ENGINEERS IRELAND
cpd

Practical Steps To Extend the Lives of Bridges

Engineers Ireland,
22 Clyde Road, Ballsbridge, Dublin 4, Ireland
31st January 2014

Reliability assessment of stay cables for cable stayed bridges

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Outline

- Introduction
- Traffic load
- Deterministic design
- Strength of cables
- Reliability analysis
- Reliability based inspection planning
- Conclusion and future work

Long Life Bridges Project

The main goal of this project is to extend the lives of bridges

- The reliability of an old bridge can be good without strengthening it due to the conservative initial design.

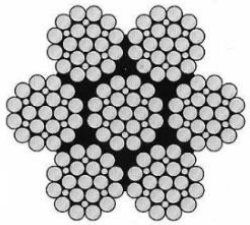
- One goal is to develop a methodology to obtain an accurate reliability assessment for different parts of bridges

Application on stay cables

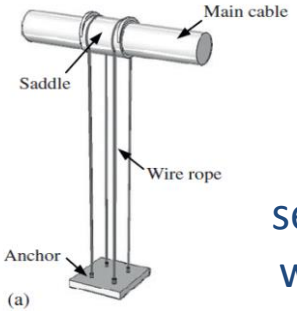
2 types of cable bridges

Cable stayed bridge

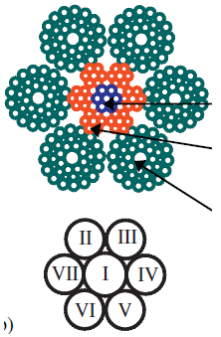
This study will focus on cables of cable stayed bridges



Suspension bridge



Cross section of a wire rope :

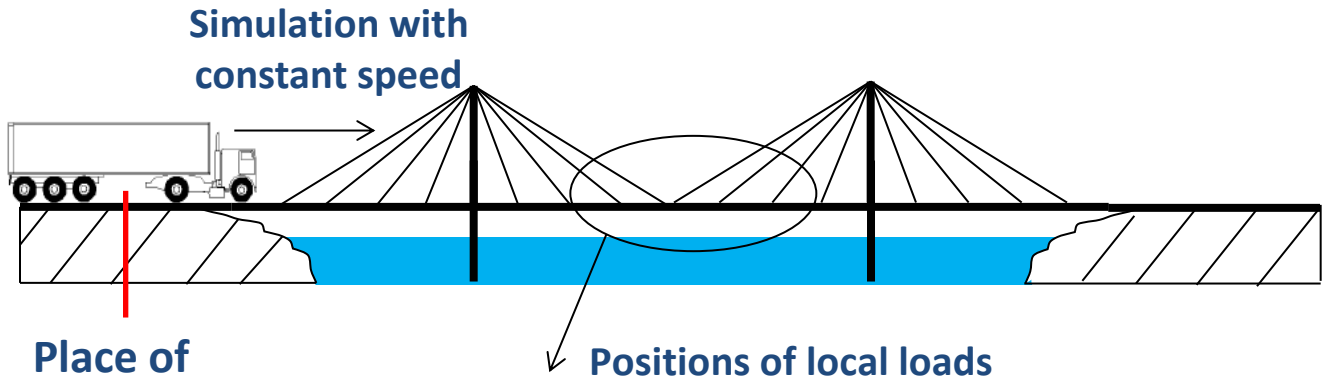


It could be extended to wire rope of a suspension bridge

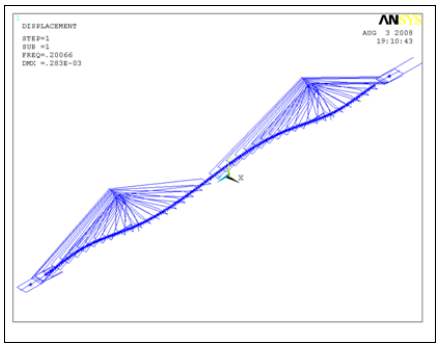
Cables are subjected to fatigue and corrosion

Traffic flow from measurements

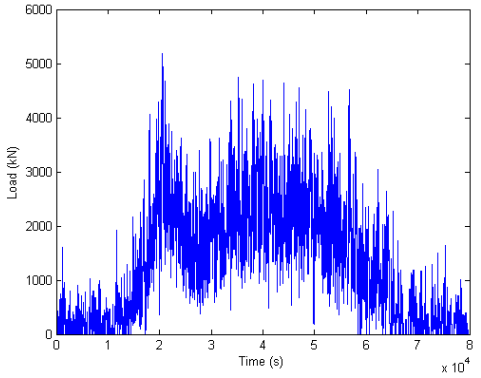
Construction of traffic loads from measurements



