EDUCATION & DISSEMINATION ISSUES IDENTIFIED IN THE FENET PROJECT

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SUMMARY
This paper reviews the Education and Dissemination FENET Workshops and attempts to draw out the important messages.

In particular, the need for continuing education of analysts is highlighted. The rôle of NAFEMS in creating awareness and disseminating best practice is shown to be of the highest importance to the analysis community.

1: INTRODUCTION

During the life of FENET, the Education & Dissemination workshops addressed the following topics:

i) Barriers to the effective use of FEA in industry (Copenhagen & Zurich)

ii) Education & training requirements for finite element analysts (Trieste & Barcelona)

iii) Best practice in the modelling of details common in fabricated plate/shell construction (Noordwijk & Palma)

iv) Dissemination of best modelling practice (Glasgow)

v) Design by analysis (DBA) (Budapest)

As well as these workshops, a survey (Barriers to the effective use of finite element analysis in industry) was carried out and a round robin conducted on the analysis of welded joints. In particular, this raised the issue of modelling using shell elements which are based on a mid-surface representation.

Rather than dwell on a detailed report on these meetings, the authors wish to discuss some of the more important messages that came from these meetings and from the worldwide survey. The various presentations made at the meetings, the results of the survey and the benchmarks for the welded joints can be found on the FENET web site.

2: THE FENET SURVEY

This world-wide survey, which sought to establish the significance of barriers to the effective use of finite element analysis across a range of industry sectors, consisted of over 450 questions. These questions included a wide range of issues covering education and awareness, the staffing of FE projects, the cost of FE products, support-related matters in

the widest sense, and an extensive list of functionality-related matters, including integration of the analysis function. Particular emphasis was placed on the Research and Development Topics (RTD) of multi-physics & analysis technology (MPA), durability & life extension (DLE) and product & system optimization (PSO), as these were identified themes within the FENET project.
In the questionnaire, there were sections specific to the three RTD areas as well as questions specific to the eight industry sectors identified in FENET.

2.1 General Information
From the 1300 replies, it was clear that the survey had mainly reached experienced users. Interestingly, 40-50% of respondents (range indicates difference between EU and North American responses) worked in "business units" with less than 5 users and over 50% of respondents had Unix platforms. Over 60% reported that their use of FEA is growing and 75-80% did not see an end to the ever increasing level of detail and complexity in models.

2.2 User Environment
Around 95% of respondents made use of personal contacts, thus emphasizing the importance of networking. Quite surprisingly perhaps, 70-80% of respondents indicated that they use newsgroups and discussions forums and over 80% felt that some way of capturing and re-using experience would be useful.

2.3 Systems and Supply
Positively, almost 90% of respondents felt that their FE investment had been effective but it should be remembered that the survey didn't reach the non-users of the technology (and possibly former users). Vendors received a pat on the back, with almost 90% of responses for vendor support ranging from important to vital. Consultants did not fare as well and while around 50% put some degree of importance on support from consultants, only 10% rated the support as excellent with 20% rating it as inadequate.

In terms of non-purchase of an FE system (again, it should be noted that only users of the technology were surveyed), 75% of respondents indicated that cost was a common or major issue. There is also a demand for easier to use software. New functionalities in finite element systems result in little benefit if they are difficult to use and/or staff do not have the time to explore the functionality and around 65% of respondents reported that time pressure was a common or major issue for not getting the most out of the technology. Over 70% of respondents felt that the lack of understanding of the business benefits of FEA by management, resulted in some form of barrier.

2.4 Staffing and Development
In terms of staffing, 45-40% felt that the recruitment of suitably qualified staff was a significant or very significant barrier to their use of the technology and around 45% reported that staff turnover was a common or major issue.
The responses to staff development questions would seem to indicate that there is a market for education and training resources aimed at self-learning, as 80% of respondents felt that time off the job while training was some form of barrier. This point was reinforced by the fact that a similar percentage saw the lack of adequate and convenient training as some

form of barrier. Similarly, around 65% reported that a lack of investment in training was a common or major issue in not using their system effectively.

2.5 Integration

The number of detailed questions relating to the general topic of integration of the analysis and simulation function into the wider business enterprise is testimony enough to the importance placed on this area by the various industry coordinators involved in the development of the survey. The various replies confirmed the importance.

2.6 Technology and Industry

The technology specific questions in the survey were structured around the notion of a Technology Readiness Level (TRL) and Priority Level (PL), which used ratings from 0(low) to 9(high) to indicate the maturity and the priority of the particular technology in the respondent's business sector.

The highest priority for DLE at 6.2 was fatigue life prediction and assessment, whilst the lowest maturity at 3.3 was damage/deterioration modelling and assessment. The highest priority for PSO at 5.5 was application of structural and system optimisation tools, whilst the lowest maturity at 2.9 was for the use of decision support tools for management issues. In addition, 65% of PSO respondents felt that user education and training was a barrier to the effective use of the technology and 55% of PSO respondents also felt that management education and awareness was lacking. The highest priority for MPA at 7.1 was automatic meshing, whilst the lowest maturity at 1.74 was magnetic hydrodynamics.

