MODEL UNCERTAINTY IN RELIABILITY ANALYSIS OF FRP-TO-CONCRETE BOND WITH GROOVES

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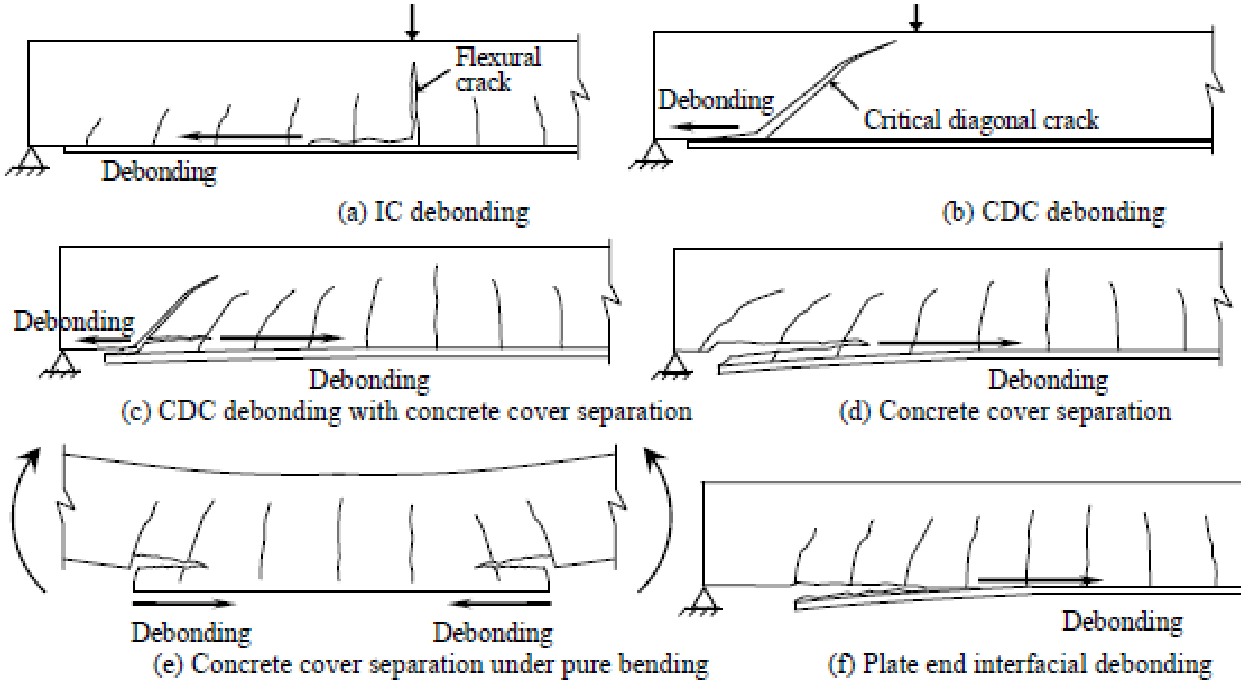
Outline

- Introduction of Grooving Method (GM)
- Reliability Analysis Model
- Effect of Model Factor
- Characterization of Model Uncertainty
- Conclusion

Introduction

- External bonding of FRP composite is a popular technique for strengthening of concrete structure

- Debonding failure problem for conventional joints.



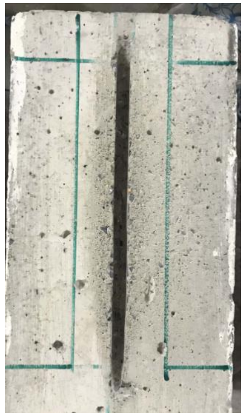
(Teng et al, 2007)

Grooving Method

- Grooving method (GM): FRP laminate is attached on the pre-cut concrete surface, has shown great potential in improving the performance of FRP strengthening.

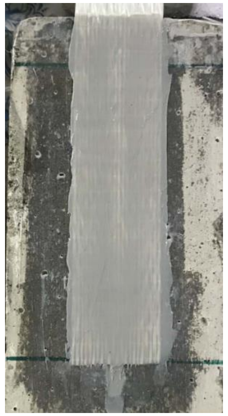


(Omboko 2017;
Jiang et al. 2018)



