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U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Fatigue assessment of old riveted railway bridges

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Introduction



• Na Europa, um **vasto numero** de pontes foram **construídas no fim do século XIX** e foram dimensionadas para condições de tráfego bem diferentes das atuais.

•**Fadiga é a principal causa de dano** no caso das pontes.

• A compreensão do fenómeno e o desenvolvimento de metodologias e ferramentas para avaliar a segurança de estruturas existentes tem ganho uma importância cada vez maior.

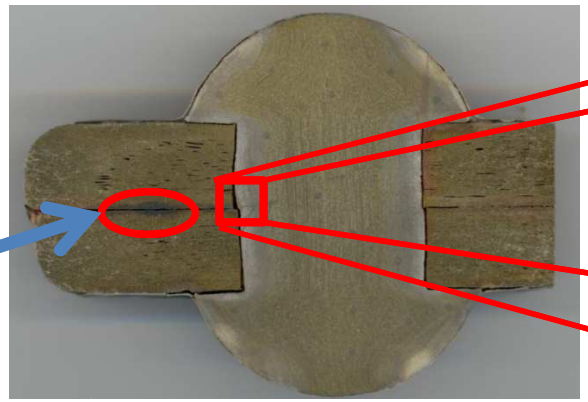
Problemas da execução



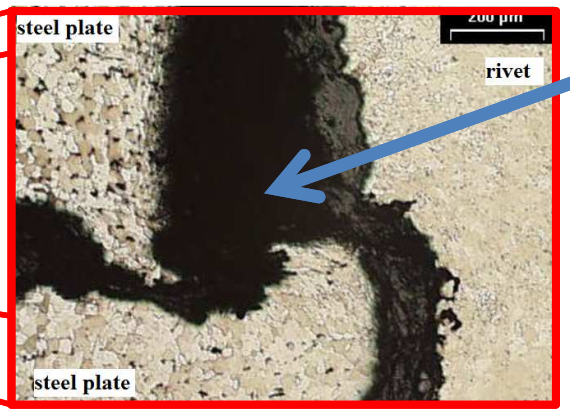




Defeitos locais macro e microscópicos que potenciam o aparecimento de fendas por fadiga



corrosão



efeitos térmicos

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Case study: Trezói bridge

Ponte metálica rebitada (1956 - …)



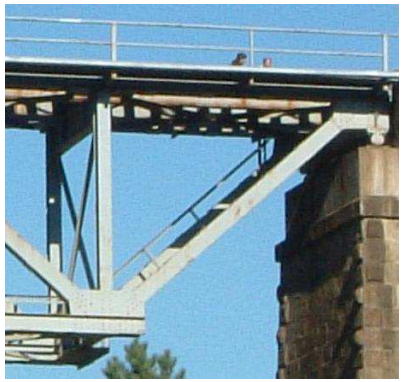


- Duas vigas treliçadas Warren invertidas com 5.68 m de altura.
- Vãos de 39 / 48 / 39 m; largura constante de 4.40m





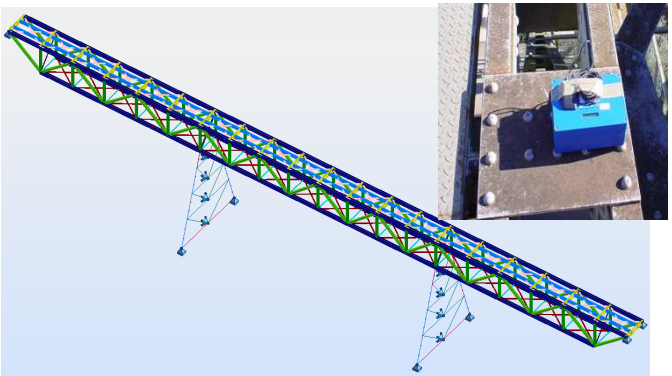




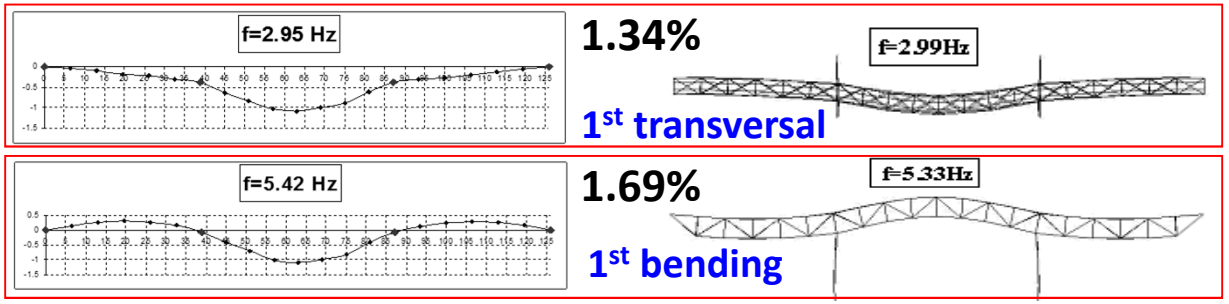
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Ambient vibration test and local modes identification

