the same time period as the embankment placement.

```

config gw ext=5
grid 20 10
mod elas
ini x mul 2
prop d=1500 b=2e8 sh=1e8
prop perm=1e-12 poros=0.5
water dens=1000 bulk 2e9
set grav 10
fix x pp sat i=1
fix x pp sat i=21
fix x y j=1
fix pp j=11
ini syy -2e5 var 0 2e5
ini sxx -1.5e5 var 0 1.5e5
ini szz -1.5e5 var 0 1.5e5
ini pp 1e5 var 0 -1e5
step 10 ; check on equilibrium
set flow=off
;-- surcharge from embankment --
;-- triangular stress distribution --
apply syy=0 var -5e4 0 i=5,8 j=11
apply syy=-5e4 var 5e4 0 i=8,11 j=11
;-- embankment base is impermeable --
free pp i=5,11 j=11
; get to mechanical equilibrium
step 1000
his pp i=7 j=10
his pp i=7 j=8
his gwtime
save emb.sav
    
```

The characteristic time (T) for the flow-only response can be estimated from the equation below.

$$T = \frac{L^2 n}{k K_w} = 40e3 \text{ seconds}$$

where L = average flow path = 12.5 m;

n = porosity = 0.5,

k = *FLAC* permeability = $1e-12$ (m/sec) / (Pa/m),

K_w = water bulk modulus = $2e9$ Pa.

The data file below is used to produce the pore-pressure histories shown in Figure 2.

```

res emb.sav
set mech off flow=on
solve age 50e3
save embla.sav
plot hist 1,2 vs 3
    
```

The histories show that the pressures beneath the embankment reach a steady value after about $40e3$

seconds which agrees with the estimate. This period is the characteristic response time for the flow field, without mechanical interaction.

The characteristic time (T) for the full consolidation response can be estimated from the equation below.

$$T = \frac{L^2}{c} = 50e4 \text{ sec}$$

where L = average flow path = 12.5 m,

$$c = k / [n/K_w + 1/(K + (4/3)G)] = 3e-4 \text{ m}^2/\text{sec},$$

$$k = \text{FLAC permeability} = 1e-12 \text{ (m/sec) / (Pa/m)},$$

$$n = \text{porosity} = 0.5,$$

$$K_w = \text{water bulk modulus} = 2e9 \text{ Pa},$$

$$K = \text{soil bulk modulus} = 2e8 \text{ Pa}, \text{ and}$$

$$G = \text{soil shear modulus} = 1e8 \text{ Pa}.$$

The data file below is used to produce the pore pressure histories shown in Figure 3.

```
res emb.sav
set flow=on nmech=200 force=250
ini xv 0 yv 0
solve auto age=6e5
save emb1b.sav
plot hist 1,2 vs 3
```

The plotted histories show that consolidation ends after about 50e4 seconds, which again agrees with the estimate. In this case there is full mechanical coupling, which prolongs the characteristic time because the apparent fluid stiffness is reduced.

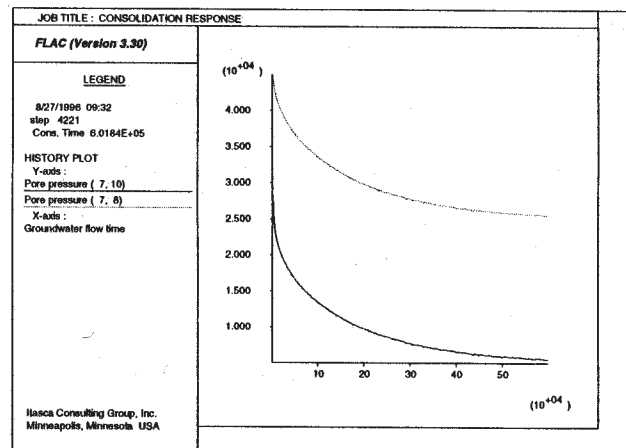


Figure 3. Pore pressures versus time for consolidation response.

— Workshops, continued from page 1

workshop was held in August in South Africa. The workshop was organized by Itasca Africa and held at Witwatersrand University. Fifteen engineers from South Africa, Brazil and Botswana attended the workshop, which was led by Loren Lorig. A special feature of the workshop was a half-day lecture by Dr. Lee Atkinson of Hydrologic Consultants, Inc. (Denver). Dr. Atkinson presented field investigations and analysis methods used in open-pit mine dewatering.

FLAC^{3D} Training Courses — In April, 13 South Korean engineers from 11 companies traveled to Minneapolis for one week of **FLAC^{3D}** training conducted by Pedro Varona. The training focused on solution of tunneling problems. A second training course was held in Minneapolis during the last week of August for another group of South Korean engineers. The course was conducted by John Tinucci. Both training courses were organized by Basis Consulting, Inc., Itasca's agent in South Korea.

Itasca Seminar in India, 1997 — An Itasca codes seminar is being planned for early 1997 in New Delhi. The seminar is being organized by Dr. Biswajit Dasgupta, who worked for Itasca in Minneapolis for three years before moving to India. Since moving to India, Dr. Dasgupta has been continuously involved in



Participants in **FLAC^{3D}** Training Course in April at Itasca's Minneapolis Office.

analysis of underground and surface structures, mainly for hydroelectric projects. The seminar will include a brief introduction to all Itasca codes and will include a more in-depth treatment of **FLAC** with some hands-on problem solving. The seminar will be presented by Loren Lorig and Dr. Dasgupta. Persons interested in attending the seminar are asked to contact Dr. Dasgupta or Itasca's Minneapolis office. Dr. Dasgupta can be reached via telephone: (+91-11 683-7281) or telefax: (+91-11 644-8660).