FEA

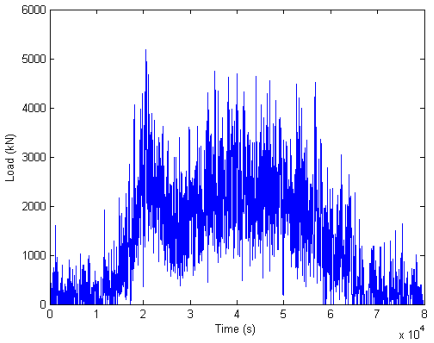


Time history of cable loads



Deterministic design (Eurocode)

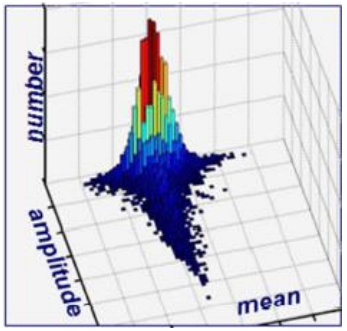
Fatigue and extreme loads :



Assumptions

- Safety factor = 1.5* (1.35 in Eurocode)
- Cable area = A cm²
- Ultimate strength = 1860 MPa
- Mean load = 5817 kN
- Effect of mean stress
- Characteristic SN curve
- Miner rule

Rainflow counting method



A = 112,5 cm²

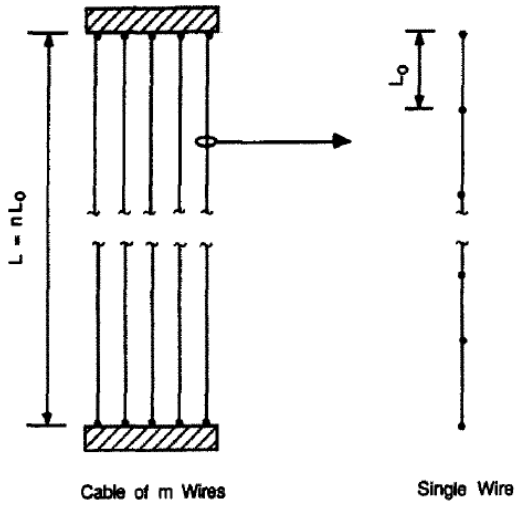
Strength of cable

The cable strength depends on:

- Cable length
- Corrosion
- Wire failures
- Load sharing

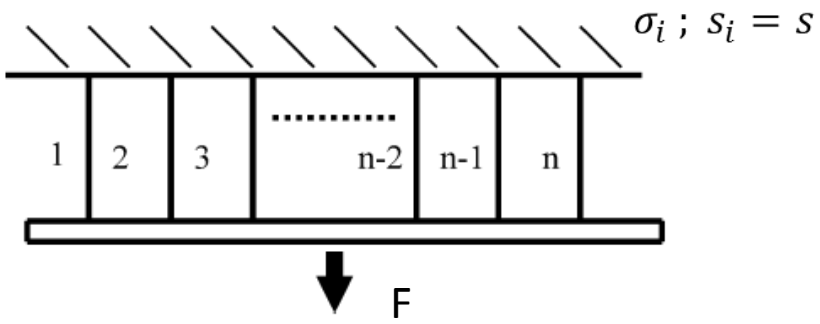
A wire of length L is composed on n wires of length L_0

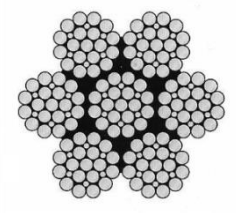
- S-N curve is known for short wires
- A wire failure occurs when one of the short wire fails