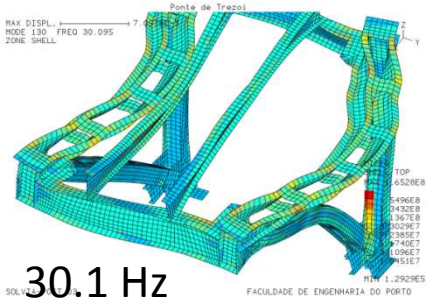
Modelo global

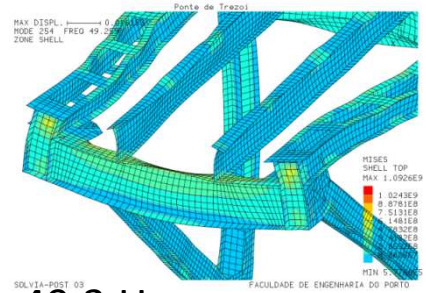


- **Modos vibração e frequências naturais: experimental vs. numérico**

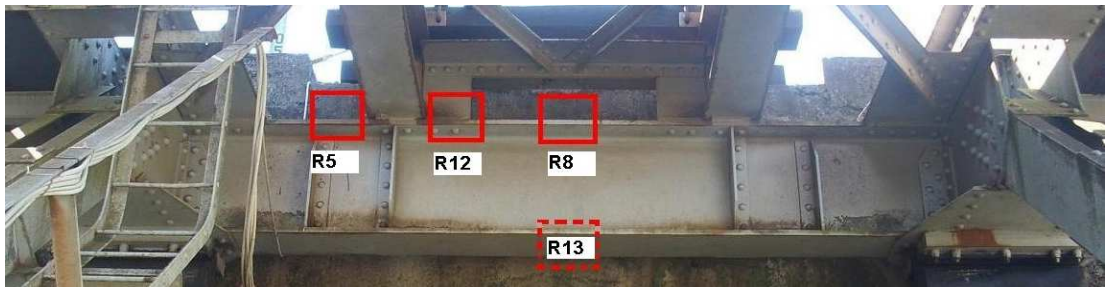


Modelo local

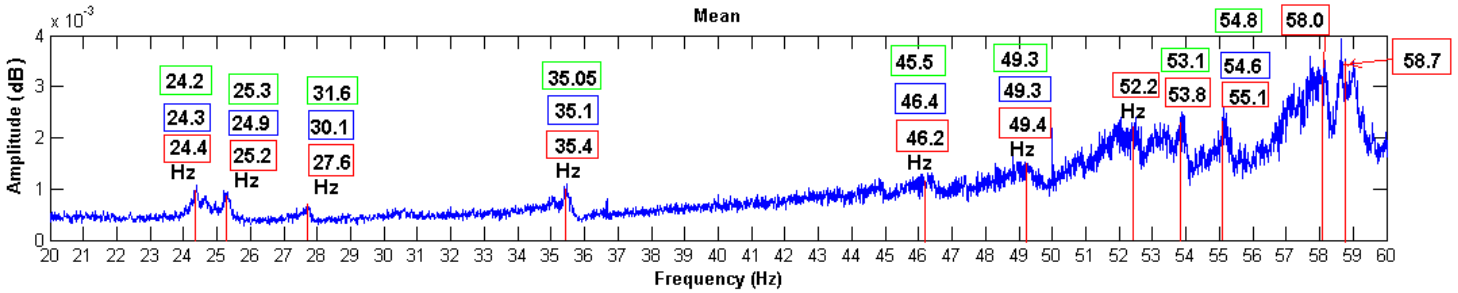




