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Assessment of environmental influence on fatigue crack growth in an Electron Beam (EB) welded flange connection

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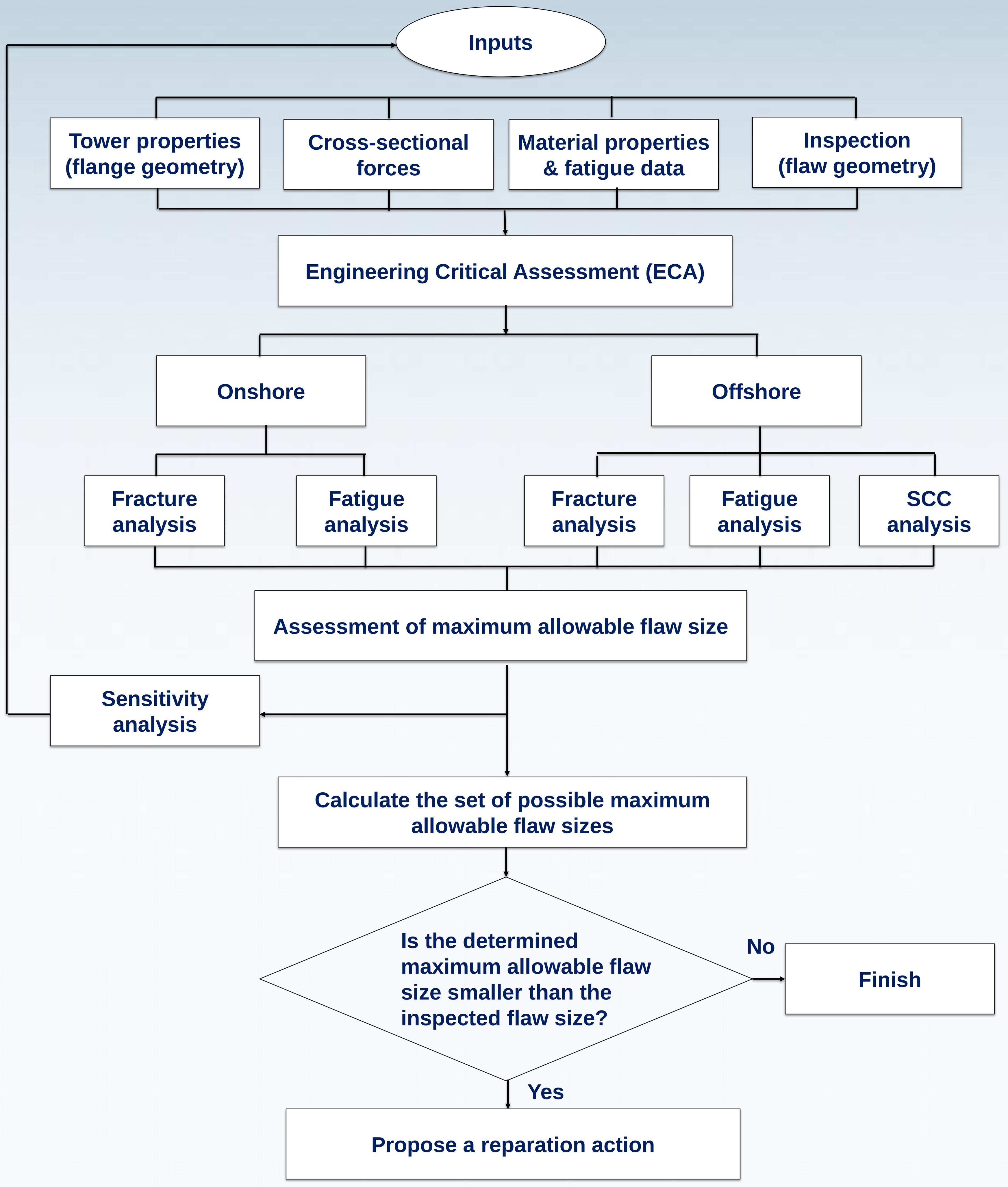
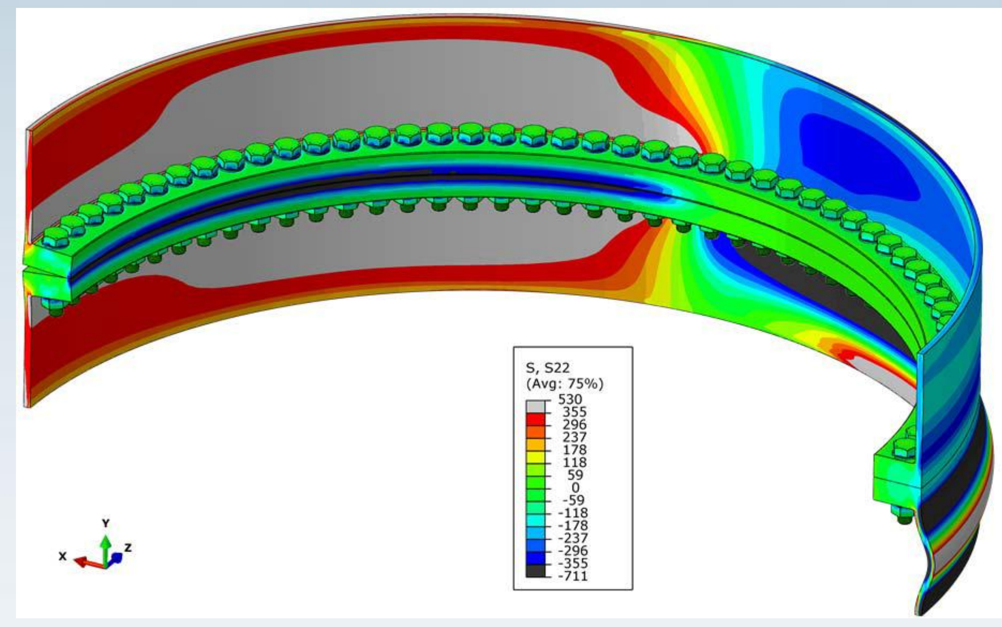
Abstract. Fatigue assessment of the ring-bolted flange connection under variety of load levels and corresponding number of cycles has shown to be more critical than that of fracture using Engineering Critical Assessment (ECA). The main objective of this paper is to determine the maximum acceptable flaw size of wind tower flanges which have a weld made by electron beam welding. The lowest temperature of a construction site used in the case study is -40 °C. Comparison is made between on-shore and off-shore conditions according to the recommended Paris law parameters acc. to BS 7910 and ASME, Sect. XI. Fatigue crack growth for a range of flaw length/depth (aspect ratio) from 1 to 10 is considered for centric and eccentric embedded flaw in a plate t=24mm (the shell segment closest to the ring flange), and internal and external circumferential surface flaw in the shell.

