CRISP NEWS

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Editorial

Although one cannot claim that finite elements are a routine geotechnical design tool, they **are** being used increasingly in practice. It is now quite rare to find a major consultant or contractor that does not possess (or have access to) a geotechnical finite element package.

Some have openly criticised or expressed strong reservations about the commercial distribution of such software. But back in 1993, Mike Gunn and I presented a paper on the education of geotechnical FE users to a NAFEMS workshop, in which we argued that, as you could not "un-invent" finite elements, surely the responsible thing to do was to educate users - rather than attempt to dissuade them from using the software.

This view is shared by members of the CRISP Consortium, and has lead to the creation of specifically focused training courses for users (both new and old) of CRISP. More details are given elsewhere in this newsletter. May I encourage you to consider whether you would personally benefit from attending one of these courses - or recommend them to someone who would. It has been said: "If you think education is costly - try ignorance" !

Rick Woods

NEW Courses and Workshops formats

Once again, we are expecting a busy year for SAGE CRISP. We have already run two courses in South East Asia and are now working hard on the next release of SAGE CRISP - Version 4, the most significant upgrade since SAGE CRISP was first released.

We have carefully analysed the feedback from previous courses and are busy producing the new look course and workshops in the format our delegates have suggested. The first of these is the one day seminar "Retaining wall analysis using finite elements" at Birmingham University on 2nd April. We are planning to have two more in the UK this summer and by September we will have produced a new 3 day practical course for overseas that will cover Retaining Walls, Embankments and Tunnels. If you have any ideas for other one day seminars, please let us have your suggestions.

SAGE and The CRISP Consortium are also holding an informal SAGE CRISP workshop at SAGE's offices in Bath on Tuesday 7th April. This will be aimed at both users and potential users and is the first of several such workshops to be held bi-monthly throughout '98. If there is sufficient demand, we will even run the workshops more frequently.
Delegates will be able to: bring problem analyses for advice; get expert advice on the interface and engine; put into practice what was learnt at the Retaining Wall seminar; see version 4 before it is released; try out the program; discuss their FE requirements and receive advice on the suitability of SAGE CRISP for meeting these needs.

I hope these new formats will prove popular with our users - if you want any further information on any course please contact Roger Chandler at SAGE

Diary Dates

2nd April 1998 - UK
Retaining wall analysis using finite elements

Birmingham University
Contact Roger Chandler
Tel:- 44 1225 426633
Email Rchandler@sage-uk.com

7nd April 1998 - UK
SAGE CRISP Workshop

SAGE Engineering , Bath, UK
Contact Geoff Watson
Tel:- 44 1225 426633
Email GWatson@sage-uk.com

TBA (June) - Hong Kong
SAGE CRISP Seminar and Workshop

Venue to be announced
Contact Allan Wai Hoong WONG
Email awhwong@hkstar.com

TBA (September) - Malaysia
Advanced Gectechnical analysis using SAGE CRISP

Venue to be announced
Contact Ir Lee Eng Choy
Fax 603 469 0320

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Continuum versus Beam Elements

Mike Gunn takes a further look at the computation of bending moments

It is often more convenient to use eight noded quadrilateral (continuum) elements rather than beam (line) elements to model a retaining wall or slab when using SAGE CRISP. Previous technical articles in the newsletter have dealt with the issues of how a structural pin can be modelled and how the bending moments are calculated from the element stresses.

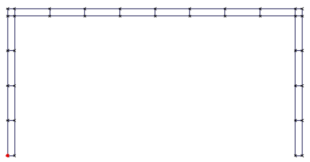

Figure 1

This article points out that we shouldn't expect to get exactly the same answers from analyses using continuum and beam elements. To illustrate this we examine the results of three analyses of a simple portal frame of nominal height 4m and nominal width 8m. There is a central vertical load of 100 kN and the base of each column is completely restrained. If this structure is analysed using the traditional assumptions of beam/frame theory (plane sections remain plane, axial and shear deformations are ignored) then the bending moment under the load is 120 kNm (sagging) and the bending moment at the junctions of the beam with the columns is 80 kNm (hogging).