Measurement points



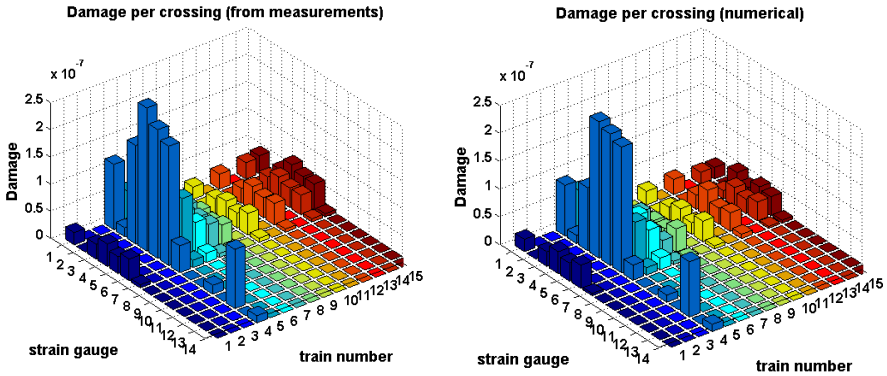




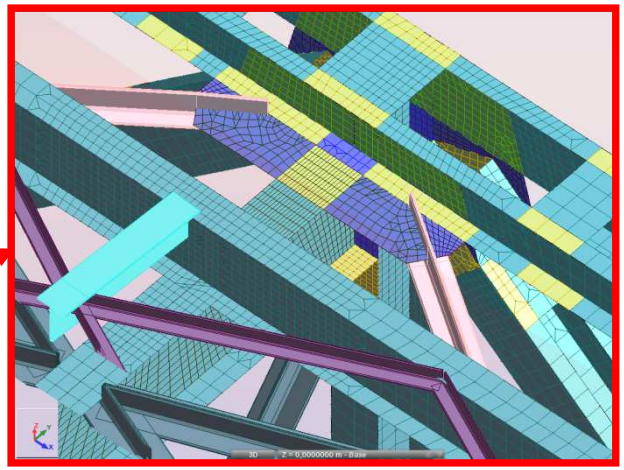
Global fatigue analysis

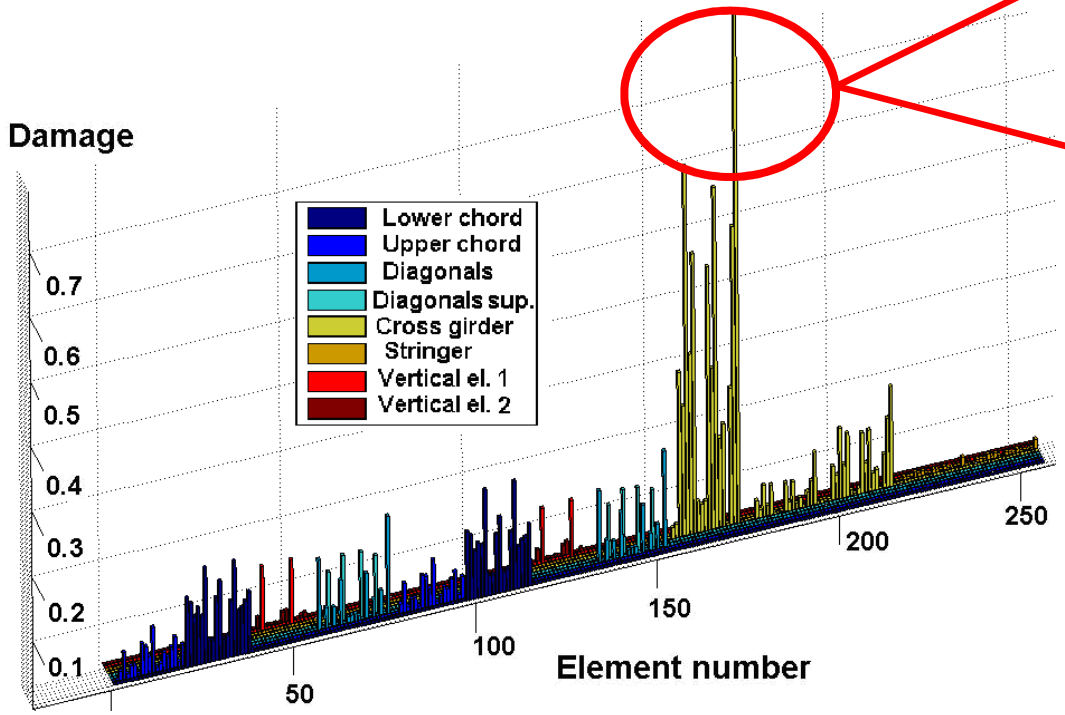
Índices de fadiga para a totalidade dos elementos estruturais da ponte