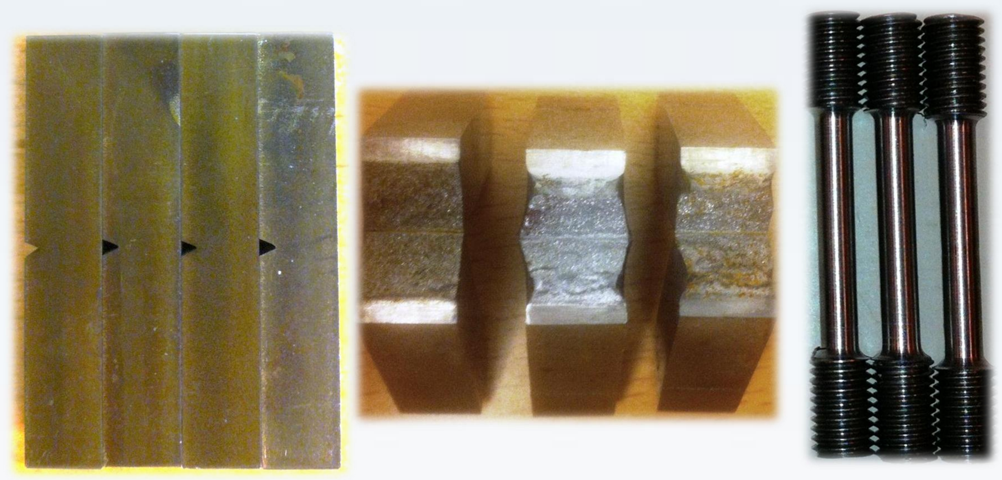
METHODOLOGY

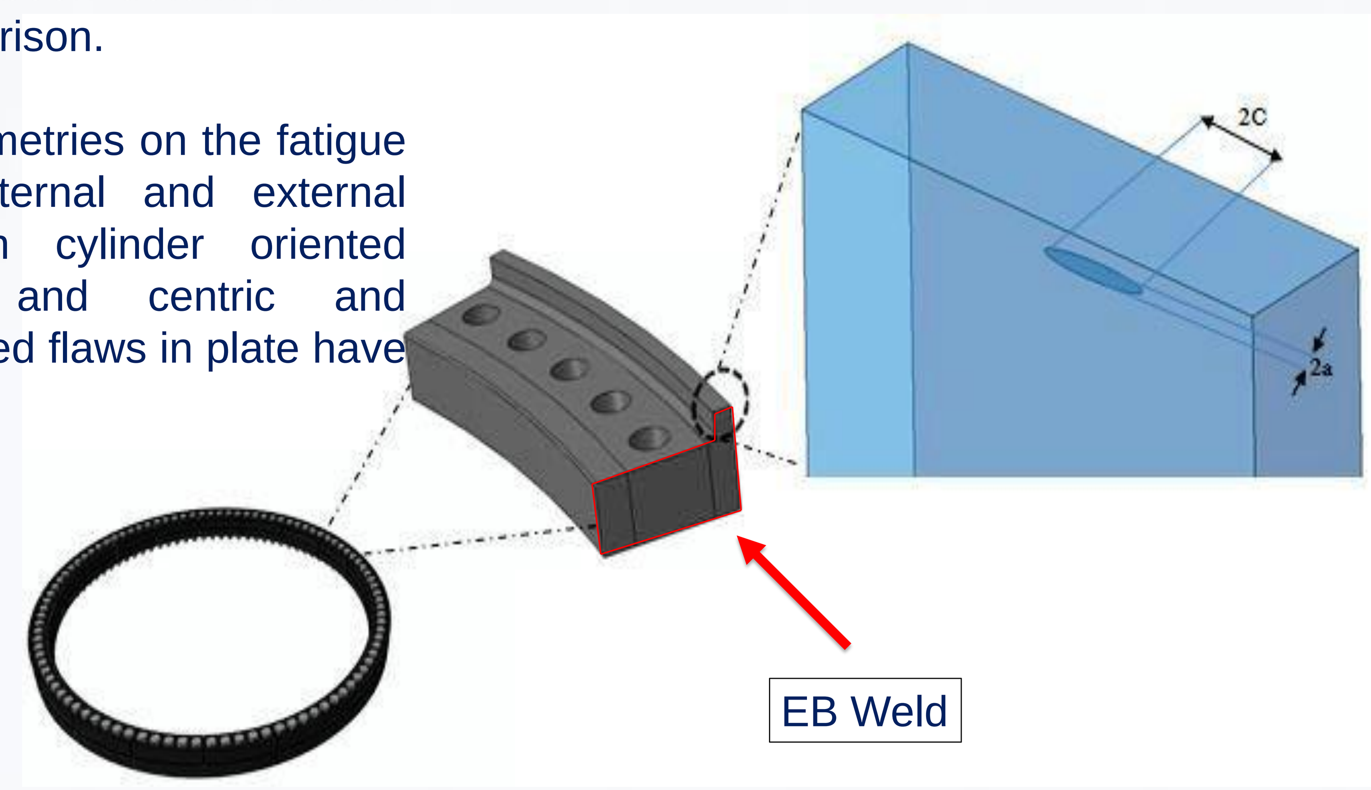


CASE STUDY

- FEA using the commercial ABAQUS finite element software have been used to define the stress levels of 3374 mm diameter EB welded ring flange connection used in towers for wind turbines.
- The fracture toughness of the flange made of S355 at -50°C (the most sever operational conditions) has been determined using the Charpy values in terms of T_{27J} , and master curve approach.
- Fatigue assessment using Paris law is performed according to BS 7910 and ASME.
- The maximum allowable size of flaws, assuming the same loading conditions both for on-shore and off-shore conditions during wind tower's lifespan (25 years), have been determined for the sake of comparison.
- Effect of flaw geometries on the fatigue crack growth, internal and external surface flaws in cylinder oriented circumferentially and centric and eccentric embedded flaws in plate have been considered.

