Appendix D

Term paper topics

D.1 Introduction

The following list gives you a short description of seventeen term paper topics that you can choose from. That of course, does not mean that you should not try and dig out other papers from the reference list given at the end of the key paper or by searching the library database (INSPEC and Compendex are quite helpful tools in this regard) I have also mentioned the key paper from which you can start reading about your chosen topic. I have tried to strike a balance between analytical (lot of mathematical manipulations), computational and experimental topics.

Topics that have a '*' beside their names are 'advanced' in nature and carry extra credit if you can successfully complete them. You will not get any extra credit for just choosing these topics.

The last topic is purely computational and involves using a software. If any group chooses this topic, they have to work in the Smart structures lab and install this software in one of the computers there.

For each term paper you are expected to give a 15-20 min talk sometime towards the end of the course.

Some term papers can be taken jointly with Prof Kishore's FEM course and Dr. Bhattacharya's Smart Materials course. In that case you do a single term paper for two courses. It will also mean that we will expect a little more out of your term paper in that case.

IMPORTANT: The idea of the term paper is not to just look up the mentioned paper and vomit the equations contained in it. It does not really matter if you do not understand all the equations or derivations. But the essential idea of the paper, the importance of the work and some independent thought on what more can be done in the particular area of research has to be clearly stated. Marks will be given for how much of your independent opinion you can give to the topic, how critically you look at what is said in the paper and how lucidly you present what you have read (for example, ideally, it will be great if you can present a highly mathematical paper without showing a single equation or can explain a topic with illustrative schematic diagrams and figures). Please remember that it is your responsibility to make your friends understand what you have read.

D.2 Reading topics

1. **Specimen effects on the characterisation of crack tip fields:** Various experimental specimens are used routinely for estimation of fracture toughness of a material. It is assumed that small-scale yielding assumptions hold and the crack tip stress fields are well approximated by the stress intensity factor. For a range of geometries used this is however, not the case and non-singular terms in the asymptotic series do play a role.

   Ref: *Larsson S. G. and Carlsson A. J. (1973) J. Mech Phys Solids, v 21, pp 263-272*

2. **Cleavage Fracture:** We have learnt that cleavage or brittle fracture ensues when $K = K_c$. But a major question is why does a crack in a brittle material start off the way it does. It turns out that brittle fracture is triggered off by high principal stress values.

   Ref: *Evan A. G. (1983) Metall. Trans. A, v14A, pp1349-1355*

3. **Calculation of J-integral through volume integrals:** In numerical calculations the line integral form of the J integral gives very poor results with regards to contour independence. So a area or volume integral based formulation is sought.

   This term paper topic can be combined with a term paper for ME623. That means you can do one term paper for two courses.

   Ref: *Moran B and Shih C F. (1987) Engng. Fracture Mech., v27, pp615-642*

4. **Dislocation emission from a crack tip*:** In ductile fracture, large amount of plasticity is generated at the tip of a crack and the sharp crack tip blunts. The blunting is related to the emission of dislocations from the tip of the crack. **Ref:** *To be collected from me.*

5. **Atomistic fracture mechanics*:** With the advent of very small machines and very small scale structures, the fracture behaviour of a material at small length scales, and even at the atomic level begins to matter. This paper will be concerned with how we model cracks that have atomic dimensions.

   Ref: *Abraham, F. et al. (1997) J Mech Phys Solids, v45, pp1595-1619.*

6. **Aspects of ductile fracture:** Ductile fracture is caused by nucleation, growth and coalescence of microvoids within a material by several mechanisms. This paper describes some of these mechanisms that lead to ductile fracture.

   Ref: *To be collected from me.*

7. **Aspects of stress wave dominated fracture:** This paper describes some features of fracture caused by sudden sharp transient loading pulses. Fracture under these circumstances is quite different from quasi-static fracture.

   Ref: *Knauss W. G. and Ravi-Chandar K. (1985) Int J Fracture, v27, pp127-143.*

8. **Fracture of piezoelectric materials:** A piezoelectric material responds to both electrical and mechanical loads. So under a combined electromechanical loading, the stress fields at the crack tip look very different from an elastic solid that we have studied.

   This term paper can be combined with the term paper for the Smart Materials course.

   Ref: *Park, S. B. and Sun, C. T. (1995) Int J Fracture, v70, pp203-216*

9. **Fracture along bimaterial interfaces:** Elastic fracture along bimaterial interfaces is an important problem in coated systems as well as composite materials. The crack, unlike the one we have studied in the class, lies at the interface between two materials and the elastic analysis is quite different.

   Ref: *Rice J R and Sih G C, (1965) Journal of Applied Mechanics, v32, pp. 418-423.*

10. **Fibre pullout in composites*:** In composite materials fibre breakage and subsequent pull-out is one of the major causes of failure. This paper looks at a simple model of fibre pull-out from a ceramic (brittle) matrix based on fracture mechanics concepts. **Ref:** *Hutchinson J W and Jensen H M. (1990) Mechanics of Materials, v9, pp139-163.*

11. **A Griffith crack as a distribution of dislocations:** The crack tip stress fields that we calculated in class can also be arrived at by considering the crack to be formed of a large number of dislocations. The calculation is based on the superposition of the elastic fields of these dislocations. **Ref:** *To be collected from me.*

12. **Cohesive zone models of fracture:** Crack propagation is very often modelled by the 'cohesive zone' method. The cohesive zone is a thin region with a infinite stiffness at the onset but loses stiffness as deformation proceeds. **Ref:** *To be collected from me. Also, Xu X P and Needleman A (1994) J. Mech. Phys. Solids, v42, pp397-1434*

13. **Fracture mechanics of polymers:** Polymers fail by unique mechanisms of crazing and shear yielding. These mechanisms are tied intimately to the molecular structure of polymers. This paper is experimental and tells us about what happens when a polymeric material starts to fail. **Ref:** *Kramer E J and Berger L L (1990) Adv. Polymer Sc. v90/91. Can be collected from me.*

14. **Cracking of coatings:** Coatings are routinely used on materials for protective or decorative purposes. The cracking of these coatings is a common problem that may lead to damage to the underlying substrate. This paper discusses the fracture mechanics of coatings. **Ref:** *Nairn J A and Kim S-R (1992). Engng Fracture Mech, v42, pp195-208.*

15. **Fractography:** is the study of fracture surfaces. A wealth of information can be generated by looking at the features on the fracture surface under high power microscopes. **Ref:** *Phillips A, Electron Fractography Handbook and ASM Handbook on Fractography, both available in the library. There are a lot of resources on the internet as well.*

16. **Shear bands:** In metals a shear band is very often a precursor to a crack. These are narrow bands of intense localised deformation formed within a material. The study of these bands is important in understanding why fracture happens. **Ref:** *Wright, T W, The Physics and Mathematics of adiabatic shear bands. Available in the library.*

17. **Viscoelastic fracture mechanics:** Fracture mechanics of viscoelastic materials where deformation is dependent on strain rates. **Ref:** *Kanninen and Popelar, the book that you use as text for this course*

D.2.1 Computational topics

1. **Franc2d:** Download and install Franc2d, a software for doing 2-d Finite analyses of cracked bodies. Then use this software to solve a few fracture problems and compare with existing analytical solutions. The problems to be solved should be discussed with me first.