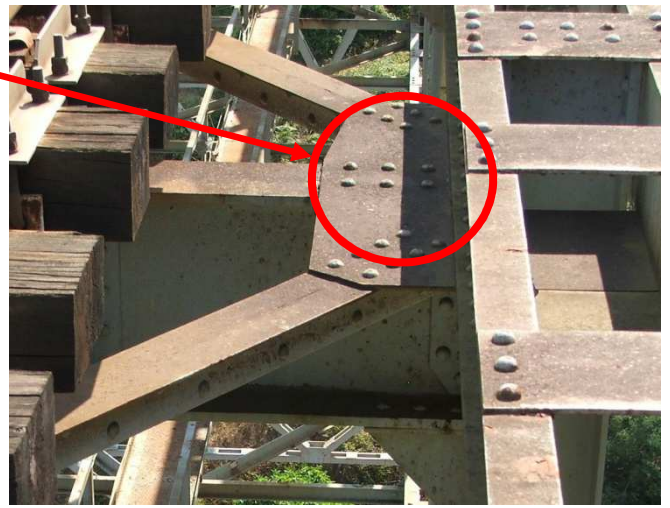
Carlingas











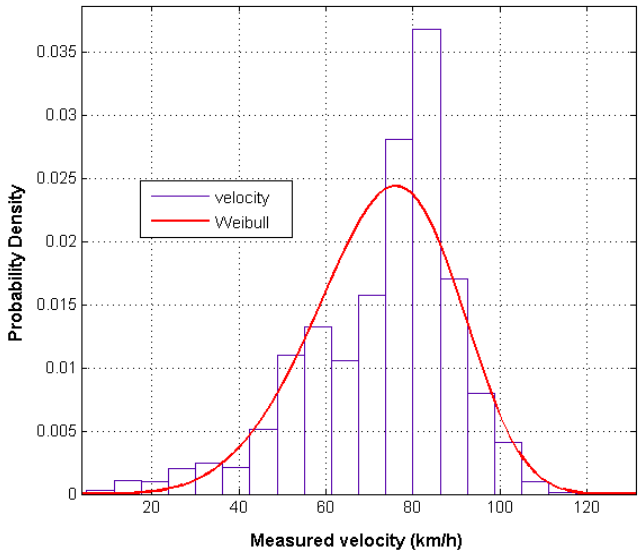
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Traffic characterization using bridge weigh in motion

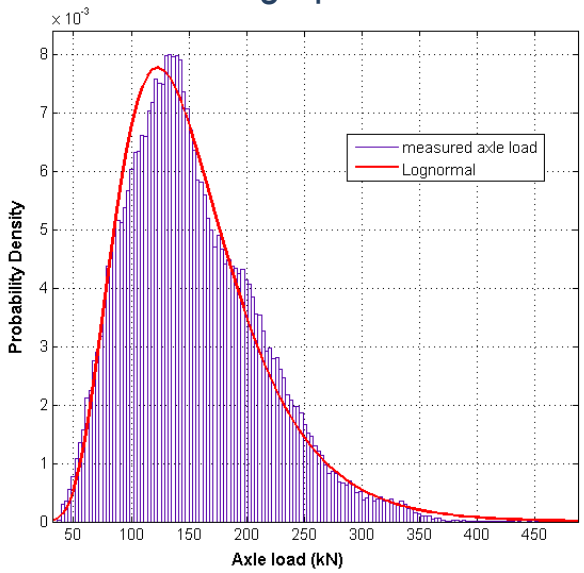
$$\{P\} = [[IL]^T [IL]]^{-1} [IL]^T \{\varepsilon^m\}$$

Methodology proposed by Moses et al.