Cut grooves

Application of epoxy adhesive

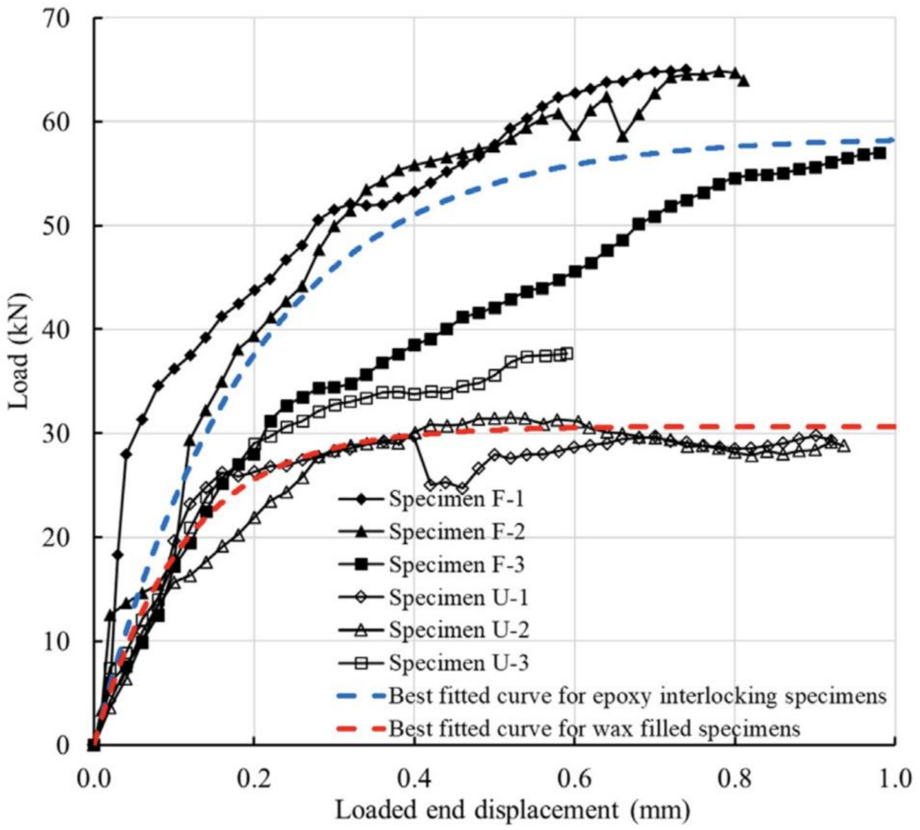


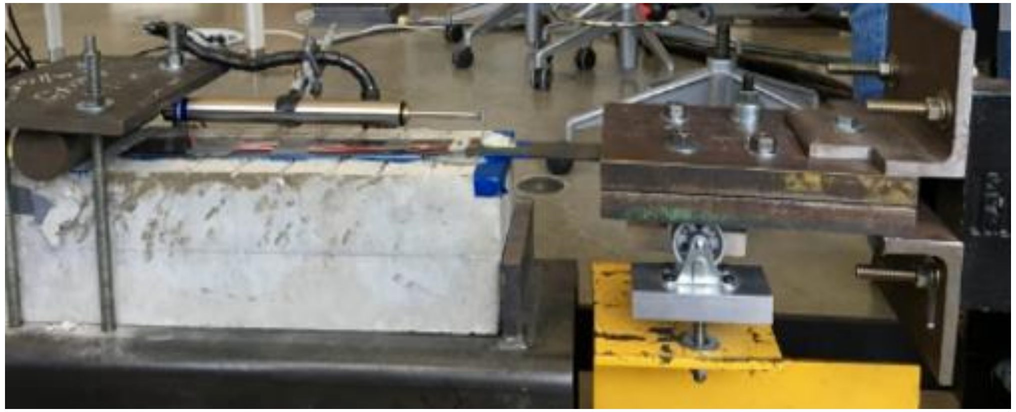
Bonding FRP to concrete

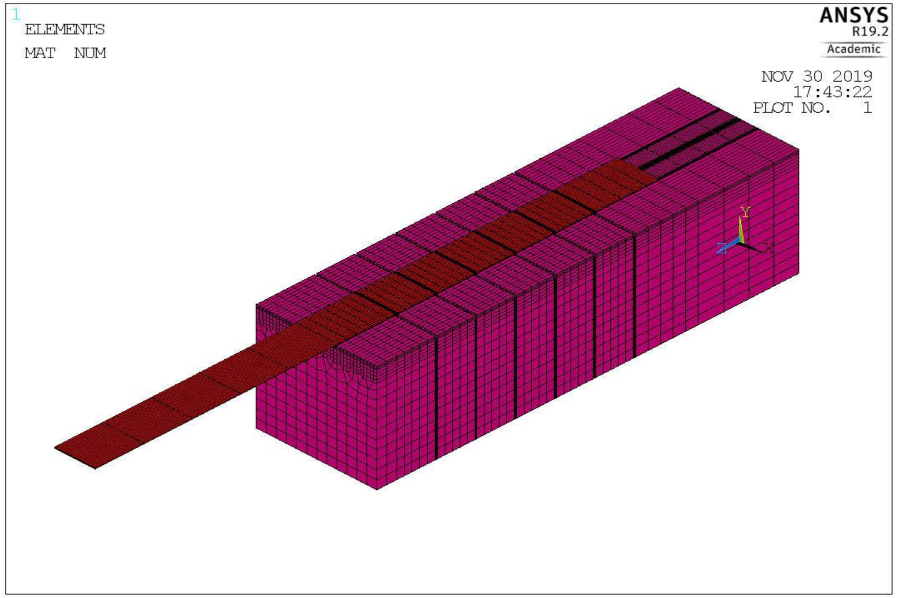
(Mostofinejad and Moghaddas 2018)

Introduction

Experimental work and FE analysis have been conducted.

