

Final project report

<i>Project ID</i>	2003/11.2
<i>Title</i>	Fracture and fatigue behaviour of metallic structural elements submitted to cyclic loading under low temperature conditions
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<i>Duration</i>	2 years
<i>Assigned funding</i>	Euro 20,000

Activities and results

The present research project focused on the study of the fracture and fatigue behaviour of metallic structural elements used under severe low temperature conditions. More in details, the influence of low temperatures on the fundamental mechanical parameters of metallic materials has been studied. Moreover, existing fatigue propagation laws for extreme environmental conditions have been verified and new laws have been proposed. Then fatigue life assessment of structural components having geometrical and loading conditions typically encountered in the field has been carried out following a damage tolerant design approach which allows a limitation of costs for a given level of structural safety.

The research aimed at offering a comprehensive view in the understanding of fatigue fracture failure of structural components under service environmental conditions characterised by low temperatures.

The research activities included:

- state-of-the art investigation of the fracture behaviour (fracture toughness) and fatigue (fatigue limit, material parameters of crack growth laws such as Paris law) of metallic materials (with reference to structural steels and high-strength aluminium alloys) under low temperature conditions;
- experimental tests of fracture toughness and of fatigue limit under low temperature conditions for a structural steel (S275 J2) and a high-performance aluminium alloy (Al7075 T6). The temperatures being investigated were: 293 K (+20 C), 243 K (-30 C) and 193 K (-80 C);
- observation, analysis and critical interpretation of the experimental results;
- development of micromechanical models for the understanding and prediction of fracture and fatigue behaviour of metallic materials under variable temperature conditions, with emphasis to low temperature conditions. Two theoretical models were developed. The first model, which is based on a generalization of the R-criterion (minimum distance of the crack tip from the plastic zone near the crack), allows the determination of the crack propagation paths in metallic materials under low temperatures. The second model, which is based on energy balance arguments for a multiphase reference volume having thermo-mechanical characteristics typical of the alloy components, allows the prediction of fracture toughness as a function of temperature.
- Comparison of the theoretical predictions according to the above models with the experimental results.

The objectives of the present research project have in general been achieved.

Products

A – papers in scientific magazines

1. Andrea Carpinteri, Roberto Brighenti, Sabrina Vantadori, Danilo Viappiani Static crack extension prediction in aluminium alloy at low temperature, Special Issue Int. J. Engineering Fracture Mechanics, Vol 75/3-4, pp 510-525, 2007.

Programma Nazionale di Ricerche in Antartide (PNRA)

2. Andrea Carpinteri, Roberto Brighenti, Alan Davoli, Sabrina Vantadori. A micromechanical model for the prediction of the temperature fracture behaviour dependence in metallic alloys, Special Issue of Int. J. Engng Fract. Mech., Vol.. 75, pp 3646-3662 2008.
3. Andrea Carpinteri, Roberto Brighenti, Fracture and fatigue properties of metallic alloys S275 J2 and Al7075 T6 at low temperatures, Int. Journal of Materials Science, Vol. 43, pp. 4780-4788, 2008.

B – book chapters

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C - proceedings of international conferences

1. Andrea Carpinteri, Roberto Brighenti, Sabrina Vantadori, Danilo Viappiani. Crack Growth Prediction in Aluminium Alloy at Different Environmental Temperatures, Proceedings of the International Conference on Crack Paths (CP '06), p. 113, Parma, Italy, 14th-16th September 2006.
2. Andrea Carpinteri, Roberto Brighenti, Sabrina Vantadori, Danilo Viappiani. A micro-mechanical model for the prediction of the temperature fracture behavior dependence in metallic alloys, Proceedings of the Fifth International Conference on MATERIALS STRUCTURE & MICROMECHANICS OF FRACTURE (MSMF-5), Abstract booklet p. 114, Brno, Czech Republic, June 27 - 29, 2007.

D – proceedings of national meetings and conferences

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E – thematic maps

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F – patents, prototypes and data bases

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G – exhibits, organization of conferences, editing and similar

1. International Conference on Crack Paths (CP '06), Parma, 14-16 September 2006

H - formation (PhD thesis, research fellowships, etc.)

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Research units

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Date: 31/12/2008

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