Velocidade



Carga por eixo



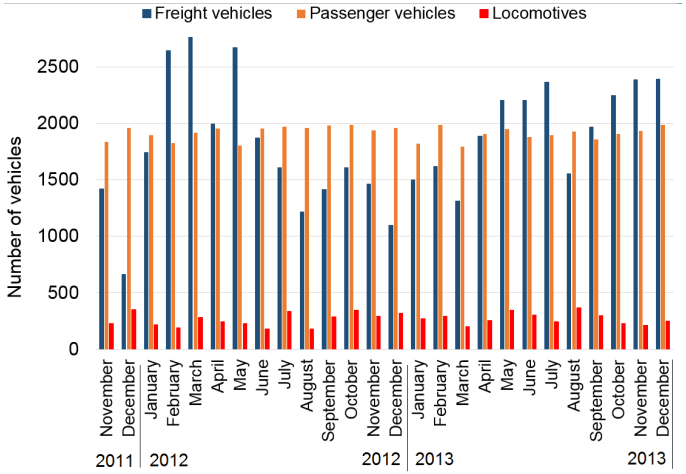


22.50 ton 10.0



21.75 ton 3.0 10. m

Tipo de comboios por mês



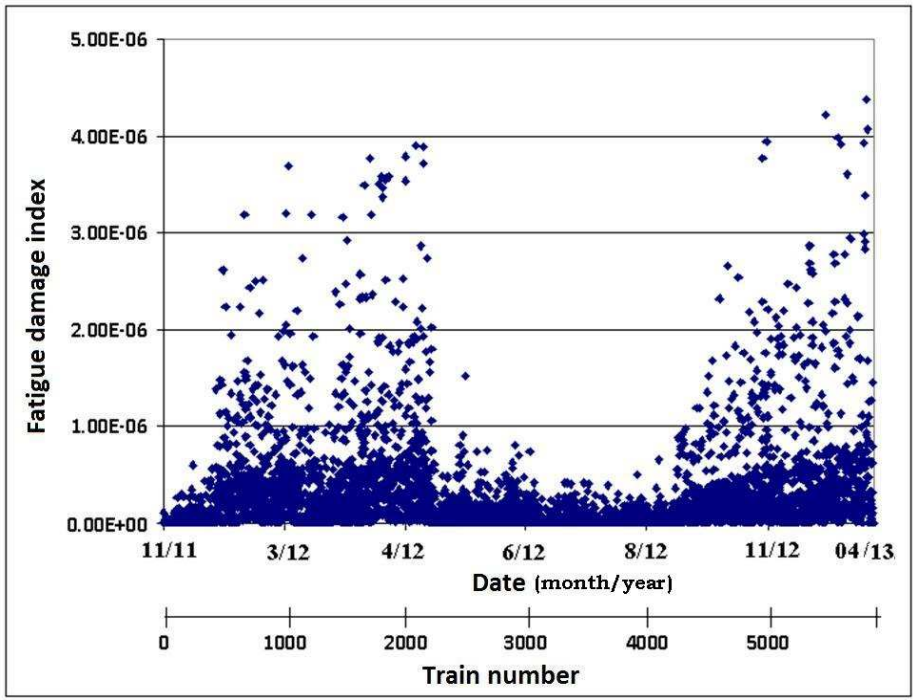


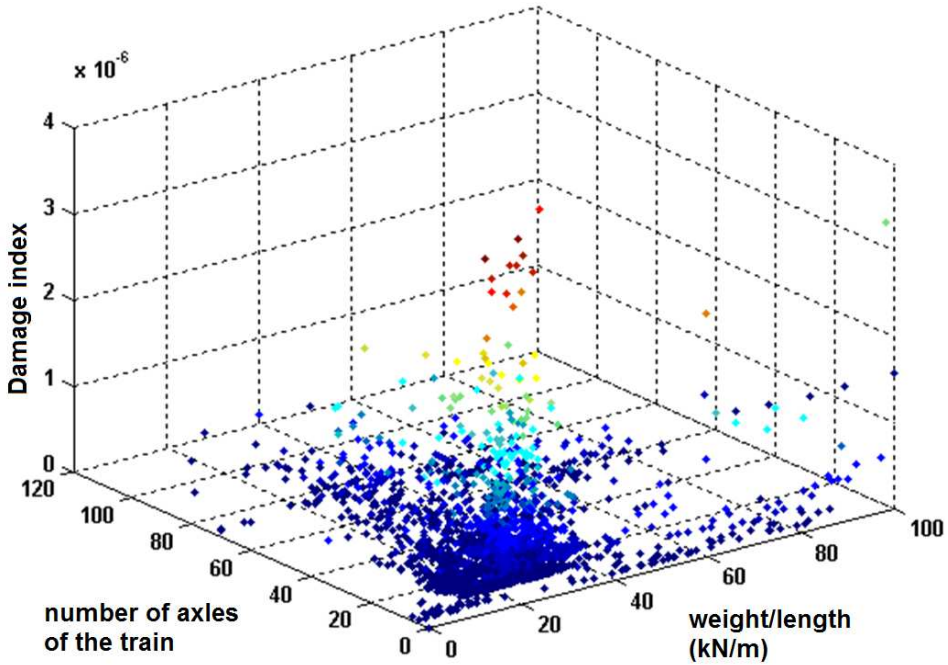
11.77 ton 2.56 m 18.0

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Damage calculation using measurements