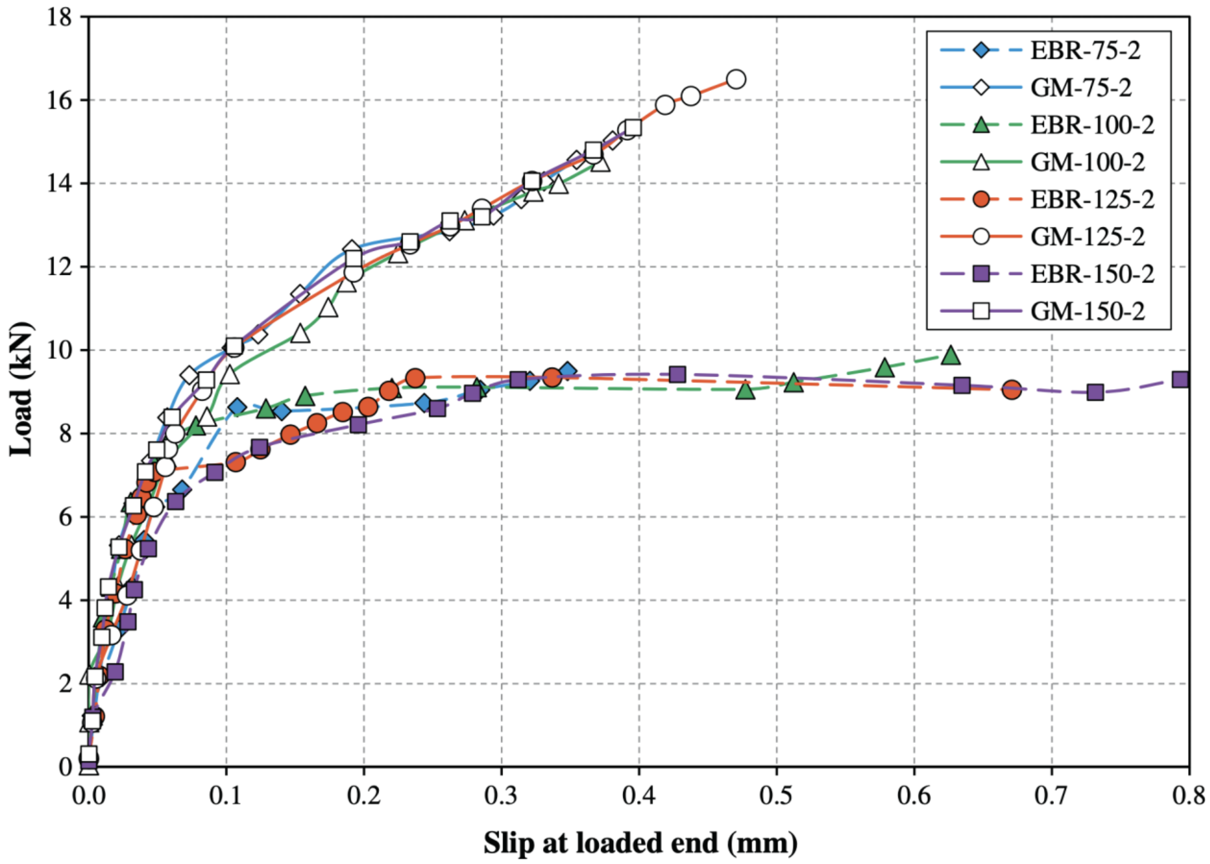


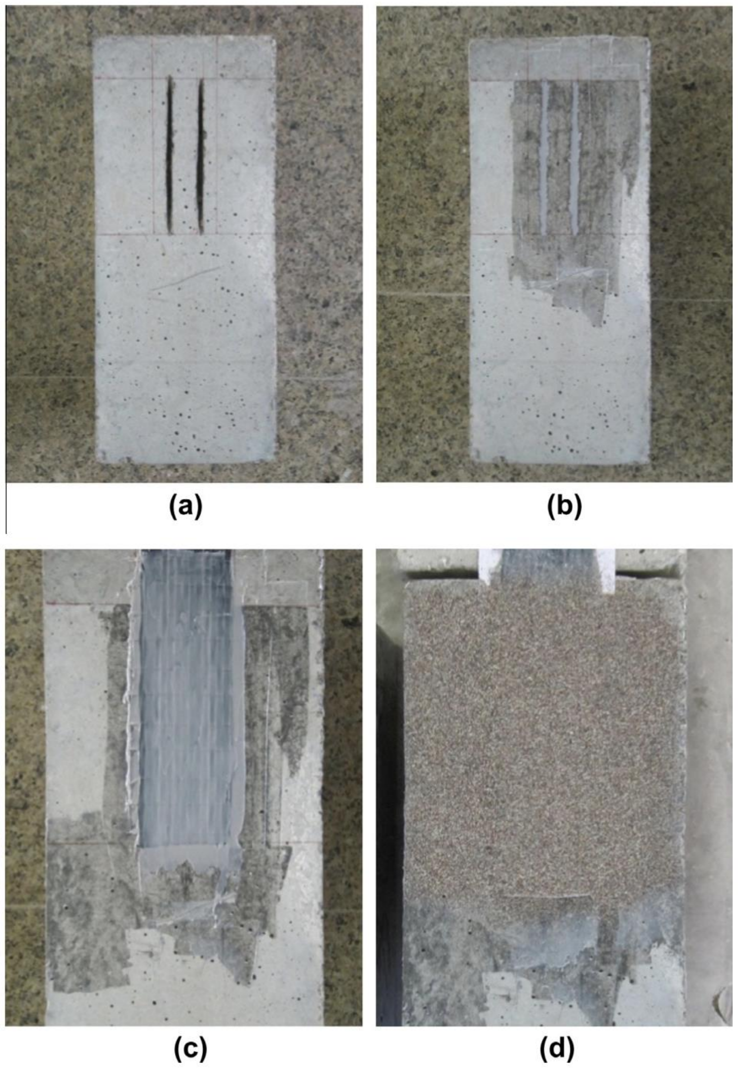




(Omboko 2017; Jiang et al. 2018)

Introduction





(Hosseini and Mostofinejad, 2013)