Figure 1 shows the first mesh used and Figure 2 shows the bending moments obtained for the beam.
Of course expect to see a 'V' shaped distribution here. The three bending moment values from each quadrilateral element can be clearly seen and the values at the ends appear anomalous. The depth of the beam was taken as 0.2m and the length of each element was 0.975m giving an aspect ratio (length/depth) of approximately 5. The aspect ratio has a significant effect on the results when quadrilateral elements are used to model part of a beam. This is demonstrated by carrying out two further analyses. In the first more elements are used (each of length 0.3m giving an aspect ratio of 1.5). In the second analysis the depth of the beam and width of the columns is changed to 1m but the same number of elements is used as in the original analysis. This leads to elements with an aspect ratio of approximately 1. The bending moments for all three analyses are shown in Figure 3

The main conclusions from these results can be summarised:

1. A much smoother bending moment distribution is obtained when we use elements with lower aspect ratios.

2. Bending moments from finite elements may be close to bending moments from beam theory, but they will never be precisely the same (particularly under point loads and near corners /supports). There are two main reasons for this:

(a) beam theory ignores the finite width of columns and the consequent effect on spans;

(b) beam theory can be regarded as a special case of a more general elastic continuum analysis. However, there are areas where there is a conflict between the two, for example the boundary conditions at supports (see for example Theory of Elasticity, Timoshenko & Goodier, 3rd ed McGraw Hill, 1970). .

3. It makes no sense to try and plot the bending moments in the corner elements. The concept of bending moment has no meaning here. Also the program has a difficulty in deciding which sets of stresses to use to calculate the moments, leading to arbitrary results. This is responsible for the anomalous results shown at the ends of the plots shown below.

Mike Gunn
South Bank University

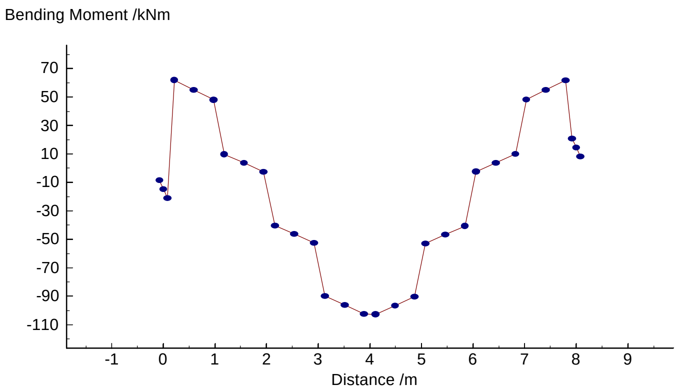

Figure 2

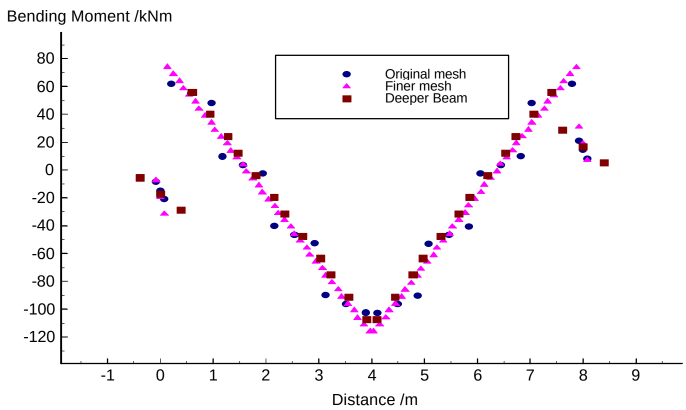

Figure 3

3D Analysis of Deep Excavations

Fouk-Hou Lee Profiles the use of CRISP at the National University of Singapore

Over the past few years, the Centre for Soft Ground Engineering (CSGE) has made considerable use of CRISP, in various modified forms, for a variety of problems. These include propagation of ground shock and vibration, cyclic response of offshore footings, and a host of static problems such as deep excavations. As the study of deep excavations forms a major research theme within the Centre, this article will focus on the use of CRISP for 3D analysis of deep excavations. The other aspects will be reported on as future opportunities arise.

