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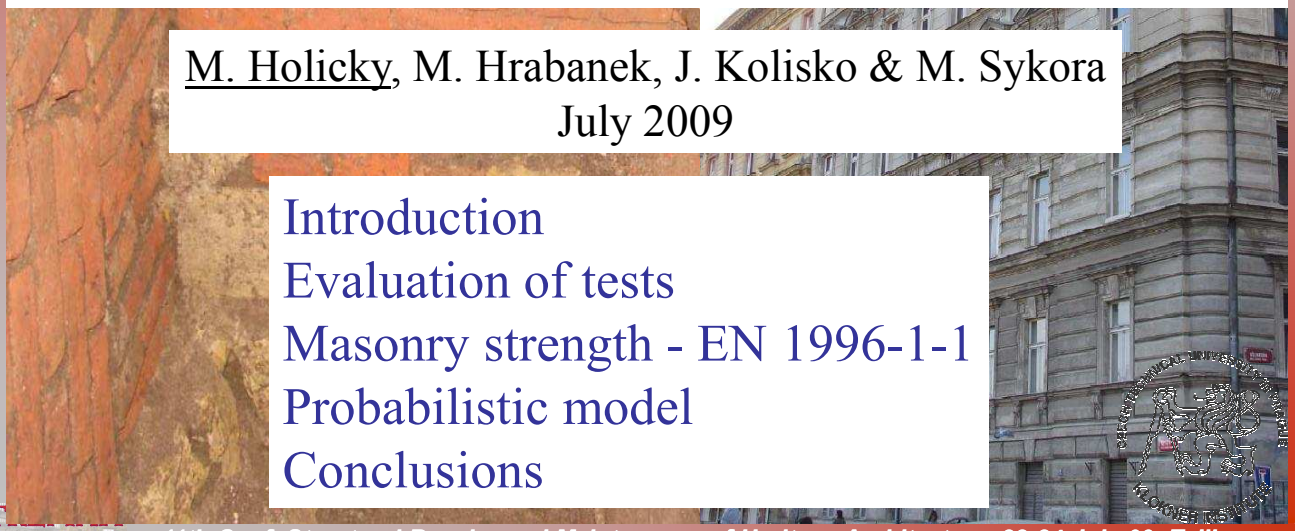
A/CZ0046/2/0013 ASSESSMENT OF HISTORICAL IMMOVABLES

Assessment of Masonry Strength in a Heritage Building



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Introduction

• ***Heritage structures*** are often affected by numerous ***environmental influences*** yielding deterioration.

• Decisions about interventions should be based on the ***complex assessment*** including input data on ***actual material properties***.

• Due to ***variability*** of historical masonry, information on mechanical properties is usually obtained from ***tests***.

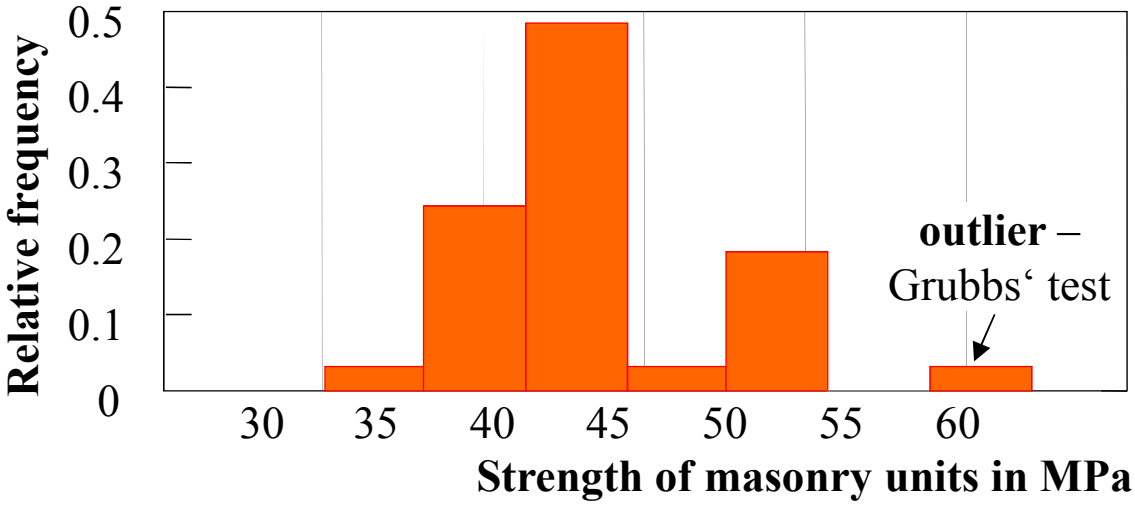
• ***Assessment of masonry strength*** from measurements is an important issue of the assessment of heritage structures.

