Designing the ‘right’ mortar for the job

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Meera Ramesh, Ph.D.
Restoration Engineer
Ryan Biggs Clark Davis

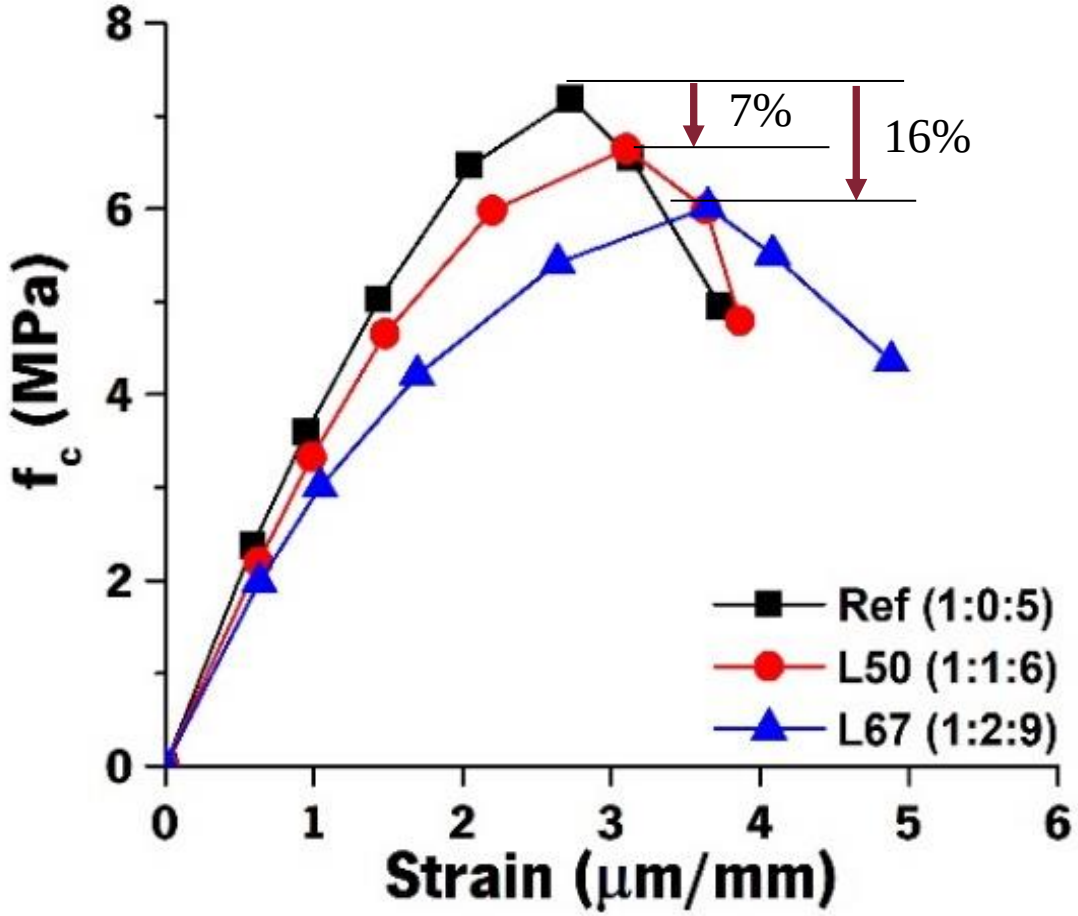
RYAN BIGGS CLARK DAVIS
ENGINEERING & SURVEYING

THE MASONRY SOCIETY

- How much does strength of mortar contribute to strength of masonry?

$$f_k = K\, f_b{}^{\alpha} f_m{}^{\beta}$$

- Value of β – 0.18 to 0.5
  Average – 0.3 (Eurocode 6)