Parallel system

A cable consists on n wires

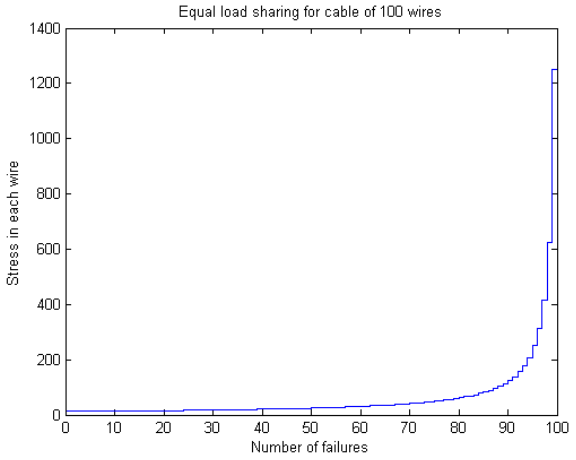




Assumption : equal load sharing after failures

At the beginning : $\sigma_i = \frac{F}{n.s}$

After *k* failures : $\sigma_i = \frac{F}{(n-k).s}$



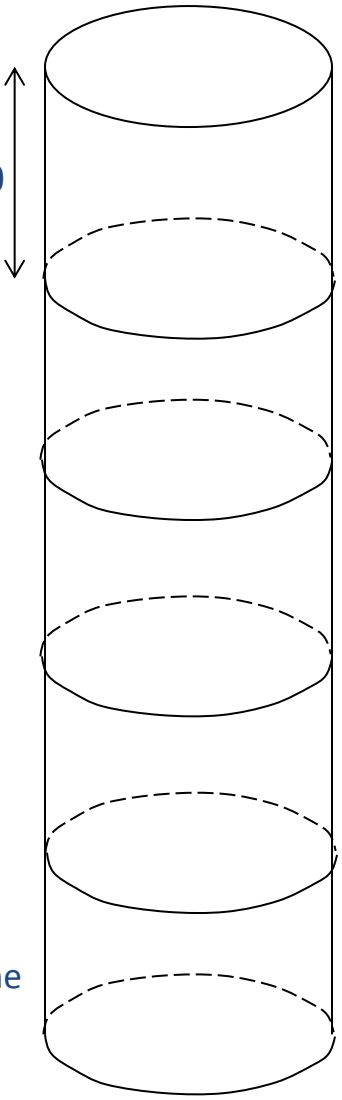
Reliability analysis

Reliability assessment process:

Monte Carlo simulations

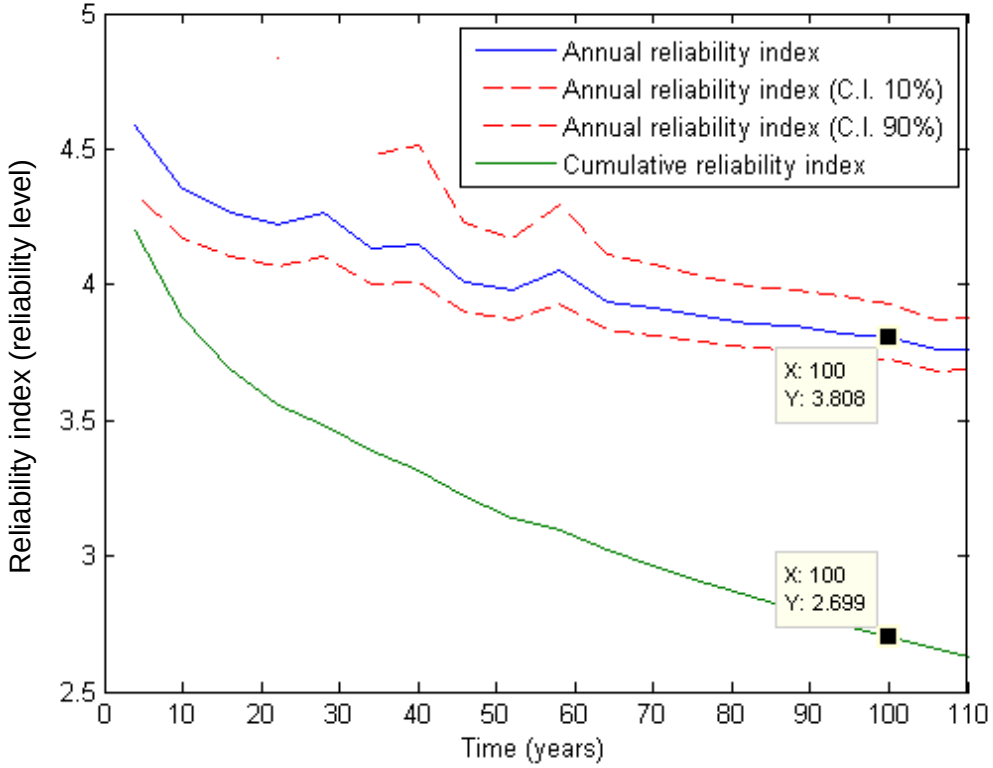
- Traffic load : F_amplitude, F_mean, F_extreme
- Corrosion depths
- Stress assessment
- Damage assessment
- Failure modes
  - Global damage = 1
  - Mean stress ≥ Ultimate strength
  - Extreme stress ≥ Ultimate strength
- Number of broken wires