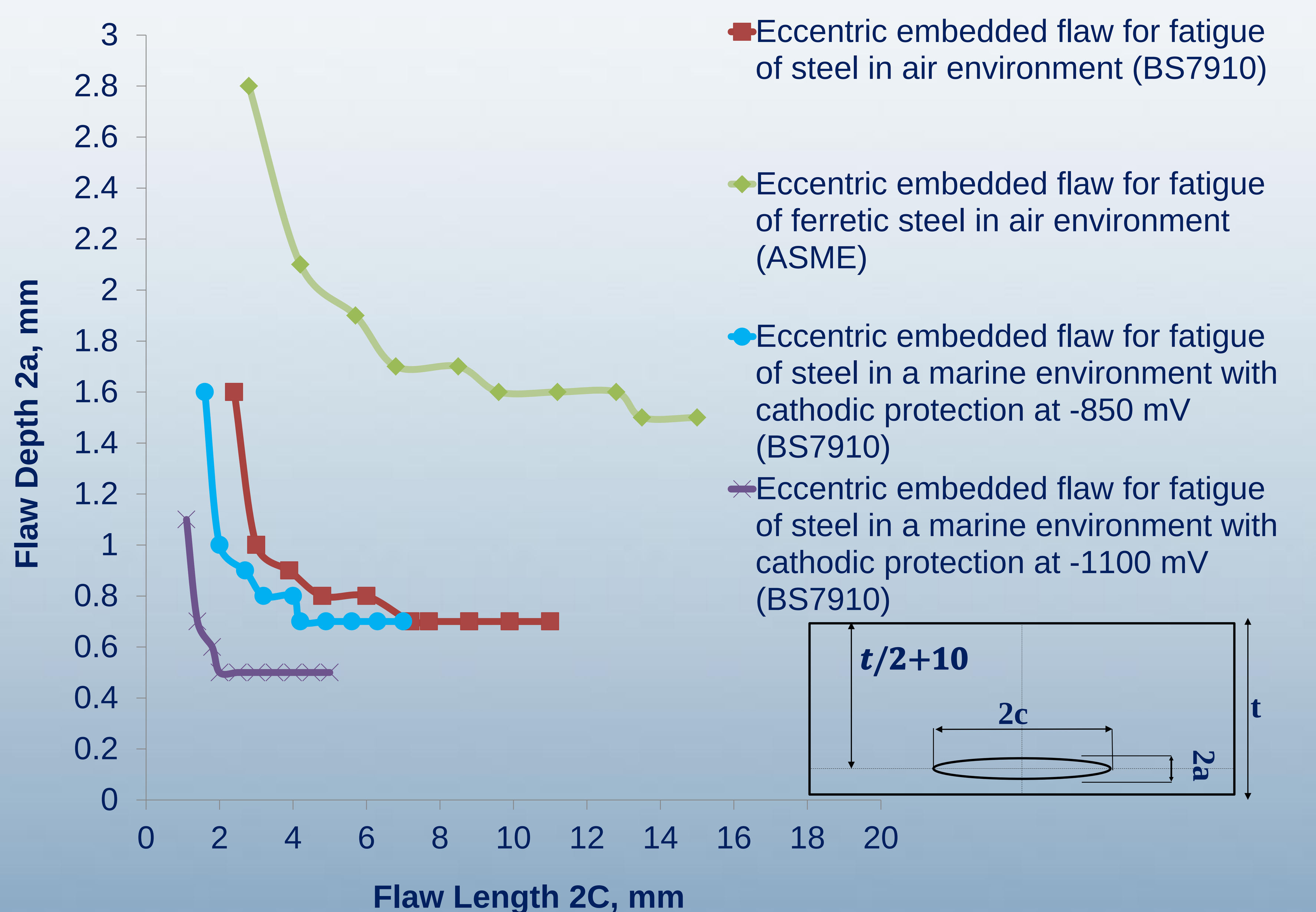




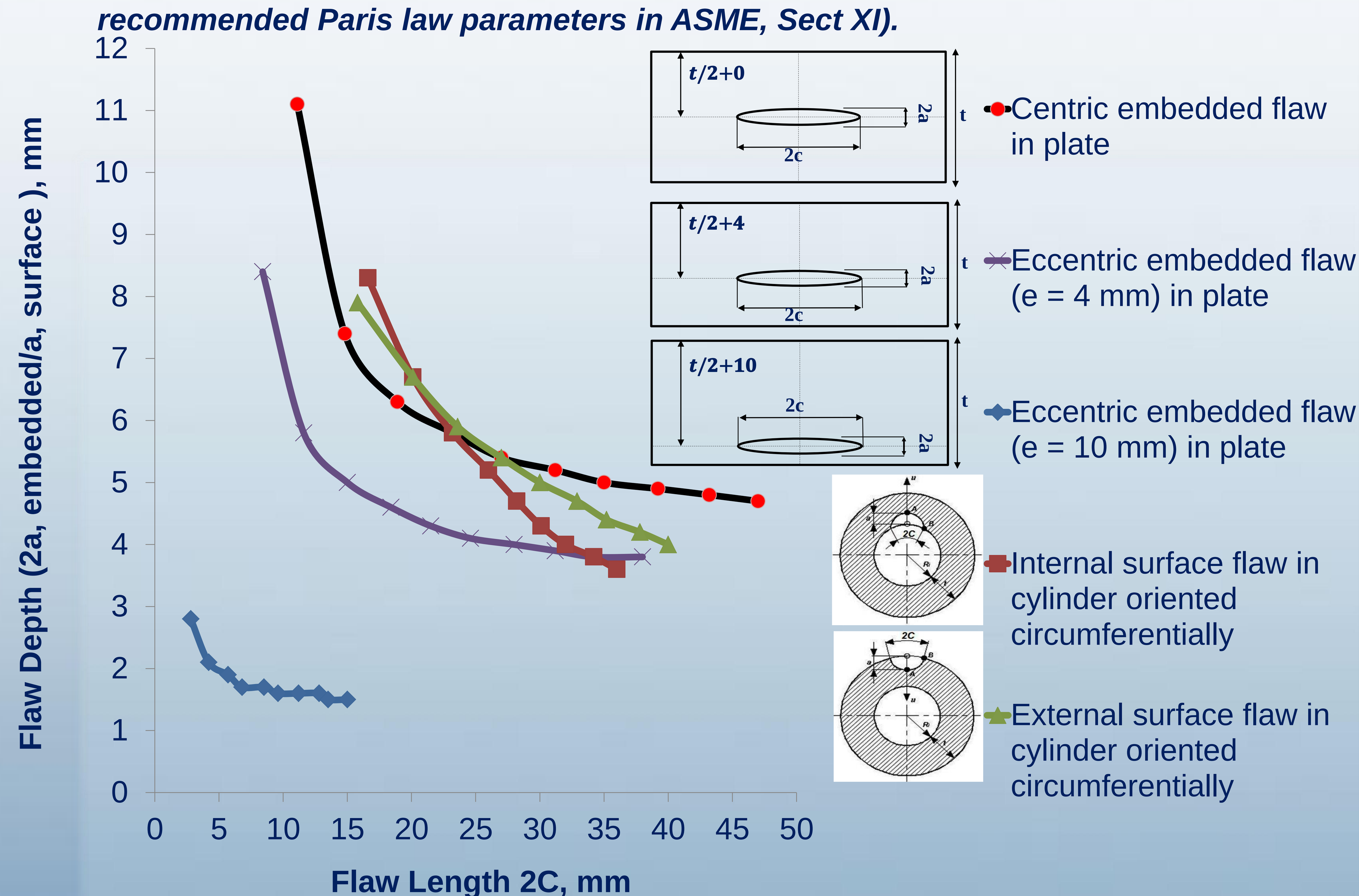


MAIN RESULTS

The acceptance criteria calculated for an eccentric embedded flaw (e = 10 mm) in a plate for fatigue of steel in the air and marine environment (acc. to the recommended Paris law parameters in BS 7910 and ASME, Sect XI).



The set of acceptance flaws calculated for internal and external surface flaw position in the shell (circumferential orientation) and centric and eccentric embedded flaw in the shell for ferritic steels in the air environment (acc. to the recommended Paris law parameters in ASME, Sect XI).



CONCLUSIONS

- Eccentric embedded flaw (e = 10 mm) represents most critical acceptance criteria of those considered.
- ASME is predicted less conservative acceptance criteria in comparison to BS 7910 for fatigue of steel in air or other non-aggressive environments.
- Eccentric embedded flaw (e = 10 mm) for fatigue of steel in a marine environment with cathodic protection at -1100 mV (according to the recommended fatigue flaw growth parameters in BS 7910) represents most critical acceptance criteria.
- The validation study demonstrates that the ECA procedure can be used for failure assessment of wind turbine tower structures containing flaws.

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Refrences:

- BS 7910:2005. *Guide to methods for assessing the acceptibility of flaws in metallic structures.* The British Standard, July 2005.
- P. Dillstrom et al. *A combined deterministic and probabilistic procedure for safty assessment of components with cracks handbook,* Swedish Radiation Safety Authority, 2004.

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