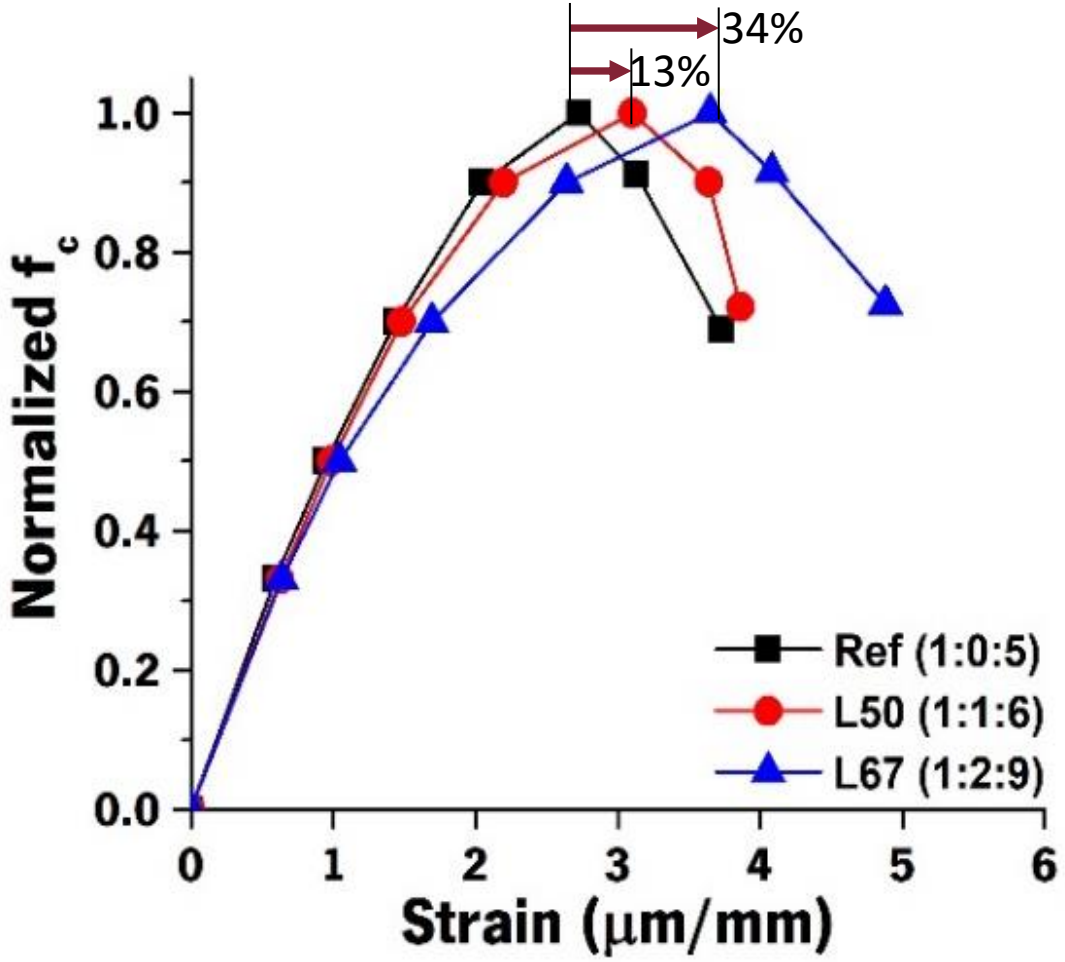
M. Ramesh, Ph.D. thesis, University of Minho

ASTM C-270

X1.6.3.2 Perhaps because of the previously noted confusion regarding mortar and concrete, the importance of compressive strength of mortar is overemphasized. Compressive strength should not be the sole criterion for mortar selection. Bond strength is generally more important, as is good workability and water retentivity, both of which are required for maximum bond. Flexural strength is also important because it measures the ability of a mortar to resist cracking. Often overlooked is

- How much does the ~~strength of mortar~~ contribute to deformability of masonry?

- How much does the type of mortar (binder) contribute to deformability of masonry?



