Course: MinE 663 – Geomech. Modeling with FLAC

Semester: Fall 2008

Course Format And Credit Hours: 3 hr Lecture

Prerequisites: MinE 661 or Consent

Instructor: Dr. Keith A. Heasley, 359H Mineral Resources Building Mining Engineering Department, CEMR, WVU (304) 293-7680 x3307, keith.heasley@mail.wvu.edu

Schedule: Tues. 9:00 – 11:30

Location: MRB 243

Office Hours: Open Door Policy or by appointment

Course Objectives: This course seeks to introduce the mining, civil or geotechnical engineer to the Fast Lagrangian Analysis of Continuum (FLAC) program for modeling mining, geologic and soil structures. The emphasis of the course is on practical application of the program with a sufficient understanding of the underlying mathematical formulation in order to prevent miss-application of the program or mis-interpretation of the results. FLAC is a two and three dimensional finite difference program for engineering mechanics computations. This program simulates the behavior of structures built of soil, rock or other materials that may undergo plastic flow when their yield limits are reached. Materials are represented by elements, or zones, which form a grid that is adjusted by the user to fit the shape of the object to be modeled. Each element behaves according to a prescribed linear or non-linear stress/strain law in response to the applied forces or boundary restraints. The material can yield and flow, and the grid can deform (in large-strain mode) and move with the material that is represented. The explicit, Lagrangian, calculation scheme and the mixed-discretization zoning technique used in FLAC ensure that plastic collapse and flow are modeled very accurately. Because no matrices are formed, large two-dimensional calculations can be made without excessive memory requirements. All programs and documentation are provided in the course.

Expected Learning Outcomes:
By the end of the course, students will be able to:
1. build and run FLAC models of practical geomechanical problems,
2. utilize the graphical user interface in FLAC to pre and post-process the input data,
3. understand the inherent strengths, weaknesses and best practices for applying the FLAC program to specific geologic environments, mining geometries, and material behaviors,
4. understand the implications of boundary and initial conditions in FLAC for solving practical problems,
5. understand the use of interfaces for simulating faults, slips and bedding planes in FLAC,
6. understand the use of structural elements to simulate, roof bolts, cable bolts, piles, arches, etc. in FLAC,
7. understand the use of pore pressure and effect stress in FLAC and their implication to practical geo-mechanical problems,
8. develop proficiency in programming within the FLAC program using the FISH language
9. build and run FLAC3D models of practical geomechanical problems
10. perform an in depth FLAC solution to a practical mining problem.

**Required Texts:** FLAC User's Manual (Provided Electronically)

**Grading:**
- Homworks & Quizzes 70%
- Final Project 30%

**Grade Assignment:**
- 100 – 90 A
- 89 – 80 B
- 79 – 70 C
- 69 – 60 D
- 59 – 0 F

**Grading Policy:**
No make-up exams except by prior arrangement with instructor.
Late assignments are docked 10% per day, or part of a day, that they are late. Exam or project grading appeals must be submitted in writing on the day the exam or project is returned.

**HW Assignments:**
Homework assignments and/or quizzes will be given approximately every week and each assignment will be worth approximately the same credit.
The sum of the homework assignments and quizzes will be worth 70% of the class grade.

**Quizzes:**
Short quizzes to judge student preparedness and understanding may be given throughout the class. The sum of the homework assignments and quizzes will be worth 70% of the class grade.

**Final Project:**
A final design project will be given to each individual student during the term. The project will essentially consist of developing an appropriate Displacement Discontinuity model to solve a practical mining problem developed by the student. The project deliverables will include a succinct write-up of the problem, analysis and solution, as well as all input and output files from the numerical analysis. The final project will be due the week before dead week and will be worth 30% of the final grade.
**Attendance Policy:** Consistent with WVU guidelines, students absent from regularly scheduled examinations or quizzes because of authorized University activities will have the opportunity to take them at an alternate time. Make-up exams or quizzes for absences due to any other reason will be at the discretion of the instructor.

**Professional Registration:** As part of the academic and professional development of young mining engineers, the Mining Engineering Department strongly encourages student to take the Fundamentals of Engineering (FE) exam and to then follow this by becoming registered as a Professional Engineer (PE).

**Social Justice Statement:** West Virginia is committed to social justice. I concur with that commitment and expect to maintain a positive learning environment based upon open communication, mutual respect, and nondiscrimination. Our University does not discriminate on the basis of race, sex, age, disability, veteran status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration.

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Disability Services (293-6700).

**Days of Special Concern:** WVU recognizes the diversity of its students and the needs of those who wish to be absent from class to participate in Days of Special Concern, which are listed in the Schedule of Courses. Students should notify their instructors by the end of the second week of classes or prior to the first Day of Special Concern, whichever is earlier, regarding Day of Special Concern observances that will affect their attendance. Further, students must abide by the attendance policy of their instructors as stated on their syllabi. Faculty will make reasonable accommodation for tests or field trips that a student misses as a result of observing a Day of Special Concern.
Course Schedule:

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction to the FLAC Program: HW – FLAC Trench Tutorial</td>
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<tr>
<td>2.</td>
<td>Basics of running the FLAC program: HW – Grid Generation Examples</td>
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<tr>
<td>3.</td>
<td>Problem solving (boundary/initial conditions, materials): HW – Mohr-Coulomb Model</td>
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<tr>
<td>4.</td>
<td>Problem solving (post processing): HW – Hole in Plate</td>
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<tr>
<td>5.</td>
<td>Theoretical Background</td>
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<tr>
<td>6.</td>
<td>Interfaces in FLAC: HW – Interface Tutorial</td>
</tr>
<tr>
<td>7.</td>
<td>Structural Elements in FLAC: HW – Coal Mine Bolting</td>
</tr>
<tr>
<td>8.</td>
<td>Discuss and assign the final project</td>
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<tr>
<td>10.</td>
<td>Programming in FLAC, (FISH)</td>
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<td>11.</td>
<td>Programming in FLAC, (FISH); HW – Slope Model</td>
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<tr>
<td>12.</td>
<td>Using FLAC3D - grid generation: HW – Coal Mine Model</td>
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<tr>
<td>14.</td>
<td>Practical application of FLAC: Final Project</td>
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<td>15.</td>
<td>Practical application of FLAC: Final Project</td>
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