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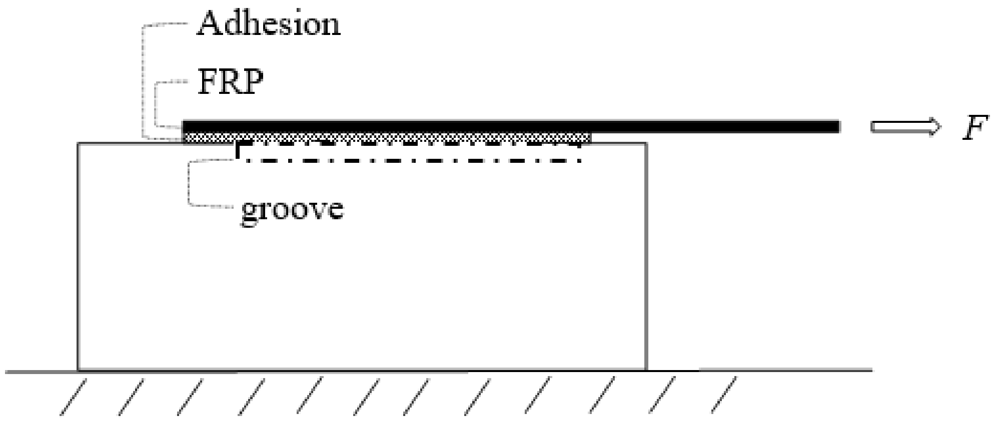
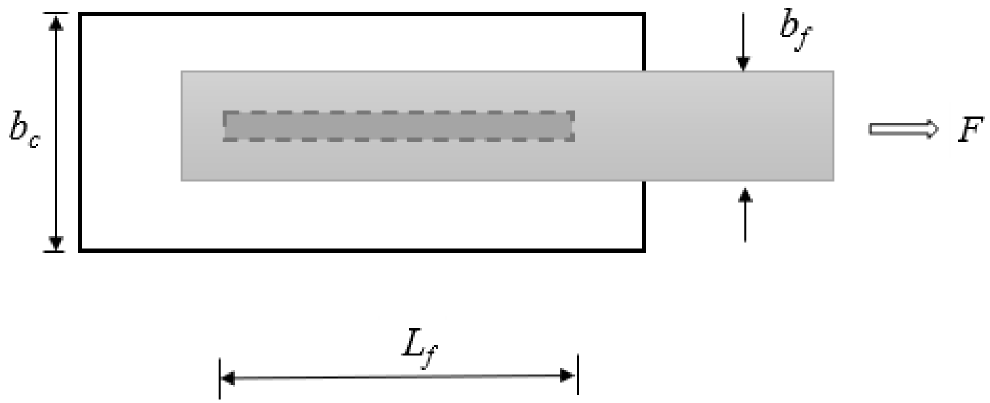
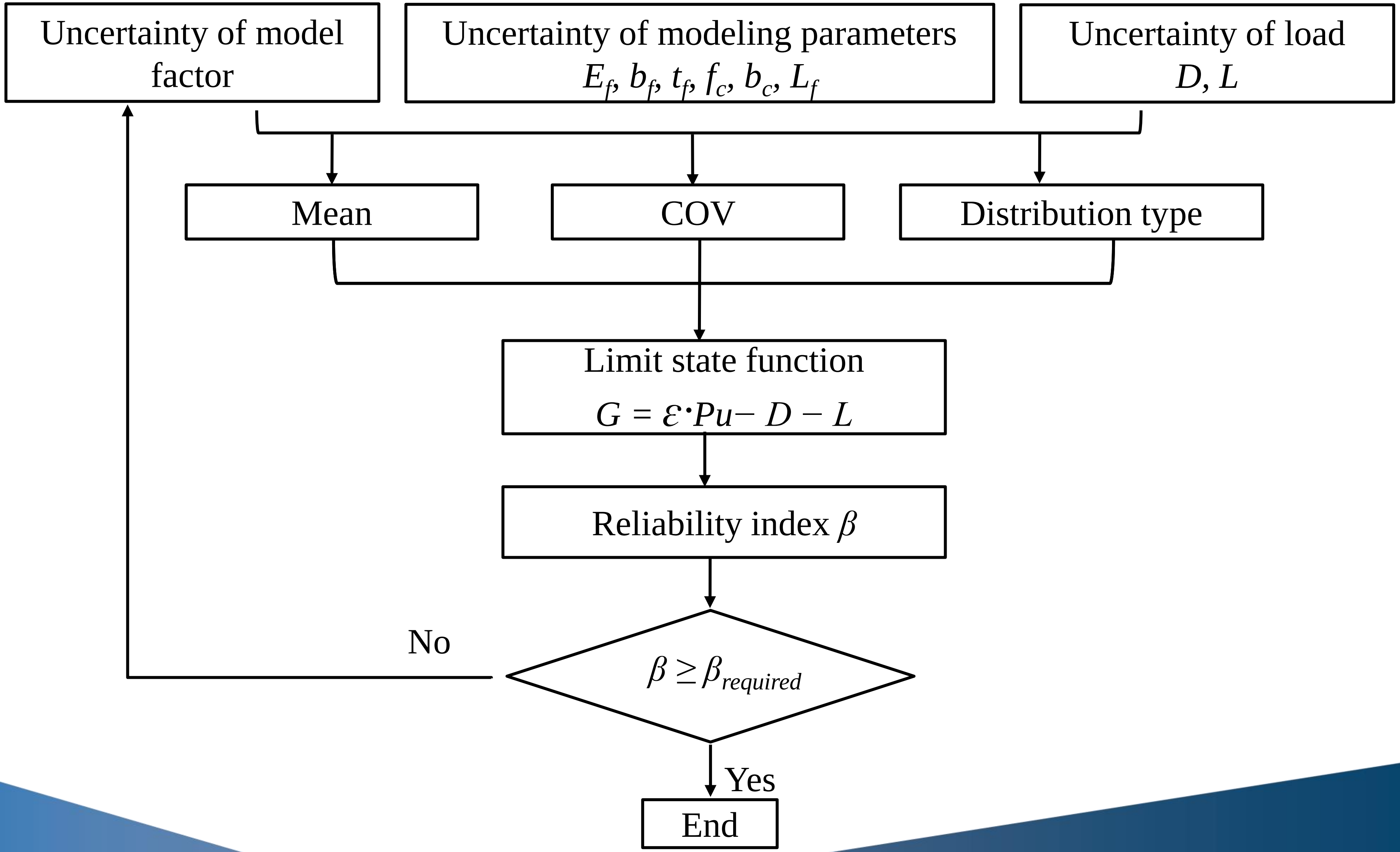
Introduction

- Limitation: hard to applied in the real-world construction projects due to lack of reliability analysis.
- Current analysis is focused on longitudinal groove.





