CHAPTER 7

Conclusion and scope for future work
7.1 CONCLUSIONS

A simple method of simulating the propagation of cracks in a ductile material over a large crack growth is described in the present work by using a parameter, $G_{fr}$. The approach is based on assessing the dissipated energy during a sub-critical ductile crack growth. Several methods, both analytical (by analysing the experimental data) and FEM, are employed to replicate the ductile tearing process by global energy balance and then finally $G_{fr}$ is evaluated. $G_{fr}$, which can be defined as the amount of dissipative energy required at the crack tip per unit area of crack growth for unit crack extension to sustain a ductile crack propagation, is appeared to work like a material constant. The present work is centred on analysing the nature of this parameter and to assess its capability to characterise a ductile crack growth process. Following conclusions can be drawn from the complete analysis of the current work:

1. The concept of $G_{fr}$, as stated earlier, is applicable when crack tip plasticity is sufficient.

2. $G_{fr}$ evaluation by analytical methods namely (a) graphical method and (b) $J_{M,pi} - \Delta a$ method are appeared to be very sound and robust in handling global fracture test data (load, displacement, crack growth). They serve as effective tools in predicting steady ductile crack growth.

3. $G_{fr}$ evaluation by Nodal Release technique (mentioned in chapter-3) gives results within a narrow band although the thickness of the CT specimen varies from 8 mm to 25 mm. The results are encouraging but this technique is not so robust as numerical difficulties arise when this method is applied for large crack growth.

4. $G_{fr}$ evaluation by cohesive layer model (discussed in chapter-4) gives acceptable results for specimens with different geometry and loading condition (CT and TPBB). The method is easy to
implement with a standard elastic-plastic FE code. One positive point of cohesive layer model is that it relates $G_{fr}$ to crack tip local deformation (plastic stretch). It justifies the geometry insensitive character of $G_{fr}$.

5. The load-LLD curve simulation of carbon steel pipes (material: SA333 Gr.6 carbon steel) shows very satisfactory results in predicting maximum load bearing capacity of a cracked pipe. Except one case, the error in prediction as compared with experimental value is within 5%.

6. As an overall conclusion it should be mentioned that engineering application of fracture mechanics lies in predicting the critical load and critical crack length of a cracked body. In this respect the critical fracture energy parameter, namely $G_{fr}$, serves as an effective fracture parameter to deal with such problems.

### 7.2 Scope for future work

1. In this work, plane strain specimens (CT and TPBB) are considered for the determination of $G_{fr}$ from laboratory specimens. $G_{fr}$ should also be determined from plane stress specimen like Centre Cracked Panel (CCP) specimen. The variation of $G_{fr}$ with crack tip triaxiality should be investigated. This work is now in progress.

2. For 3-D analysis, pipe with circumferential through-wall crack is investigated here. This work should be extended to part through crack in pipe also.