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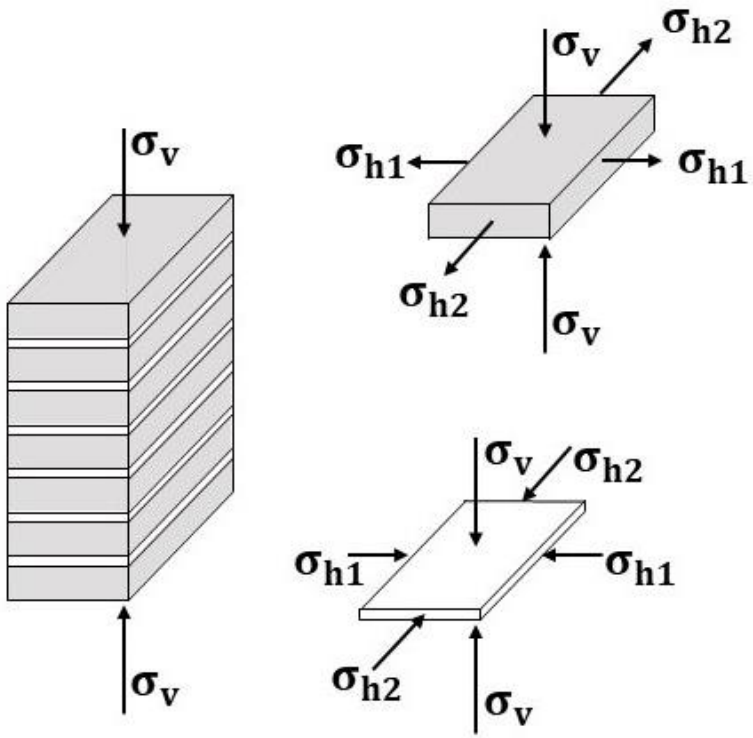
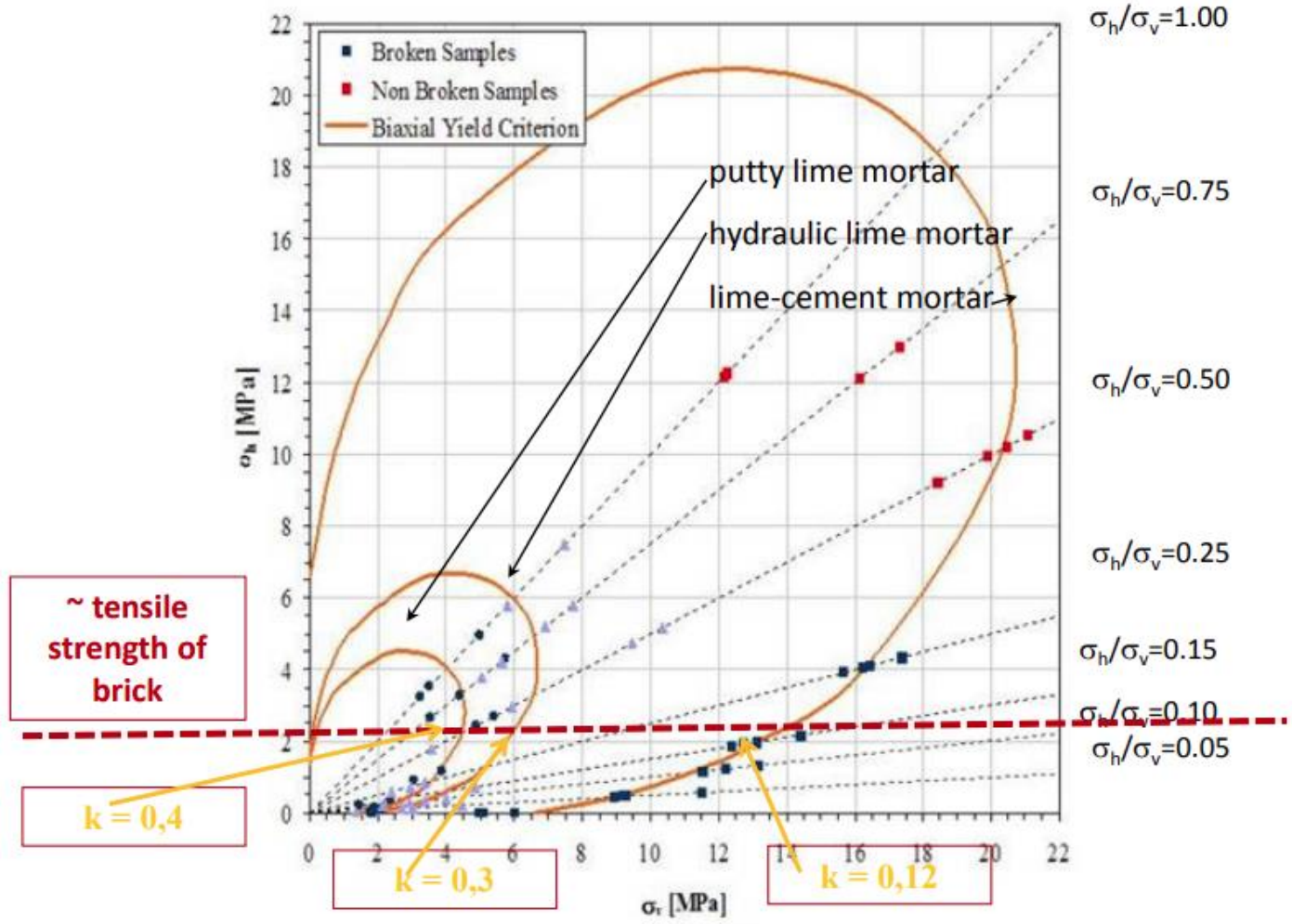


When unit is stiffer than the mortar



*R. Hayen, K. Van Balen & D. Van Gemert **

** The mechanical behaviour of mortars in triaxial compression, CIMNE, 2004*

ASTM C-270

Mortar	Type	Average Compressive Strength at 28 days, min, psi (MPa)
Cement-Lime	M	2500 (17.2)
	S	1800 (12.4)
	N	750 (5.2)
	O	350 (2.4)
Mortar Cement	M	2500 (17.2)
	S	1800 (12.4)
	N	750 (5.2)
	O	350 (2.4)
Masonry Cement	M	2500 (17.2)
	S	1800 (12.4)
	N	750 (5.2)
	O	350 (2.4)