Owing to scarcity of land, multi-storey buildings in Singapore are usually constructed with basement shopping and car parking facilities below existing ground levels. Most of these construction works take place in densely built-up areas, in close proximity to critical structures such as subway tunnels and historically preserved buildings, which are sensitive to ground movements. With the increasing demand for usable space within buildings, excavations are likely to become deeper and deeper. For instance, some recent excavation projects in Singapore are now prescribing final excavation depths of 30m or more. As a result, building authorities in Singapore now pay very close attention to the prediction and monitoring of ground movements around deep excavations. For example, according to regulations laid down by the Land Transport Authority (LTA) of Singapore, the final distortion in the plinth or track arising from nearby construction activities should not exceed 1:2000 in any plane and the total movement in the structure or track should not exceed 15mm. Thus, the reliable prediction of ground movement has now taken on added importance.

The experience of researchers in NUS suggested that 2D analyses very often over-predict ground movements in the vicinity of the deep excavations. Depending on the circumstances, the amount of over-prediction can range from slight to gross. The inability of the soil models to account for the full spectrum of real soil behaviour and the inability to fully model construction details are likely to be partially responsible for such discrepancies. However, there is also evidence to suggest that part of the discrepancies can be attributed to the additional support from the corners in a real excavation. In the light of this evidence, researchers at CSGE initiated a study to examine the importance of corner constraints in excavations in 1994. This programme was funded by the National Science & Technology Board (NSTB) and was implemented in collaboration with the Public Works Department (PWD) and several private companies.

Modifications were also made to the CRISP main program. Although CRISP has some 3D brick elements, structural elements were lacking. In particular, it was felt that, in order to exploit the advantage of the 3D analysis, the struts should be represented explicitly, and not "smeared" as is commonly done in 2D analyses. This was accomplished by incorporating a 3D bar element into CRISP. Early analyses were conducted on a 486-based PC. Apart from the necessity to limit the number of elements to about 1000, the turnaround time was also inordinately long. In early 1996, CSGE acquired two IBM 591 servers with 256MB and 512MB of RAM, respectively. CRISP was ported to these two machines, resulting in significant increase in possible mesh sizes and reduction in turnaround times. Most of the 3D CRISP analyses are now conducted on these servers, with a smaller number of PowerPC- and Pentium machines.

One of the first case histories to be studied is the City Telecommunication Centre (CTC) building which was completed in the 1980s (Liu, 1995; Lee et. al., 1997). This project involves an 11m-deep excavation in soft marine clay, the latter with thickness up to about 25m. The results of this study showed that a significant improvement in the prediction of retaining wall deflection can be obtained by the use of 3D analysis, compared to 2D plane strain analysis. In the CTC excavation, ground settlement was not monitored and thus could not be compared. This was followed by the 17m-deep basement excavation of the Immigration (IMM) building, which took place in a thinner layer of soft marine clay. The results of this second study suggested that similar 3D effects can also be observed in ground surface settlement (Lee et. al., 1998). Both of these studies involved matching with field data which had already been obtained at the time of analysis, although a conscious effort was made to use soil properties directly from laboratory tests rather than back-analyses. The third case study was different in that it involves ongoing excavation for China Square, which had not commenced at the time of analysis (Chew et. al., 1996), and therefore represents a true forward prediction. At the time of writing, five excavation and three tunnel case histories are being studied.

The results of these studies have served to shed light on the relative significance of corner constraints in a variety of situations. That the excavation is a 3D construction may seem self-evident at first sight. However, the studies showed that, in reality, the situation is somewhat more complex since the significance of corner constraints depends on a number of factors. These include the stiffness and strength of the soil especially the thickness of soft soil, the wall span-to-depth ratio as well as the stiffness of the strut system. For instance, a stiff strutting system may have the effect of suppressing corner effects in the wall deflection above excavation level. However, if there is a significant thickness of soft soil below excavation level, such corner effects may still be significant since the maximum wall deflection is likely to occur below the excavation level. Some of the findings from these studies are discussed in Lee et. al. (1998).