Um ano e meio de medições





Valores inferiores nos meses de verão

Possíveis efeitos dinâmicos importantes

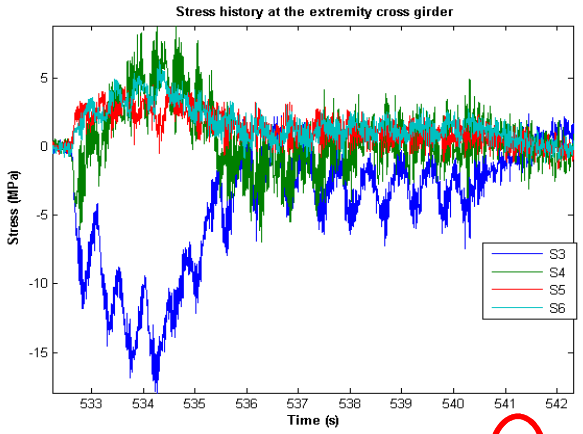
Vida residual de fadiga de 31 anos

Fatigue analysis using Fracture Mechanics and Monte Carlo simulation method

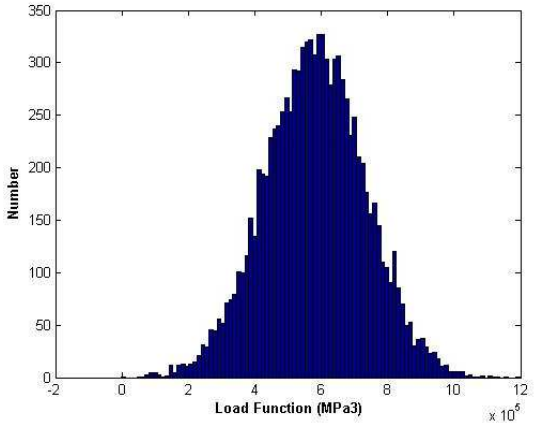
$$\frac{da}{dN} = C(\Delta K)^m$$ lei de Paris

$$a_{j+N} = a_j + C_i\left(Y(a_j)\sqrt{\pi a_j}\right)^{m(i)} h_j[B_N(w)]$$

Cálculo da função de dano usando extensões medidas nas carlingas



Rainflow



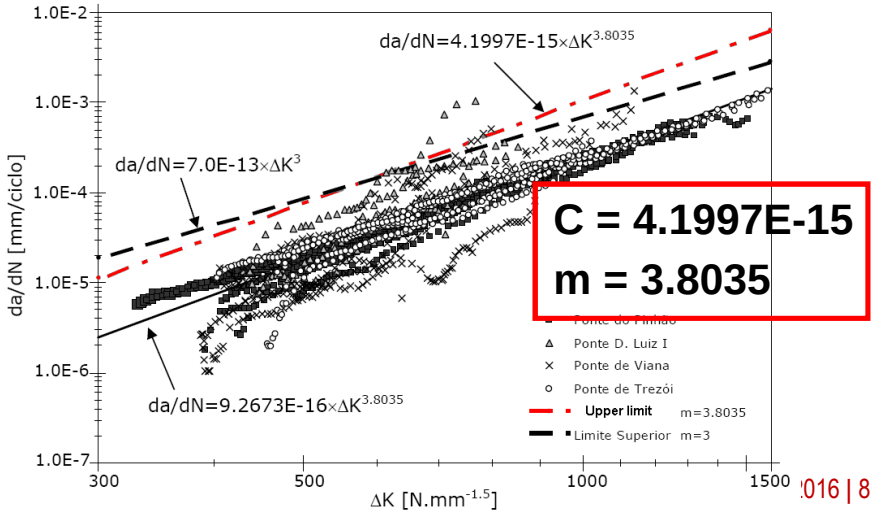
$$h[B(w)] = \sum_{i=1}^{n} (\Delta\sigma)^m$$