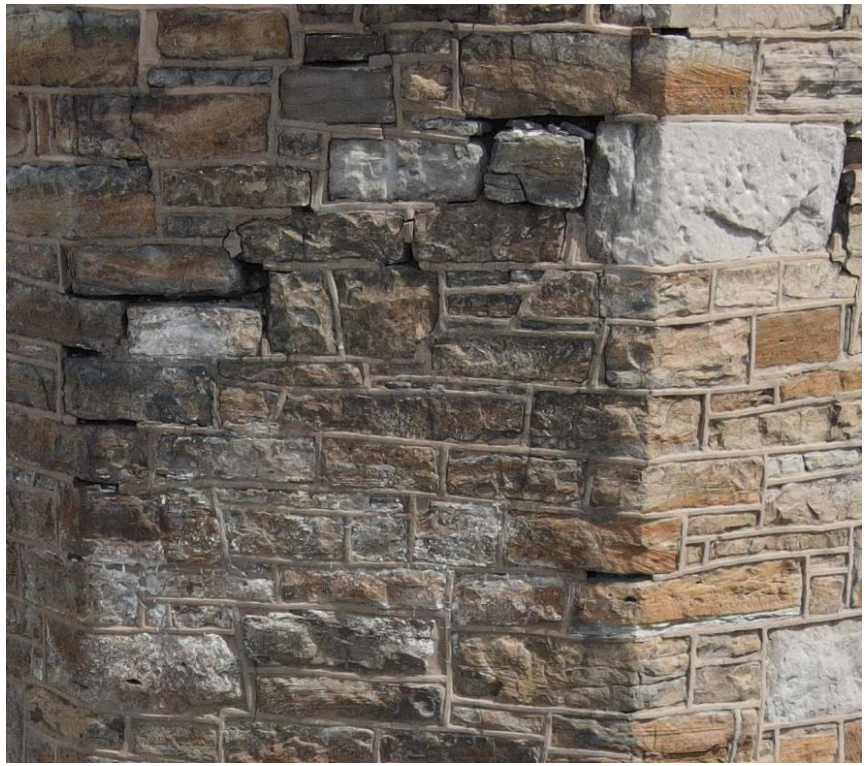
Most commonly recommended mixes in Europe – M2.5 & M5