• The ***present study*** is focused on:

- ***assessment of masonry strength*** of a structure built in the 19th century using the procedure provided in EN 1996-1-1,
- development of a ***probabilistic model*** for strength of a historical masonry.

Strength of masonry units

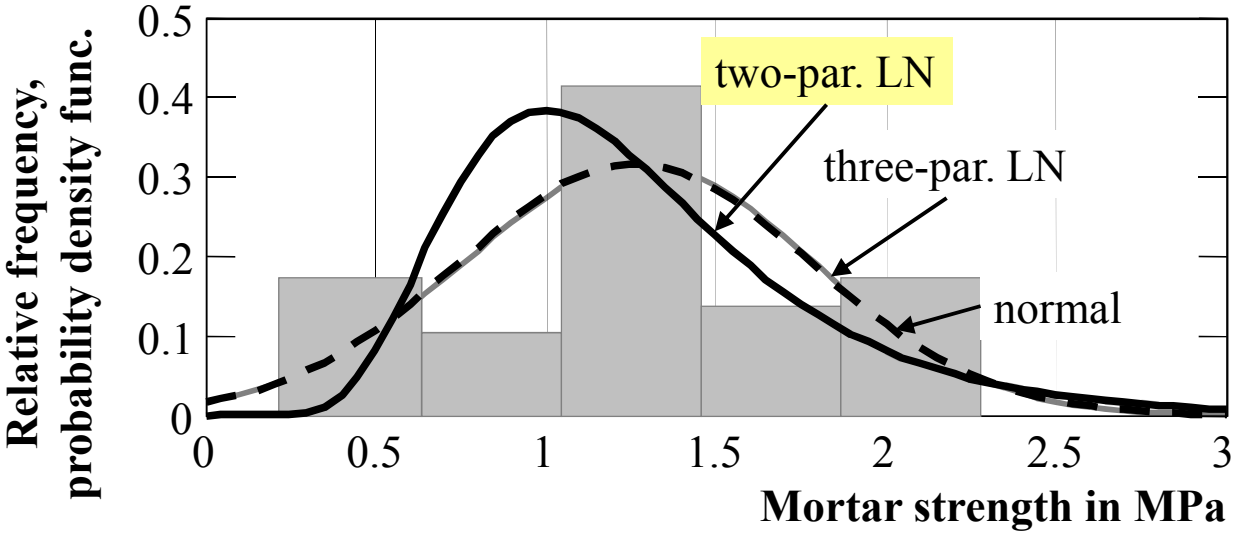
- Non-destructive tests made in 33 selected locations.
- ***Method of moments***: m = 43.1 MPa, v = 0.08, w = 0.15 (outlier)
- Goodness-of-fit tests: ***two-parameter lognormal*** distribution



- ***Conversion factor*** to determine normalised compressive strength
  - The mean value 0.45 from two measurements
  - The coefficient of variation 0.2 from previous experience.

Mortar strength

- Destructive tests rarely possible – ***non-destructive testing*** method based on relationship between hardness and strength
- 29 measurements
- ***Method of moments***: m = 1.26 MPa, v = 0.41, w = -0.06



- ***Conversion factor*** based on previous experience – the unit mean and coefficient of variation 0.2

Masonry strength according to EN 1996-1-1

• ***Model variable*** (units without holes): $K = 0.55$

• ***Characteristic compressive strength*** based on the mean values of strength of units and mortar and conversion factors:

$$f_k = K f_b^{0.7} f_m^{0.3} = K (\mu_{\eta b} \mu_{fb'})^{0.7} (\mu_{\eta m} \mu_{fm'})^{0.3} = 4.7 \text{ MPa}$$

• ***Design value*** of masonry strength derived using partial factor (γ_M estimated using EN recommendations by 2.5):

$$f_d = f_k / \gamma_M = 4.7/2.5 = 1.9 \text{ MPa}$$

• International council ICOMOS indicates that present standards are conservative and may lead to ***loss of cultural heritage values***.

