Adjusted Equivalent Static Wind Loads for non-Gaussian Linear Static Analysis

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Context

→ Equivalent Static Wind Loads?

<complex structure, load combination, codification, simplicity>
Academic Example

- Well-known wind pressure field [Main 2006]
- Limitations of existing ESWLs
- Linear & static structural behaviour <simple enough>

Non Gaussian pressure field!
Academic Example: Pressure Field

Mean $C_p$

Standard deviation of $C_p$

Skewness coefficient of $C_p$

Excess coefficient of $C_p$
Academic Example: Response in Frame #2

\[ r(t) = Ap(t) \]

Example of \( C_p \)

20 kNm

Mean Bending Moment

10 kNm

Standard Deviation of Bending Moment

0.6

Skewness of Bending Moment

2

Excess of Bending Moment

4

Peak Factor (Nonsymmetric)

61 kNm

Extreme/Design value Envelope

\[ E = \mu + g\sigma \]
Equivalent Static Wind Load

▷ Conditional Sampling technique [Holmes 1988]

Average Equivalent Static Wind Load

Block 1 Block 2 Block 3 Block 4 Block 5 Block 7 Block 6

Bending moment @ left support

Time

0 0.5 1 1.5

Cp

Bending moments under ESWL

Envelope overshooting

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Equivalent Static Wind Load

Load-Response Correlation (LRC) [Kasperski 1992]

Bending moments under ESWL

Envelope overshooting

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Equivalent Static Wind Load

Non-Gaussian Load-Response Correlation: a bi-cubic model

\[ u_r, u_p : \text{Two correlated normal R.V.} \]
\[ a_r, b_r, \alpha_r, a_p, b_p, \alpha_p, \rho_{rp} : 7 \text{ parameters} \]
\[
\begin{align*}
    r &= \frac{\alpha_r}{b_r} \left( \frac{u_r^3}{3} + a_r u_r^2 + (b_r - 1) u_r - a_r \right) \\
p &= \frac{\alpha_p}{b_p} \left( \frac{u_p^3}{3} + a_p u_p^2 + (b_p - 1) u_p - a_p \right)
\end{align*}
\]

Examples of PDFs generated with the bi-cubic model
Equivalent Static Wind Load: Comparison

- LRC: Severe over-estimation of the envelope
- Non-G. LRC: Slight over-estimation of the envelope
Two important properties & Adjustment

1. the *Envelope value condition*
   ... The ESWL associated with a given response should return the design value for that response ...

2. the *Non-overestimation condition*
   ... The responses under a given ESWL should not exceed the target envelope ...

→ 2-step adjustment
   \[ \hat{p}^{(e)} = \beta \circ (\alpha p^{(e)}) \]

\( \alpha \): load scaling coefficient
\( \beta \): local adjustment coefficient
Illustration of Adjustment

Conditional Sampling

Load-Response Correlation

Non Gaussian Load-Response Correlation

- $\alpha = 1$ for the LRC method
- $\beta$ is obtained with a constrained optimization algorithm (as close as 1 as possible)
Enveloppe Reconstruction

- Adjustment $\rightarrow$ faster reconstruction
- Conditional Sampling, LRC, nG-LRC perform equally if adjusted
Perspectives & Conclusions

**Proposition of a Non Gaussian version of the LRC**
- bi-cubic model
- regularly extends the LRC for non Gaussian pressure field/responses

**2-Step Adjustment of Equivalent Static Wind Load to meet:**
- the Envelope Value Condition
- the Non-Overstimation Condition
Thank you ...

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