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CRISP at Home

Review of two events in the UK last year

The 10th CRISP Users Group Meeting was held at City University on the 26 September 1997. To celebrate the 10th meeting, the organising committee decided to change the format of the day to encourage more informal participation by delegates. This resulted in a day packed full of presentations and discussion to which the majority of the 53 delegates contributed in some way.

The meeting started with a session looking at the use of three-dimensional analysis, which was led by Professor Powrie. The presentations stressed the potential benefits of 3D analyses, such as the greater insight into mechanism of deformation provided by the more realistic representation of the real event, but also recognised the problems caused by the much greater complexity of the mesh and consequent difficulties in processing input and results. The session finished with a presentation by Dr D Naylor promoting the use of tetrahedral elements, which was ingeniously illustrated using cardboard models.

Modelling the soil was the theme of the session before lunch. The subjects of the presentations in this session ranged from adaptive mesh refinement to evaluating soil models using comparisons between finite element analyses and centrifuge testing. Professor Atkinson, who was leading this session decided to focus on the problem of choosing appropriate soil models and invited delegates from industry to describe the models they commonly used, provoking some interesting discussion on the advantages and disadvantages of using simple models.

The post lunch session, led by Professor Pyrah, looked at finite element analysis applied to soil structure interaction problems and encompassed a wide range of different structures and complexities of projects, from an analysis of the ground response to the demolition and reconstruction of a building in central London to investigations combining finite element analysis and model tests. The meeting closed with a technical session chaired by Dr R Chandler, in which he began by explaining the role of the CRISP Consortium and reporting on planned developments of SAGE CRISP. Delegates then had the opportunity to raise technical queries, which were answered by a panel of "CRISP experts".

As is the tradition at CRISP User Group Meetings, in addition to the opportunities for discussion provided by the formal sessions, many delegates took advantage of tea, coffee and lunch breaks for a more informal exchange of ideas. This is one of the most valuable parts of the CRISP User Group Meetings and it is to be hoped that even greater numbers will come to share this experience at the 11th User Group Meeting next year.

Contributions in Session 1:

D Richards
: *3D Analysis of Retaining Walls*

G Holmes
: *Prop Loads: Comparison of 3D and 2D Predictions.*

D J Naylor
: *Tetrahedral Elements.*

Contributions in Session 2:

A El Hamalawi
: *Adaptive Mesh Refinement.*

S E Stallebrass
: *Predicting Ground Movements: Modelling the Soil.*

R J Grant
: *Evaluating Soil Models.*

Contributions in Session 2:

R I Woods
: *Modelling the Demolition and Reconstruction of Queensberry House.*

F Wan
: *Use of CRISP90 to investigate the tensile force induced in a model pile embedded in swelling soil.*

E Ellis
: *Modelling of 3D pile -soil interaction in plane strain finite element method analysis.*

Technical Panel Members:
Dr A M. Britto, Prof M J Gunn, Mr G Watson

Organising Committee:
Dr Sarah Stallebrass; Mr Rick Woods; Dr David Richards

Discussion Leaders:
Prof. W Powrie, Prof. I Pyrah, Prof. J H Atkinson;

Technical Session Chairman:
Dr R Chandler

A delegates view of the Cambridge Course

In July, in association with the University of Cambridge Programme for Industry, a 4-day CRISP course was held at the University of Cambridge. The course offered the opportunity to attend 3 modules covering: theoretical soil mechanics (esp. critical state), the use of SAGE CRISP; and practical applications of CRISP in industry and research

The course was well attended and proved to be an excellent way of providing extensive and deep understanding of the theoretical background and of the practical aspects of using SAGE CRISP

As a relative newcomer to FE, the seemingly foreboding minefield of entering into an FE analysis was certainly eased by the comprehensive content of the lectures delivered. The course enabled the delegates to learn first hand the principles and theory involved within the program. It also provided the opportunity to question and to interact with the lecturers whilst involved with hands-on problems of low to moderate complexity

The lecturing team provided expert, professional and definitive views on the topics covered within the modules. The course also gave details of further developments planned for SAGE CRISP - I am particularly looking forward to the seepage add-on.

The course was undertaken in a relaxed and friendly atmosphere, with the discussions continuing well into the evening over a few drinks!

Robert Moulds
Edmund Nutall Ltd