$$a_{j+N} = a_j + C_i\left(Y(a_j)\sqrt{\pi a_j}\right)^{m(i)} h_j[B_N(w)]$$



Laboratory tests





C = 4.1997E-15

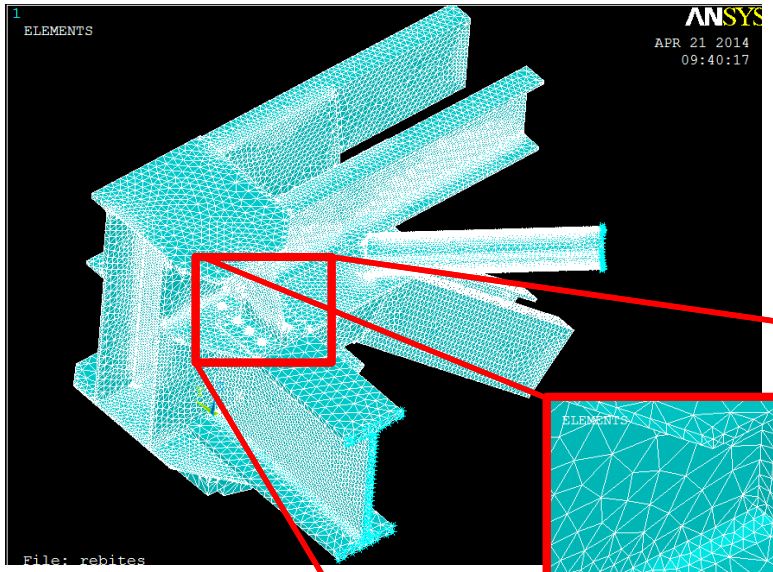
m = 3.8035

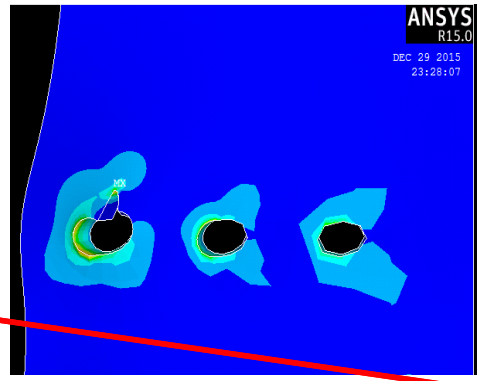
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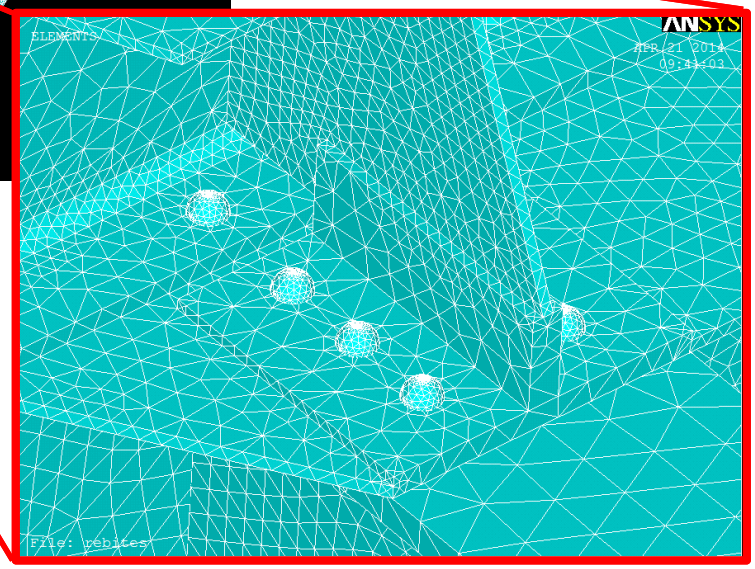
Fatigue analysis using Fracture Mechanics and Monte Carlo simulation method

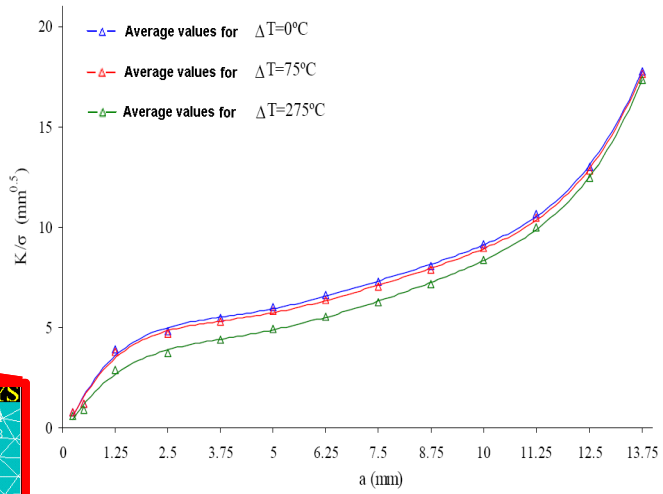
Função de forma

$$a_{j+N} = a_j + C_i \left(Y(a_j)\sqrt{\pi a_j}\right)^{m(i)} h_j\left[B_N(w)\right]$$