Reliability Analysis Model

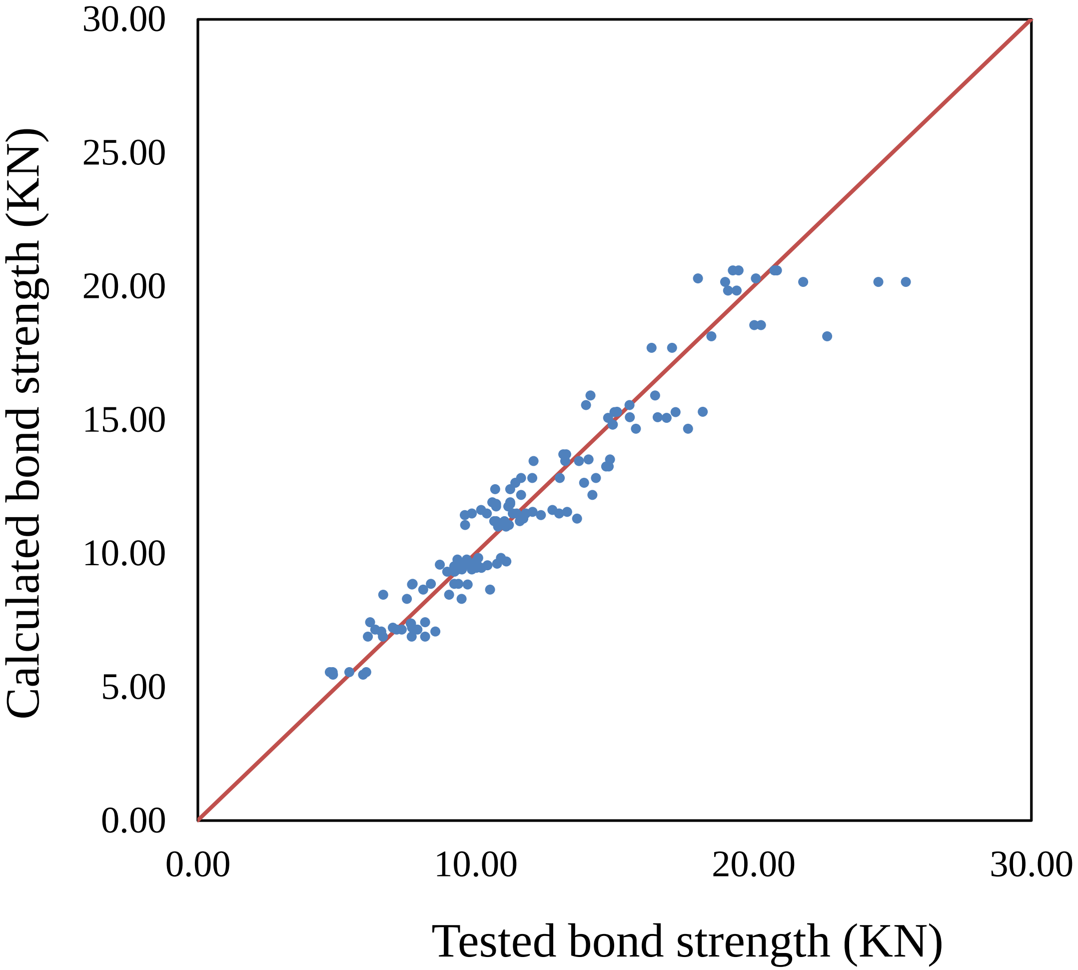


Effect of Model Factor

- A model factor, represented by ε, is introduced as the ratio between a measured value and its corresponding predicted value.

$$P_u^m = \varepsilon \, P_u^c$$

- The statistical characteristics: mean, COV, and probability distribution, reflects the performance of the prediction model.



Characterization of Model Uncertainty

- Choose Proper Prediction Model
- Collect Data
- Analyse Systematic Dependency
- Determine Mean, COV, and Probability Distribution

Prediction Model

The empirical model has been developed by Mostofinejad and Mahmoudabadi (2018) to predict the interfacial bond strength.

$$P_u = 0.427\,\beta_g\,\beta_p\,\beta_l\sqrt{f_c'}\,b_f L_e$$

$$\beta_p = \sqrt{\frac{2-b_f/b_c}{1+b_f/b_c}}$$

$$L_e = \sqrt{\frac{E_f t_f}{\sqrt{f_c'}}}$$

$$\beta_l = \begin{cases} 1, & L \geq L_e \\ \sin\frac{\pi L}{2L_e}, & L \geq L_e \end{cases}$$

$$\beta_g = f_c'^{-0.33}\left(E_f t_f\right)^{-0.88}\left(8.1 - 0.006h_g^2 + 0.1h_g + 0.04b_g\right)$$

Collection of Database

A total of 136 test results were extracted and are listed in Table.

Parameter	Range
FRP stiffness $E_f t_f$	12.9 - 78.2 kN/mm
FRP width b_f	30 - 60 mm
compressive strength of the concrete f_c'	22.7 - 48.2 MPa
groove height h_g	5 -15 mm
groove width b_g	5 - 10 mm

(Mostofinejad and Moghaddas, 2018)

Analysis of Systematic Dependency

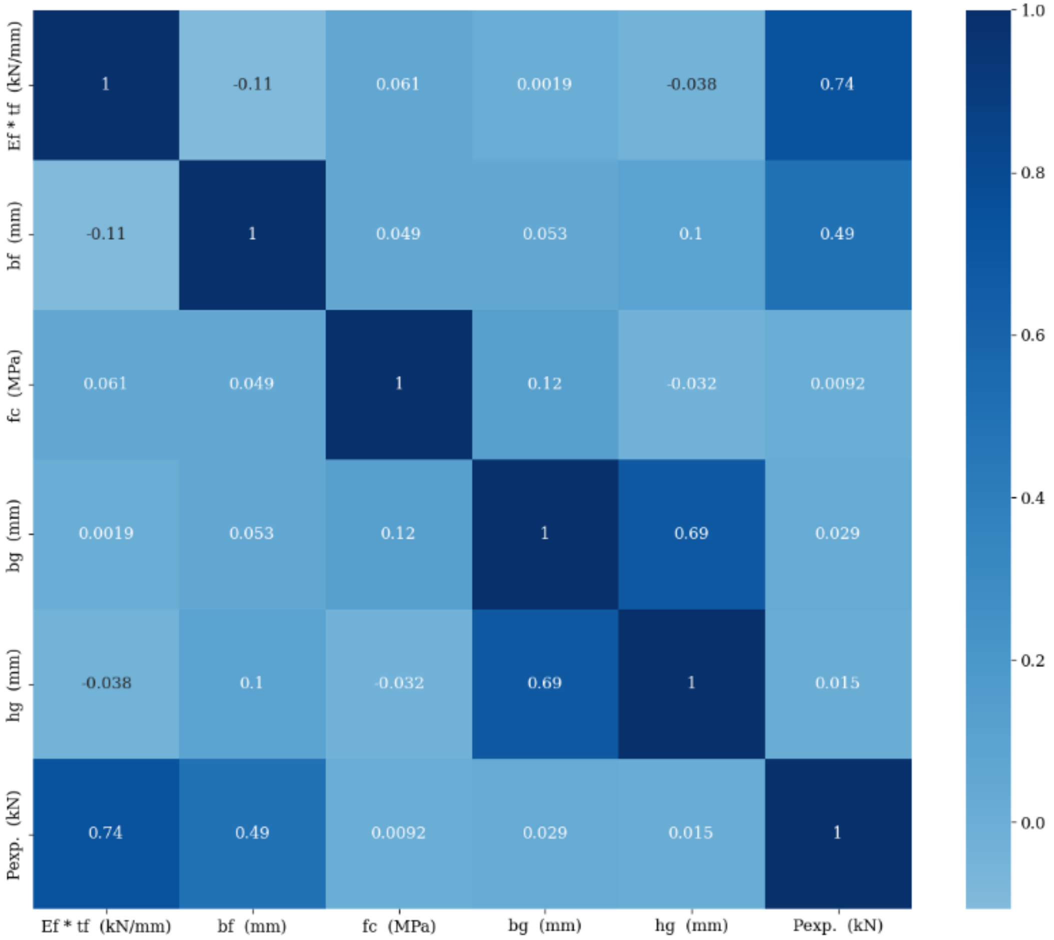
- Model factor ε, obtained directly from $P_u^m = \varepsilon P_u^c$, may not exhibit a random distribution. Instead, it may be strongly influenced by the input parameters.
- The model factor ε can be decomposed into a systematic part f and residual part ε^* which is a totally random value.

