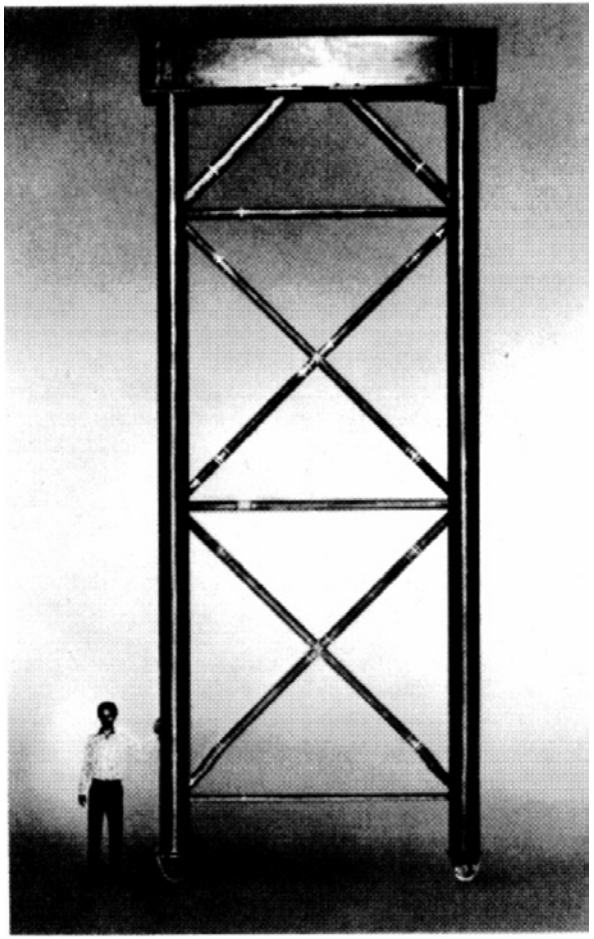
System reliability updating of welded jacket-type structures subjected to fatigue with global monitoring information



Zayas et al. (1980)

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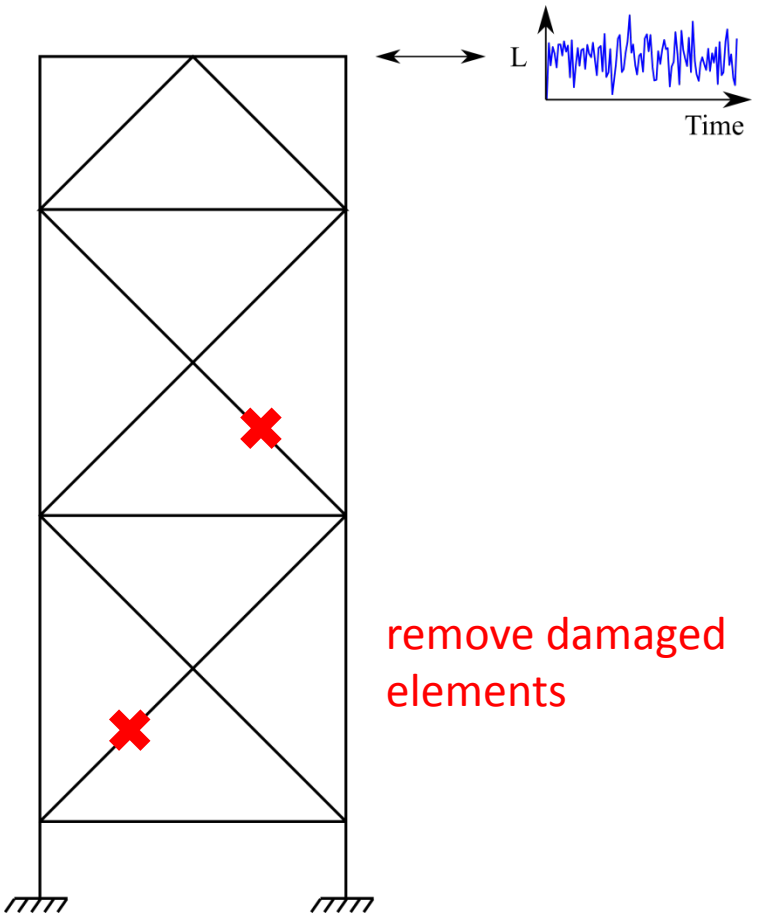
My current research interests:

- How to analyze the reliability of deteriorating structural systems?
- How to update their reliability with inspection and monitoring information?
- How to identify optimal inspection, monitoring and maintenance strategies?

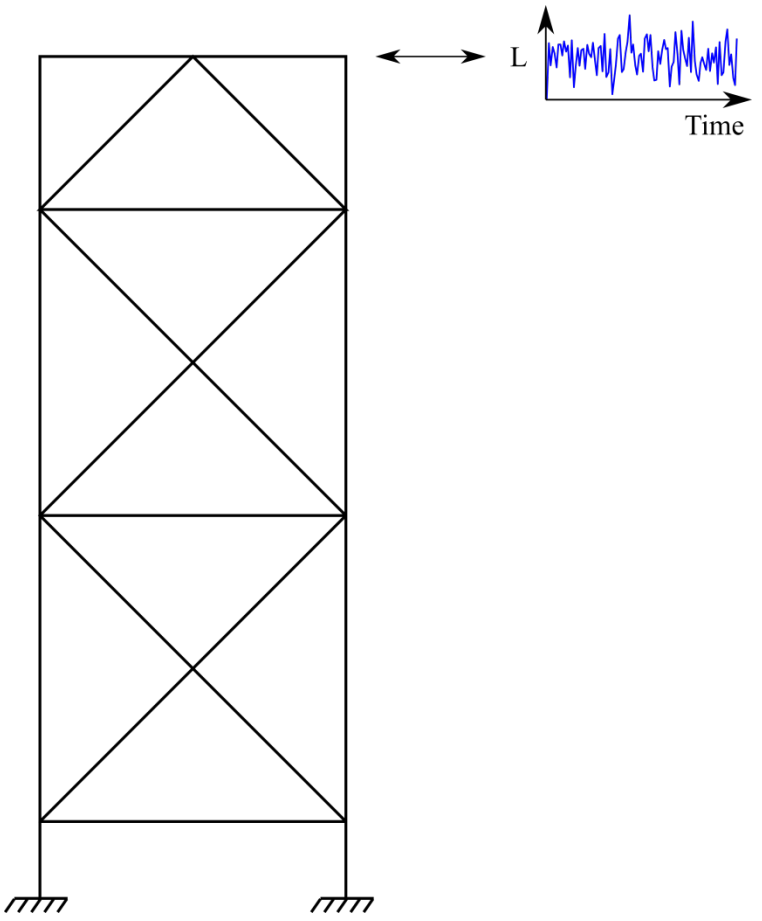
Jacket-type structure subjected to fatigue