Reports based on responses from specific industry sectors were supplied to the various FENET Industry Coordinators and these reports in turn are reflected in the FENET Industry Requirement Reports.

In the Aero Sector report, Failure Criteria for Advanced Materials had a priority of 7 and a maturity of 4. Probabilistic Methods was also highlighted as being important. In the Land Transport Sector, Modelling of Connections also had a priority of 7 and a maturity of 4. In the Civil & Construction Sector, Material Models for Buildings had a priority of 7 and a maturity of 4.5. In the Power & Pressure Systems Sector, Design by Analysis appeared as a significant issue and in the Process & Manufacturing Sector, Material Data figured prominently.

2.7 Survey of perceived differences in "old-eastern bloc" countries

A survey was also conducted to highlight the perceived differences for "old eastern-bloc" countries. This survey, which was based on the Balkan countries, showed that there is a need for investment in simulation. The usage of finite element software is low and there is a need for training analysts. However, there are centres of excellence, particularly in the Universities. As mentioned above in section 2.3, the cost of FE software was seen as a major obstacle.

3: THE NEED FOR EDUCATION

Time and time again, the need for education was highlighted both in the E&D sessions and elsewhere during the FENET meetings. Some examples are detailed below.

3.1 DBA Workshop, Budapest

At the end of the DBA sessions at Budapest, the summary stated:

A recurring message from several contributions and the discussion was the educational need for successful Design by Analysis. It is necessary to have a:

i) Knowledge of the relevant PRODUCTS

ii) Knowledge of the PHYSICAL PHENOMENA and PROCESSES involved in the application or production of the products

iii) Knowledge of the theoretical and engineering basis behind the formulae in the CODES of PRACTICE

iv) Knowledge of software TOOLS performance, possibilities, limitations and proper use

v) Knowledge of correct FE analysis results handling and processing.

3.2 Joint Benchmarks

The results for the welded joints benchmark showed that many of the solutions were incorrect. In the first example, Figure 1, the target solution for the deflection at the centre (point 1) was 4.9 mm. This was the result given by those who analysed the problem using many axisymmetric elements. One respondent used 3D solid elements and obtained a deflection of 4.4 mm whilst those who used shell elements gave results which varied from 4.8 to 5.5 mm. Considering that it is generally stated that finite elements can predict deflections accurately, this is surprising. It is thought that in some of the analyses this was because the edge, which was restrained to move vertically, was not rotationally restrained when shell elements were used. There was also a wide variation in the stresses reported.

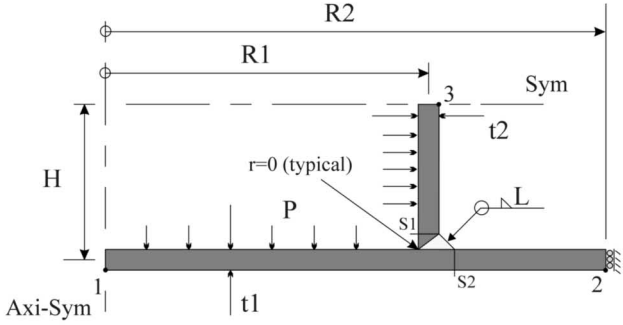

Figure 1 Shell Intersection Benchmark

For the second benchmark, Figure 2, the central deflection reported by the various respondents using axisymmetric elements varied from 1.4 to 4.2 mm, a single result using axisymmetric shell elements was 4.7 mm and results using shell elements varied from 3.9

to 10.3 mm although only two respondents gave results greater than 4.9 mm. It is thought that the wide spread in the results is because of how the two plates were joined. Were multi-point constraints correctly used?

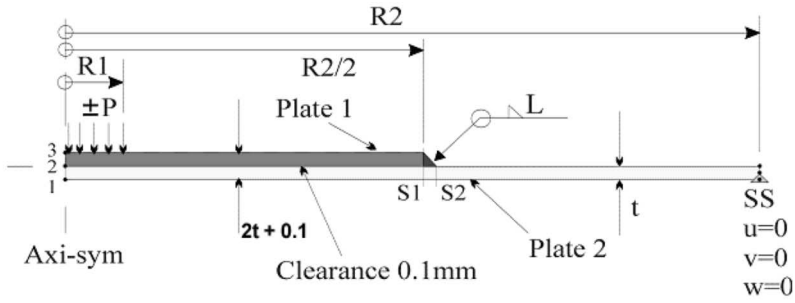

Figure 2 Reinforcing Plate Benchmark

For the third benchmark, Figure 3, only 2 out of 11 respondents realised that this is geometrically non-linear and so reported deflections at the loading point approximately twice that obtained using non-linear geometry.