$$\varepsilon = f \cdot \varepsilon^*$$

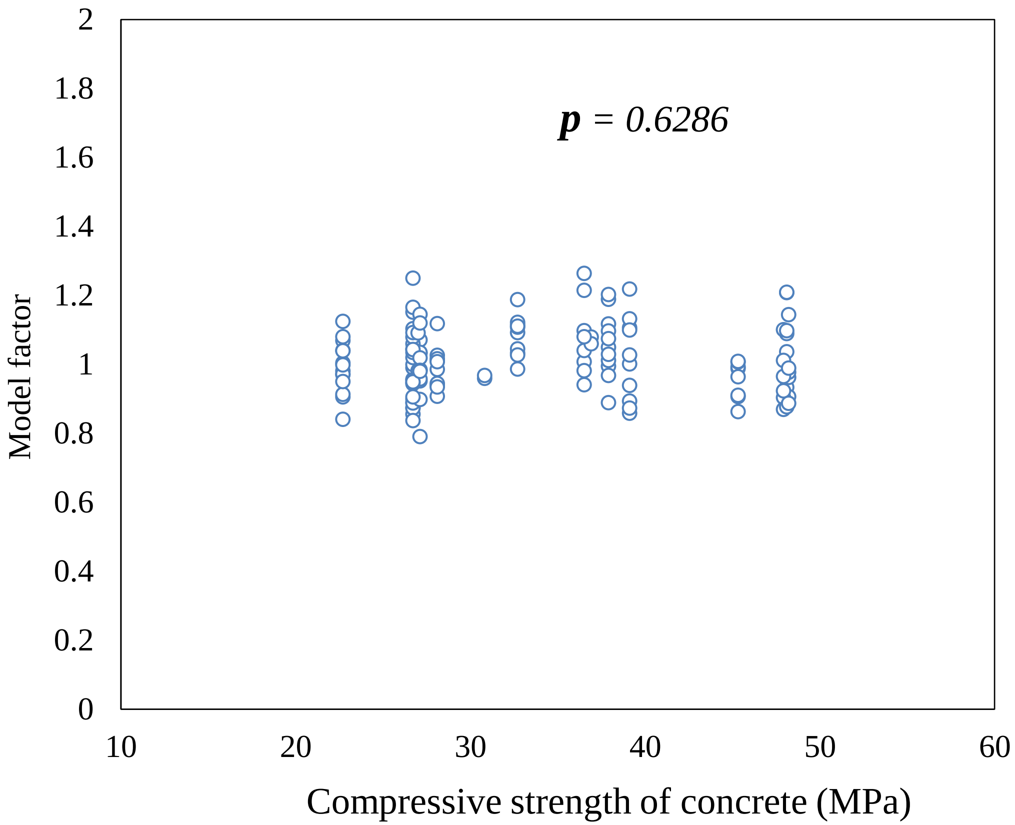
$$f = e^{A_0} \times e^{A_1/(E_f t_f)} \times e^{A_2/b_f} \times e^{A_3/f_c'} \times e^{A_4/b_g} \times e^{A_5/h_g}$$