- elementos finitos de volume
- simulação do contacto rebites/chapas e entre chapas
- simulação do atrito entre chapas

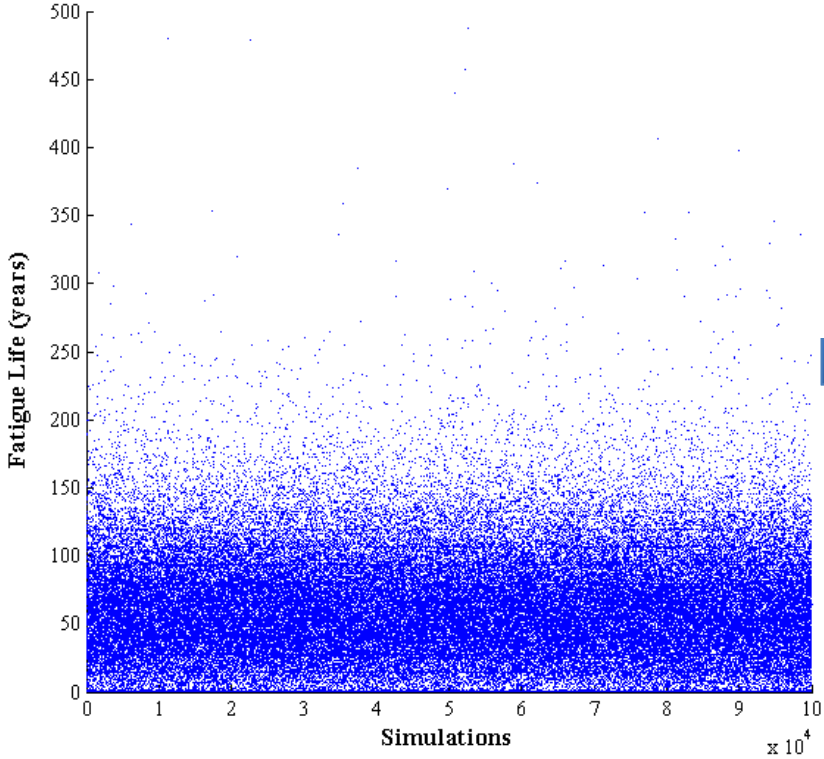
Cálculo usando 3 valores para o pré-esforço dos rebites

Simulação do crescimento da fenda – modificação da malha

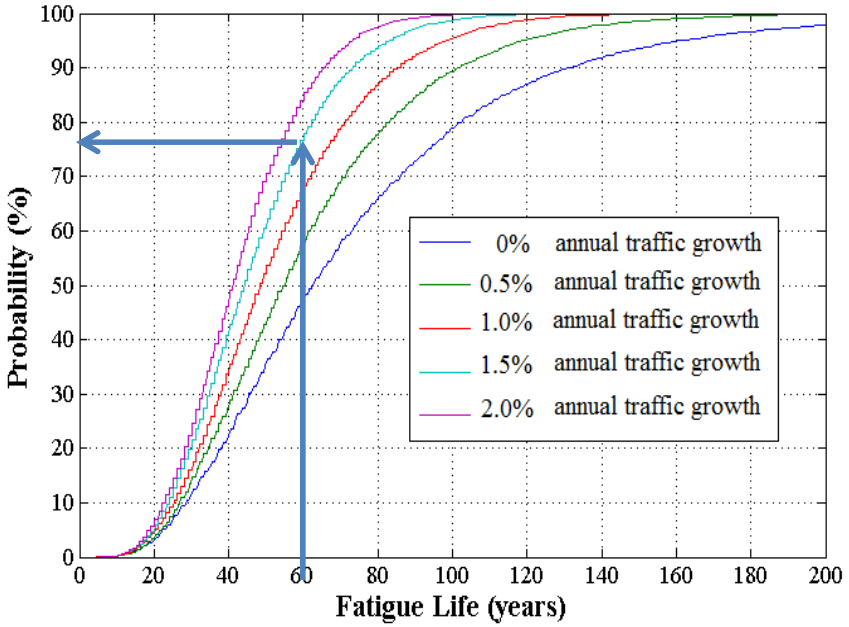
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Fatigue analysis using Fracture Mechanics and Monte Carlo simulation method

Resultados



Função distribuição acumulada



Vida de fadiga baixa para um número elevado de simulações

Probabilidades elevadas para vidas de fadiga baixas