Probabilistic model

• ***Probabilistic model*** - estimates of the characteristic and design values from ***test results*** and ***previous experience***

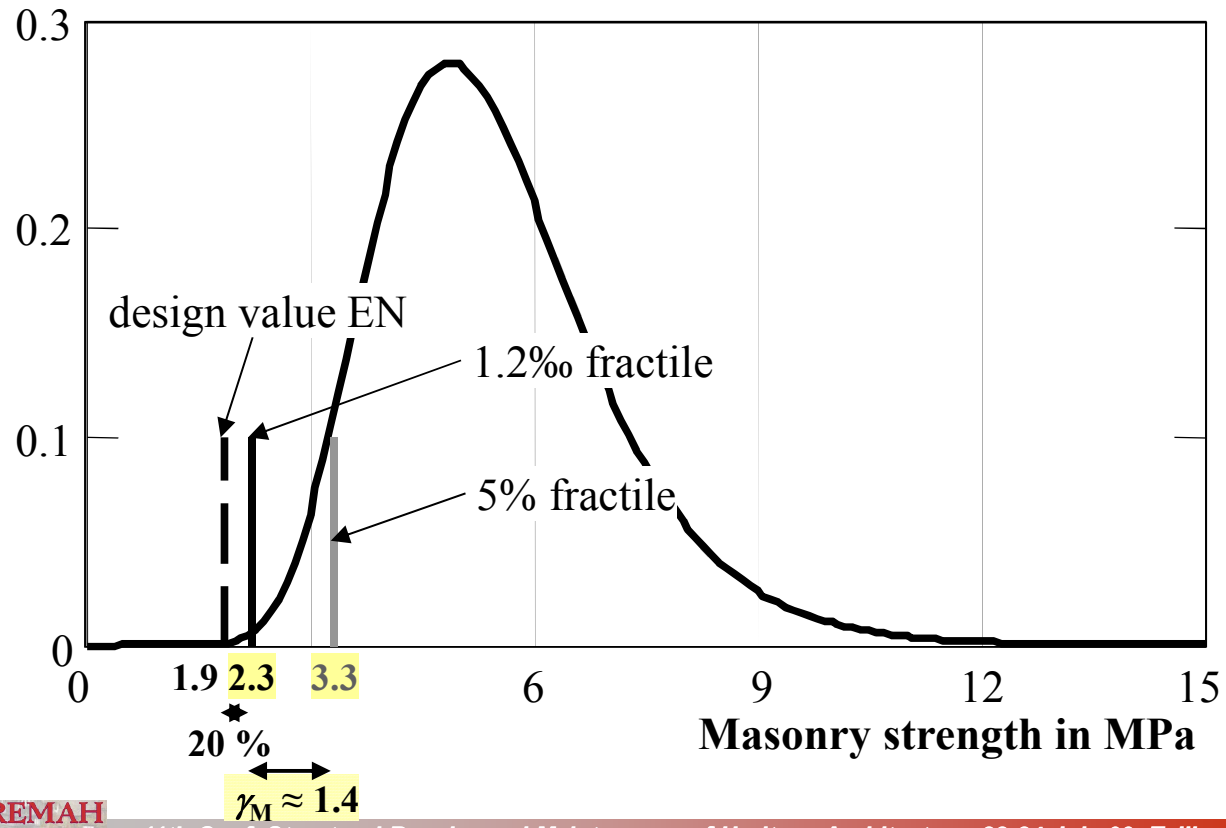
• Random ***compressive strength of masonry***:

$$f = K (\eta_b f_b')^{0.7} (\eta_m f_m')^{0.3}$$

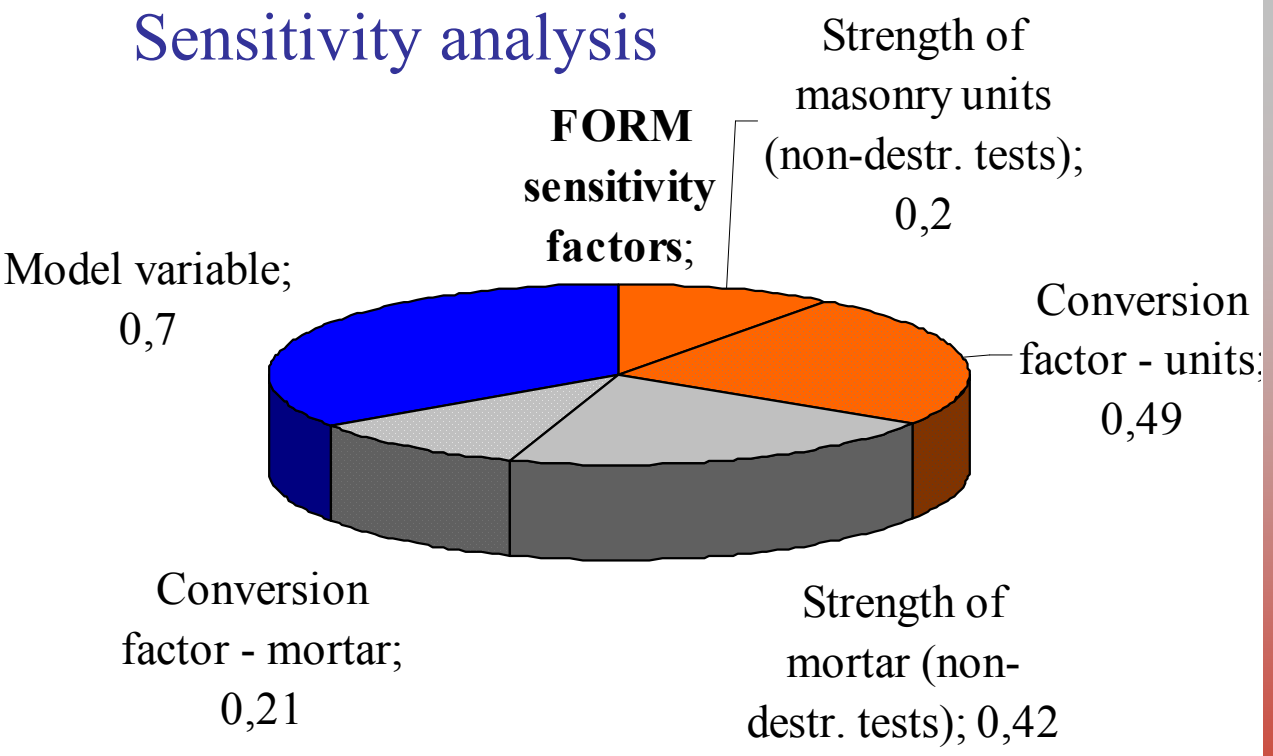
• ***Model variable K***: two-parameter lognormal distribution (mean ≈ 1.2-times value in EN 1996-1-1, coefficient of variation about 0.2)

• The ***strength of masonry*** described by a two-parameter lognormal distribution.

Probability density function of masonry strength



Sensitivity analysis



- ***Model variable K*** - the most influencing variable
- ***Improvements*** of the proposed model particularly by ***reducing variability*** of the model variable by experiments

Conclusions

• Due to inherent variability of historical masonry, information on its ***actual mechanical properties*** should be assessed using ***tests***.

• Samples should be verified by an appropriate ***test of outliers*** as extreme measurements significantly affect sample characteristics.

• Models for basic variables should be selected on the basis of ***statistical tests***, considering ***previous experience***.

• ***Lognormal distribution having the lower bound at the origin*** may be a suitable model for the masonry strength.

• The ***theoretical design value*** (1.2‰ fractile) is greater by about 20 % than the design value estimated according to EN 1996-1-1.

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Thank you for your attention.