Coordinates and Rounding Errors

The following article was written by Mike Coulthard and appeared in his March 1996 newsletter, ITASCA Software in Australasia. Many thanks to Mike for allowing us to use his article. (It is important to note that Itasca's newer generation codes (i.e., *FLAC^{3D}* and *PFC*) use double precision and, therefore, automatically overcome some of the difficulties that can appear with single-precision calculations found in *UDEC* and *FLAC*).

Users of any computer program need to be aware that rounding errors are an inevitable part of computation. Usually, the seven- or eight-decimal significant figures that are available in [single precision] 32-bit computer arithmetic are sufficient to keep rounding errors from affecting the solution. However, there are circumstances in which numerical rounding errors can affect the results of analyses. The two examples outlined below illustrate some symptoms of rounding-error problems in Itasca codes and also suggest ways of circumventing the problem if they arise.

Mine Coordinates in UDEC — When a model is being prepared, the user may adopt the same coordinate values as in the mine plan and sections that provide the basic geological and geometric data being incorporated into the numerical model. This makes it easier to refer plots and results back to the mine drawings later, but it may inadvertently magnify the rounding errors in the computation.

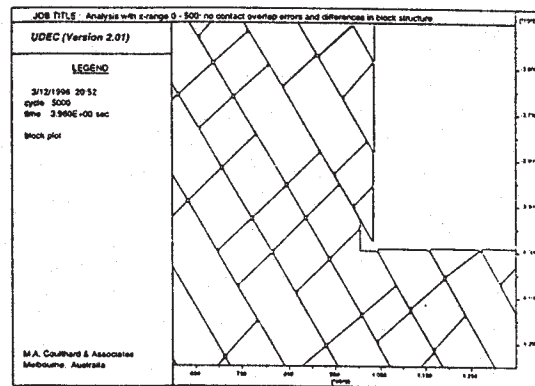
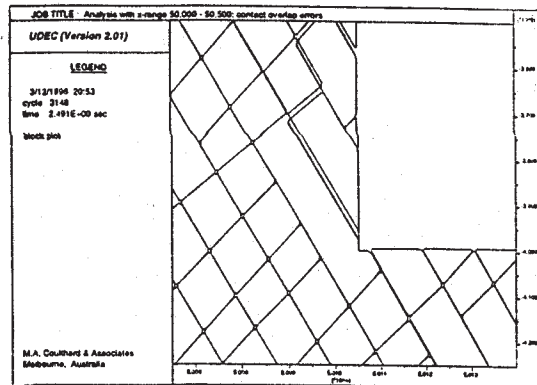
The mine coordinates often have very large values because they refer to a standard, wide-area coordinate system. *UDEC* always functions in "large-strain" mode, with coordinates being progressively updated as deformations develop in the system. If the initial coordinate values are very large numerically, significant accuracy may be lost when small displacement increments are added to them. Also, searches for block contacts, which involve differences between coordinate values, may become unreliable. The figures below show results from a trial *UDEC* analysis of an underground opening in highly jointed rock defined by two variable **JSET** commands. In the first case, the x-coordinates in the model range from 50000 to 50500, and "contact overlap" errors occur very quickly. The command **SET ovtol=1** was used to allow more visible overlaps to develop. The second case differs from the first only in that the x-coordinates were changed to range from 0 to 500. As can be seen, no spurious block overlaps then occur. Also, the actual block structure which has been formed is somewhat different, again because of rounding errors.

It is therefore best to move the origin to avoid large coordinate values, if at all possible.

Large Grids in FLAC — A similar kind of effect was observed some time ago in a large-strain nonlinear *FLAC* analysis. The grid, material property distribution and loadings were all symmetrical, but the coordinates ranged from 0 to 20000. The deformation patterns after large strains had developed were far from symmetrical because, at one end of the grid, small displacements were being added (accurately) to initial coordinate values near zero, whereas rounding errors

were much greater at the other end, where similar displacements were being added to an initial value of around 20000.

In this case, symmetrical results were obtained by moving the origin so that the x ranged from -10000 to 10000. Note, however, that this does not remove rounding errors it just makes those at the two ends comparable. This is an example of the interaction of rounding errors with computed localization or chaotic system behavior. (See *FLAC* Version 3.3 User Manual, Sections 3.2.4 and 3.10.2)



Technical corner:

Some of the faster Pentium computers have difficulty finding the hardware keys. This is a timing problem with 150 MHz and faster computers. The solution is to add the following line to your autoexec.bat file and reboot:

```
SET SSI_ACT=5,5,5
```

Multi-tasking operating systems such as Windows 3.x, Windows95, WindowsNT, and OS2 may require drivers to access the hardware key. These drivers are now included with each software purchase. The driver files and application instructions are in the files WIN.ZIP, WINNT.ZIP, and OS2.ZIP which are found in the file UTILITY.ZIP. Please contact your agent or Itasca if you are having difficulty running Itasca codes under one of these operating systems and do not have these driver files.