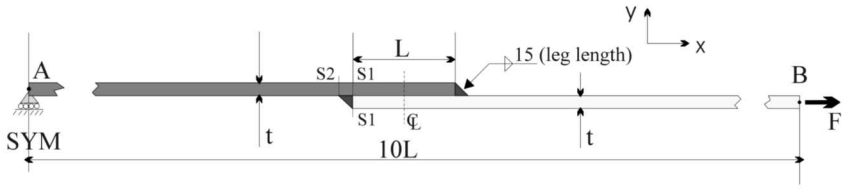

Figure 3 Single Lap Joint Benchmark

A fuller discussion of these benchmarks is being presented at this conference [1].

4: THE NEED FOR QUALITY ASSURANCE

At the Trieste workshop, the question “What is important in a company critical analysis?” was asked and it was agreed that a suitable QA procedure was important. As a consequence, NAFEMS has now re-formed the old QA Working Group, although it is now called the Analysis Management WG, and it is hoped that this will raise the awareness of the necessity of QA.

It should be noted that the respondents to the welded joint benchmarks discussed above, were probably experienced finite element analysts and not beginners. Were the analyses put though any QA procedure?

5: THE NEED FOR A FINITE ELEMENT EXAMINATION?

At present, NAFEMS provides a Registered Analyst scheme. However, there is not a wide take up.

So, at the Barcelona workshop, one of the questions asked was whether or not there was support for NAFEMS to start providing examinations in finite element theory. There was support for the idea and NAFEMS Education and Training Working Group (ETWG) has started to develop a set of tests. An introductory syllabus has been defined and a set of questions devised. Fourteen of these questions are now available on the web and this has been publicised in Benchmark. It is hoped that NAFEMS membership will look at the syllabus and questions and respond to the questionnaire. If the response is favourable, then a large set of questions will be developed. When a candidate wishes to take the examination, they will go to an examination centre where they will be provided with an interactive screen and be given a number of questions to answer. If they do sufficiently well, they will be presented with a certificate stating that they have passed the test. In future, this may be incorporated into the RA scheme.

This development needs membership support. If you have not yet accessed the site, then it is www.nafems.org/technical/ETWG/exam. And then let the ETWG know your views.

6: THE NEED FOR MATERIAL DATA

During the various FENET meetings, the problem of the lack of material data was often raised, not only in E&D sessions, but also elsewhere. As a consequence the Lisbon industrial meeting focussed on material issues. There were also presentations at the Zurich E&D workshop on material issues.

It is clear that the availability of material data is well behind the capacity of finite element programs. A simple example. In the DBA session in Budapest, a question was asked about whether to use isotropic or kinematic hardening when analysing plasticity in pressure vessels. The response was that this is not even mentioned in the pressure vessel codes and there is a lack of suitable publicly available material data. Yet the Bauschinger effect has been known for a very long time.

A further example from the Budapest meeting was a paper discussing the use of the Tresca and von Mises yield criteria in pressure vessel design. Whilst it is generally agreed that the von Mises criterion is a better representation of material yield data, the pressure vessel codes specify the use of Tresca. This can present numerical problems because of ‘the corners’ on the Tresca yield plot, although it was mentioned in the discussion that this has been realised in soil mechanics analyses and, in consequence, ‘the corners are rounded’ which speeds up the analyses.

Perhaps this is routine material testing for which there is no public funding available and so any testing that occurs is done within a company and, in consequence, becomes proprietary data not publically available.

Should this issue be raised with the research funding bodies?

7: WHAT SHOULD NAFEMS BE DOING?

Clearly, it is important that NAFEMS continues with its various tasks. These can be classified as spreading awareness and disseminating best practice. In view of the various points raised above, these are very important tasks.

Whilst the code developers do provide courses, these are often biased to driving the code. As an independent organisation, NAFEMS is uniquely placed to provide unbiased training material over the range of programme capability.

As a result of FENET activities, welded joint benchmarks are already available and some further contact benchmarks (from DLE) will shortly be available. These should provide a valuable resource to add to those already available.

Also, for example, the ETWG is currently in the process of commissioning documents on probabilistic analysis and a booklet for designers who are not necessarily graduate engineers but will be using FE programmes embedded in a CAD package.

The evidence of FENET is that all these will provide necessary guidance for analysts.

8: CONCLUDING REMARKS – THE NEED FOR NAFEMS?

The various FENET workshops have emphasised the need for NAFEMS to continue with its core tasks of creating awareness of the available technology and also to disseminate best practice. It is clear that NAFEMS is providing a useful service to the analysis community.

REFERENCES

J Wood The FENET plate/shell fabrication procedural benchmarks and ‘round-robin’ exercise, NAFEMS World Congress, Malta, May 2005.