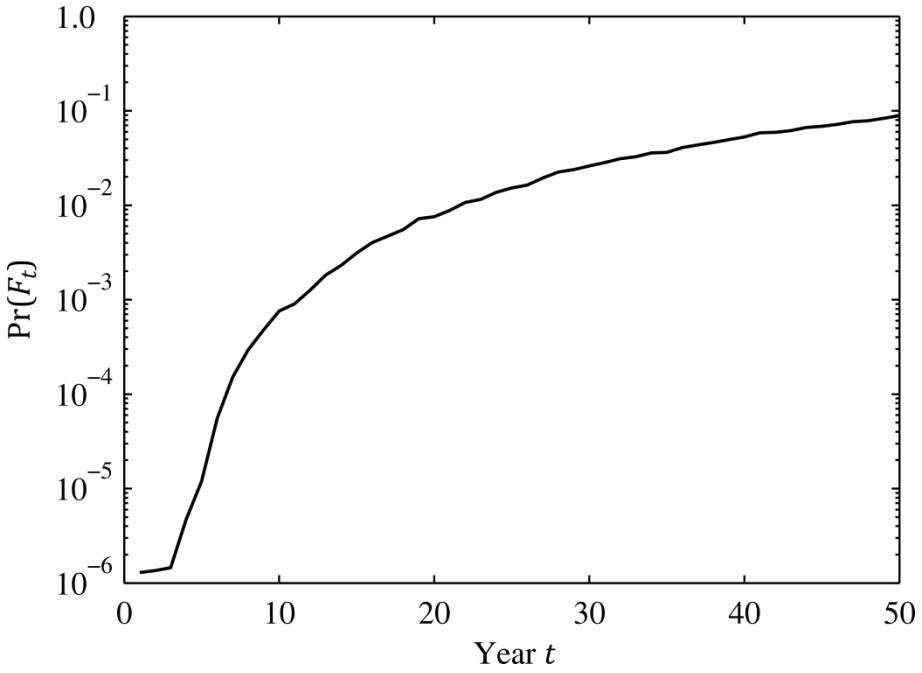
- Element i is damaged:
  $F_{i,t} = \{g_i(\mathbf{X}, t) \leq 0\}$

- Conditional annual system failure probability:
  $\Pr(F_t|\mathbf{X} = \mathbf{x})$

Prior annual system failure probability



$$\Pr(F_t) = \int_{\mathbf{X}} \Pr(F_t|\mathbf{X} = \mathbf{x})\, f_{\mathbf{X}}(\mathbf{x})\, d\mathbf{x}$$



Global damage detection system

- Probability of damage detection:

  $\Pr\left(D_t | N_{F,t} = k\right), k = 0, \dots, n_E$

- Number of damaged elements is a function of $\mathbf{X}$:

  $$N_{F,t} = q(\mathbf{X}, t) = \sum_{i=1}^{n_E} I(g_i(\mathbf{X}, t) \leq 0)$$

- Likelihood function for detection event D_t:

  $$L_D(\mathbf{x}, t) = \sum_{k=0}^{n_E} I(q(\mathbf{x}, t) = k) \cdot \Pr\left(D_t \middle| N_{F,t} = k\right) \propto \Pr(D_t | \mathbf{X} = \mathbf{x})$$

- Likelihood function for combined monitoring outcome $Z_{0:t}$:

  $$L(\mathbf{x}, t) = \prod_{i=1}^{n_D(t)} L_D(\mathbf{x}, t_i) \prod_{j=1}^{n_{\bar{D}}(t)} \left(1 - L_D\left(\mathbf{x}, t_j\right)\right) \propto \Pr(Z_{0:t} | \mathbf{X} = \mathbf{x})$$

Updated annual system failure probability

- Bayes‘ rule:

$$\Pr(F_t|Z_{0:t}) = \frac{\Pr(F_t \cap Z_{0:t})}{\Pr(Z_{0:t})}$$

- Joint probability of the events F_t and $Z_{0:t}$:

$$\Pr(F_t \cap Z_{0:t}) = \int_{\mathbf{x}} \Pr(F_t|\mathbf{X}=\mathbf{x}) \Pr(Z_{0:t}|\mathbf{X}=\mathbf{x}) f_{\mathbf{X}}(\mathbf{x})\, d\mathbf{x}$$