Time step : 10 weeks



Reliability analysis

Results

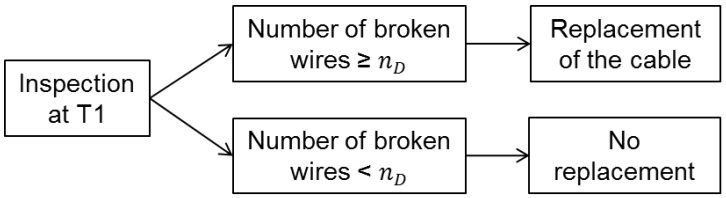


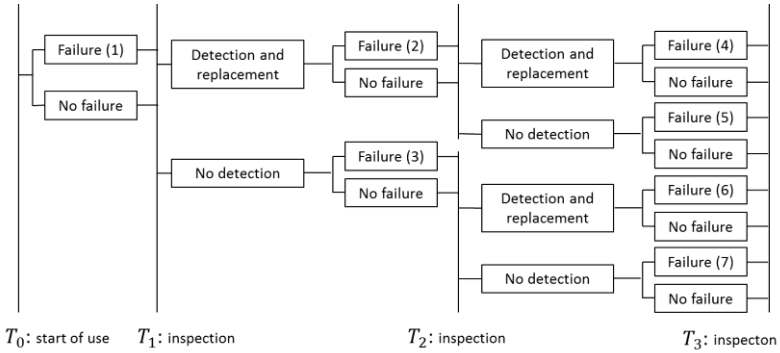
Annual reliability index after 100 years : 3.8

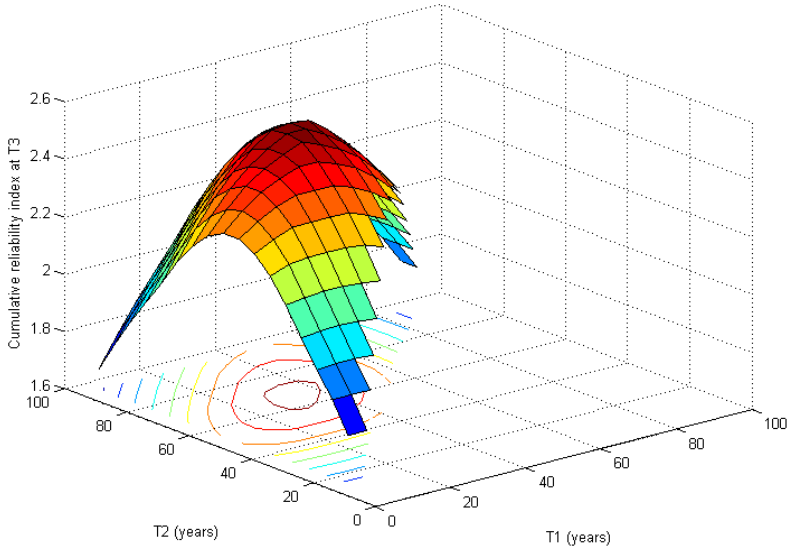
Cumulative reliability index after 100 years : 2.7

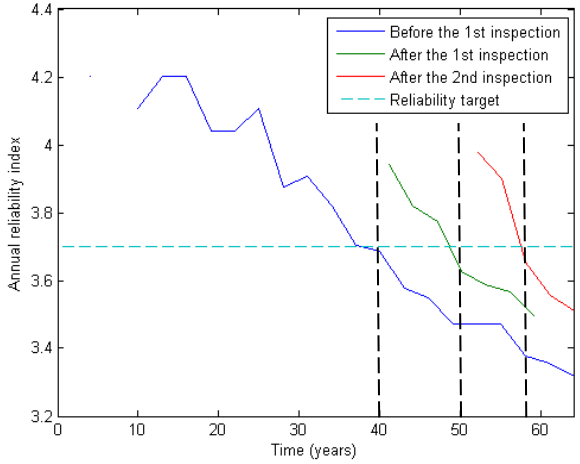
Reliability based inspection planning

Define inspection planning in order to ensure a reliability level higher than the target reliability level









Conclusion and future work

Conclusion

- Reliability assessment of each cable
- Estimation of the influence of cable length, number of wires, corrosion, traffic load, material properties…
- Reliability based inspection planning methodology

Future work

- Extend to an optimization of the life cycle costs taking into account the costs of inspection, cable replacement and failure

Thank You

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Project Website

www.longlifebridges.com

Acknowledgement

Long Life Bridges is a Marie Curie Industry and Academia Partnerships and Pathways project and is funded by the European Commission 7th Framework Programme (IAPP-GA-2011-286276).