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Title of the Thesis: Mathematical Modelling for arresting of Multiple Cracks in an Infinite Plate.

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ABSTRACT

In almost all man-made structures, use of metals has increased since the nineteenth century. Although, all engineering structures are designed in order to bear some predefined load but the occurrence and the propagation of cracks become a serious problem for such structures. Since, the strength of the structures decreases with time in the presence of crack(s) or crack like defects. Therefore, the assessment of the residual strength of the structures weakened by cracks is necessary.

"The damage tolerance approach" which was first used in the aircraft industry in 1978 is now broadly used in designing various engineering structures such as bridges, buildings, pipelines etc. In this approach, it is assumed that each material contains many initial flaws, defects or small hairline cracks which can propagate under the service loading conditions. Therefore, to ensure the safe operation of these materials containing flaws, it is necessary to predict their ultimate service life through experimental, numerical or analytical approaches accurately or approximately. This can be obtained by predicting its residual strength in the presence of cracks and the time taken by the crack to reach a critical crack size. However, this task becomes incomprehensible due to a number of factors involved in it. These factors include load applied on the structures, environmental conditions (which are often unknown), the volume of residual stresses, properties of the material etc.

In literature, problems related to the residual strength of structural components with multi-site damage are largely based on one and/ or two cracks. Solutions of such problems could often result in overestimating the actual fatigue life of the structural components because these studies generally focused on the interaction between inner to inner crack tips and interaction between inner to outer crack tips is absent or normally do not discussed.

Therefore, there is a need to model some more complicated cases of multi-site damage problems, which could incorporate the effects of interaction between multiple cracks. An attempt has been made in the present thesis to study multiple cracks in an infinite plate. The problems discussed in the present thesis are divided into two parts:

1. **Multiple straight cracks.**
   In this part we have discussed the problem of three collinear straight cracks with or without coalesced yield zones. Moreover, the effect of different stress profiles is also discussed in the thesis.
2. **Multiple circular arc cracks.**
   In this part we have discussed the problem of four circular-arc cracks with coalesced yield zones for different type of loading conditions.

The problems discussed in the thesis are based on the classical Dugdale strip yield model which was proposed to evaluate the residual strength of an infinite plate weakened by a single crack. The well-known complex variable method is used to derive the analytical expressions for stress intensity factor, applied load ratio, yield zone length, and crack-tip opening displacement. To validate the analytical findings, numerical results are obtained for yield zone length, crack-tip opening displacement and load carrying capacity of the structures and the graphs of such numerical values are also plotted. At the end of each chapter, a qualitative analysis is carried out to study the behaviour of yield zone growth, crack-tip opening displacement and load carrying capacity of the plate with respect to the affecting parameters viz. crack length, plastic zone length and inter crack distance. Moreover, the case of coalesced yield zones between two adjacent crack-tips is also discussed in each chapter.