$$\varepsilon = K_i m^{A_i}$$

Correlation

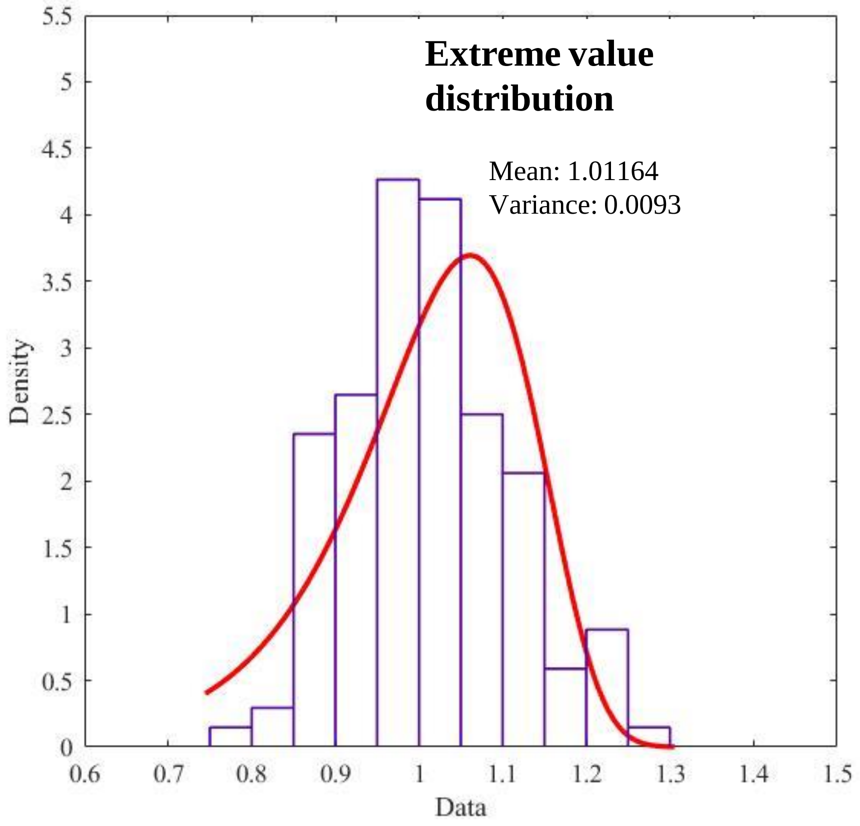


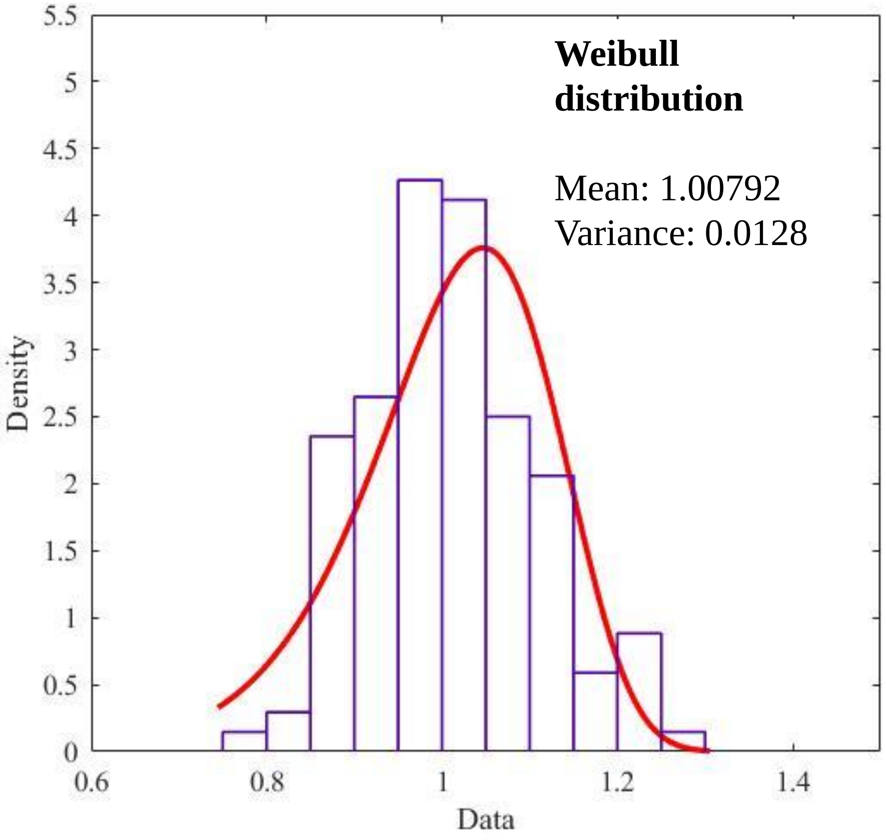
Heatmap between each input parameter and bond strength



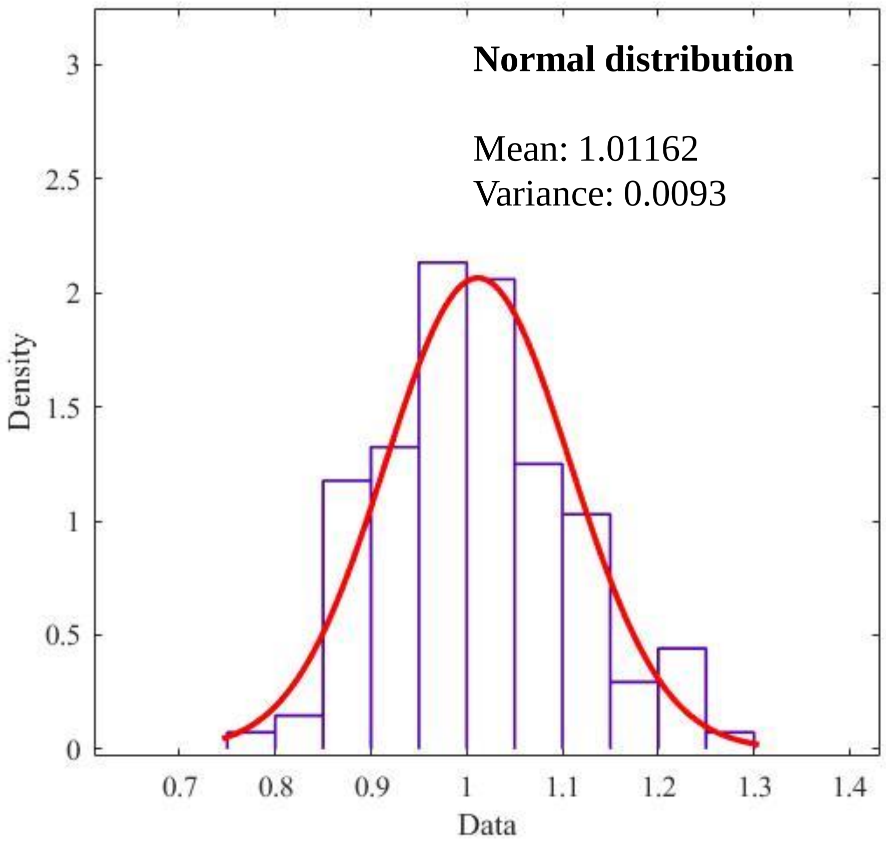
The model factor against compressive strength of concrete