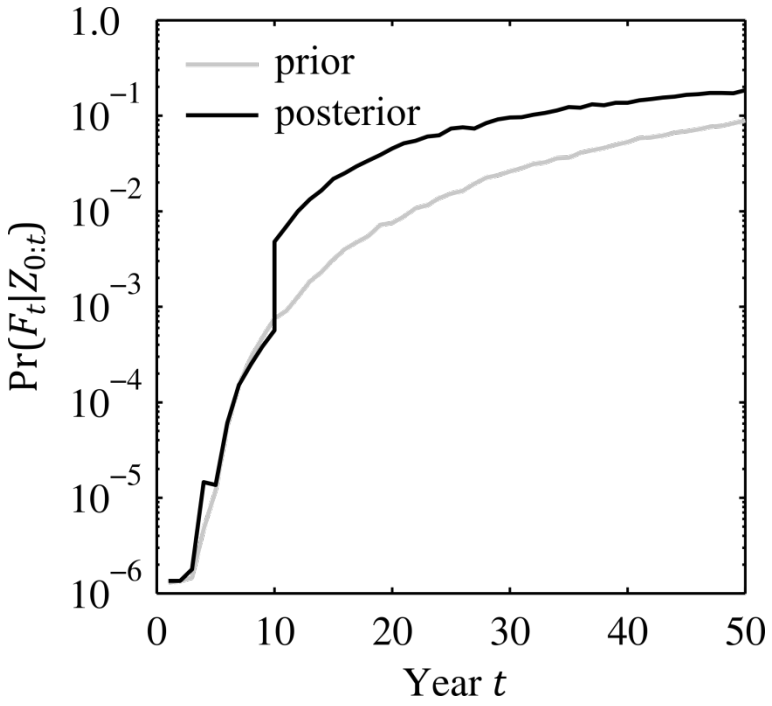
- Probability of monitoring outcomes:

$$\Pr(Z_{0:t}) = \int_{\mathbf{X}} \Pr(Z_{0:t}|\mathbf{X}=\mathbf{x}) f_{\mathbf{X}}(\mathbf{x})\, d\mathbf{x}$$

Updated annual system failure probability

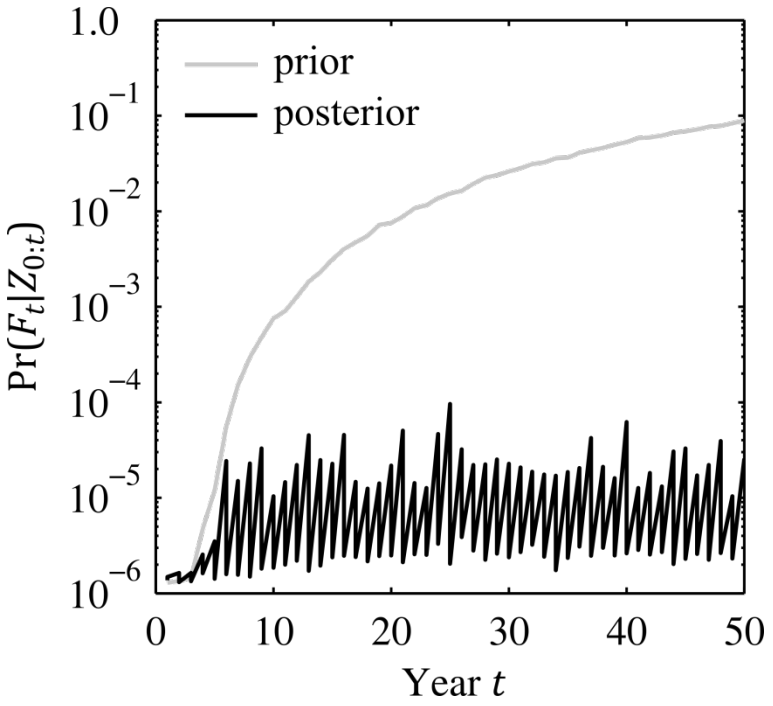
Monitoring in year 10

Damage detection



Monitoring once a year

No damage detection



References

- Schneider R., Thöns S. and Straub D. (in preparation): Reliability analysis and updating of deteriorating structural systems with subset simulation.

- Zayas V. A., Mahin S. A. and Popov E. P. (1980): Cyclic inelastic behavior of steel offshore structures. UCB/EERC-80/27, University of California, Berkley, USA