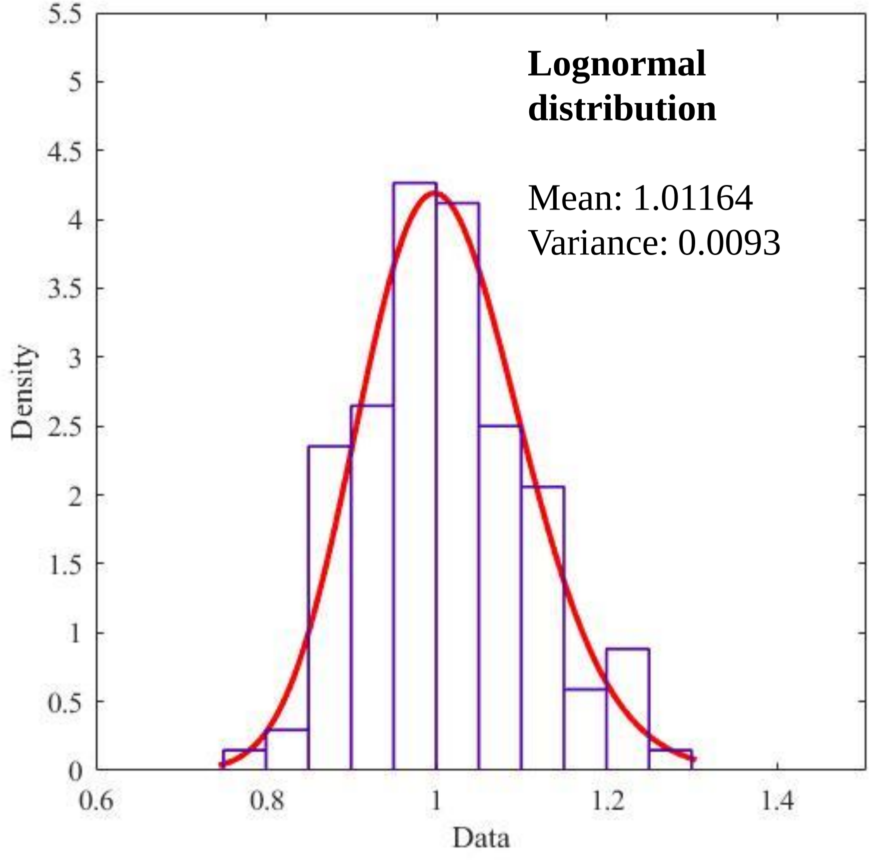
Determine Mean, COV, and Probability Distribution



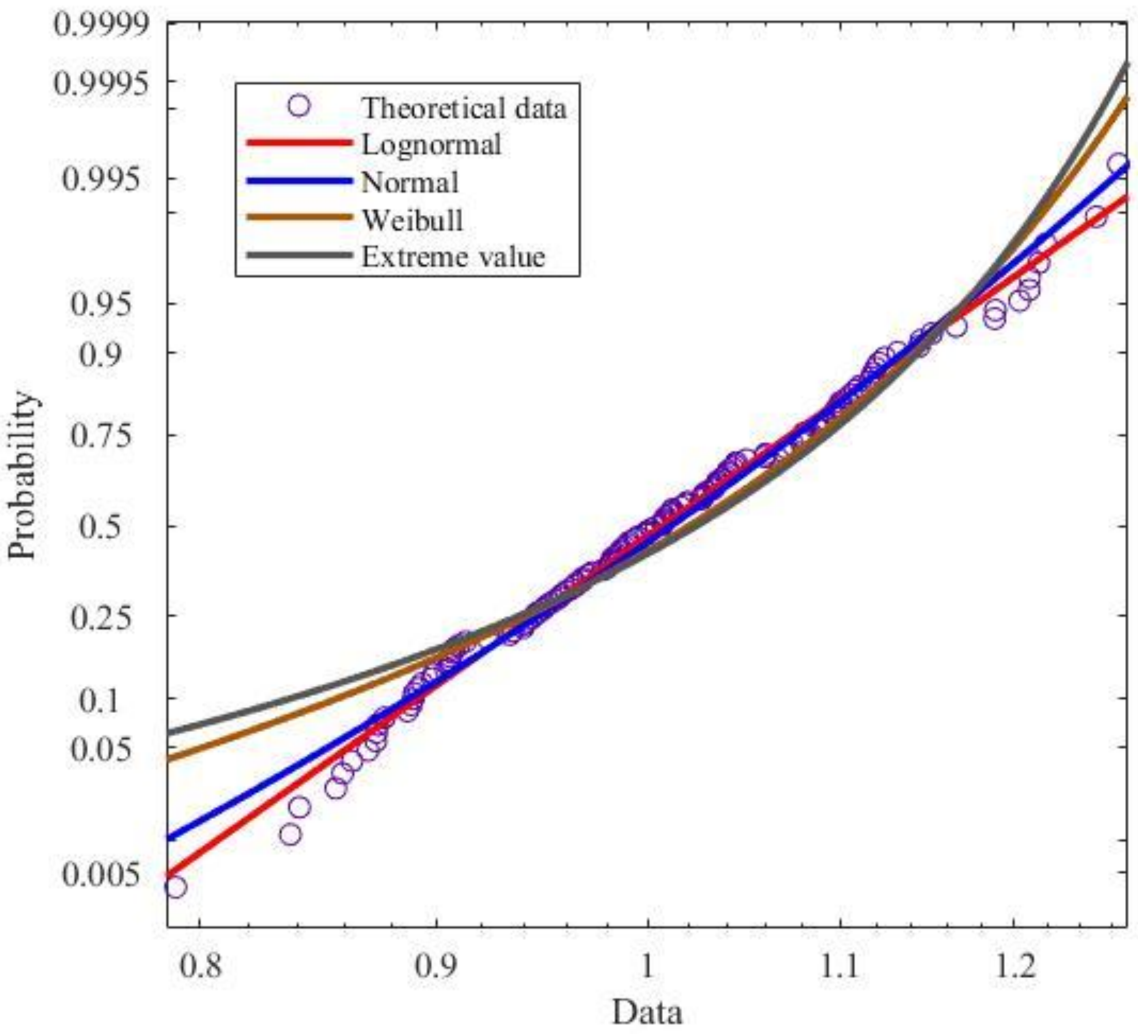


Determine Mean, COV, and Probability Distribution





Evaluate Each Candidate Distribution Function



quantile-quantile plot for all four selected distribution

Conclusion

- The model uncertainty of current prediction models for FRP-to-concrete joints using the grooving method was computed by incorporating the residual model factor: lognormal distribution, mean=1.01164, and variance=0.0093.
- This research offers a framework for analyzing the uncertainty associated with the model factor in reliability assessments for FRP repaired concrete with grooving method.
- Future work: Integrate the developed framework into reliability assessments for more widely topics of concrete repairs using FRP, bridging the gap between theoretical analysis and practical application.

Thank you!

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