Eurocode 6 – National Annexes

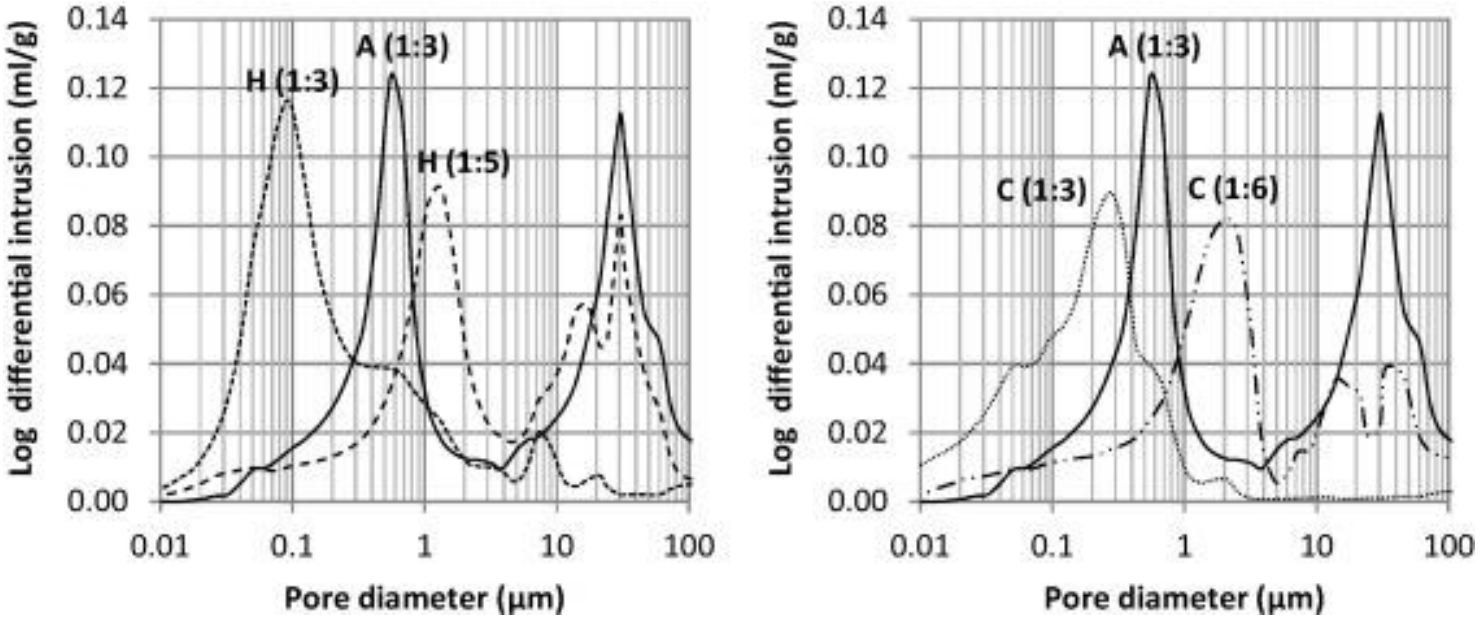
*C. Briceno, M. Azenha, P.B. Lourenco**

** Review of the national annexes of the current version of Eurocode 6 Part 1-1*

Incompatible mortars



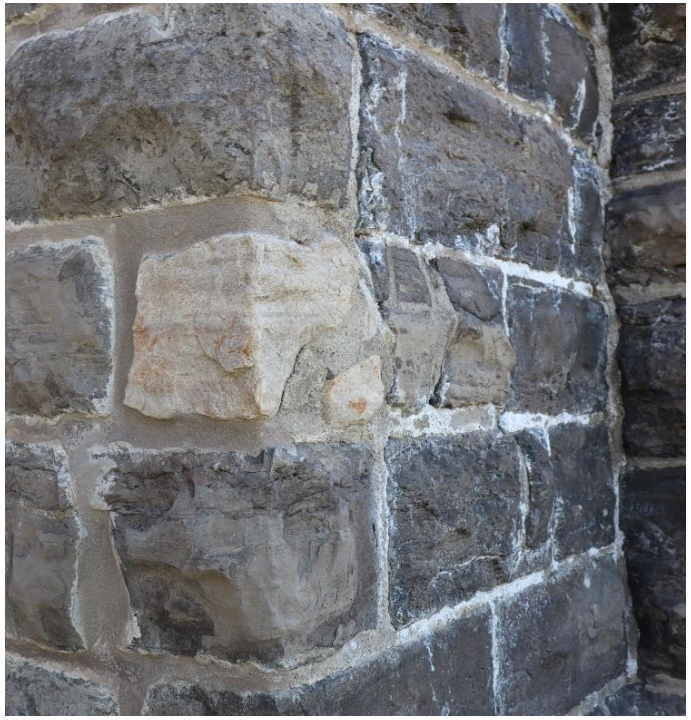
Impact of binder on pore size distribution



*B.A. Silva, A.P. Ferreira Pinto, A. Gomes**

** Natural hydraulic lime versus cement for blended lime mortars for restoration works*
2015, Construction and Building Materials, https://doi.org/10.1016/j.conbuildmat.2015.06.058

Efflorescence & breathability



Mortar design guidelines (I)

Prior to site visit:

- National Historic Register
- Existing information/documentation
    - Age of the building
    - Type of substrate
    - Information on previous renovations/repair work and timeline

Mortar design guidelines (II)

During site visit:

- Confirm and document type of substrate
- Document how mortar joints are tooled (affects appearance and function)
- Identify and document different layers of mortar/plaster - colors, locations
- Collect samples for either lab analysis or in-situ/office test

Mortar design guidelines (III)

Mortar design guidelines (IV)

Field hardness test based on Russack's method

Result of scratching the mortar	**Likely type of mortar**
Easily removable and can be crushed by hand	Type K / Type L
Easily scratched and removable from the joint	Type O
Easily scratched but NOT removable from the joint	Type N
Not easily scratchable	Type S

- *Originally developed by Tom Russack, masonry conservation practitioner, for bricks*
- *NPS, Preservation Brief 2 – Repointing mortar joints in historic masonry buildings*
- *Mohs test for mortars – David Biggs & Thomas Forsberg in the 9th Canadian Masonry Symposium*

Mortar design guidelines (V)

Following the site visit:

Type of binder based on age of building

Time period of construction	Binder type
Lime (Hydrated & Hydraulic)	1800 and earlier
Natural cements	1820 - 1910
Portland cement based	1872 (Domestic production began)
	1910 (Widespread use)

Mortar design guidelines (VI)

Following the site visit:

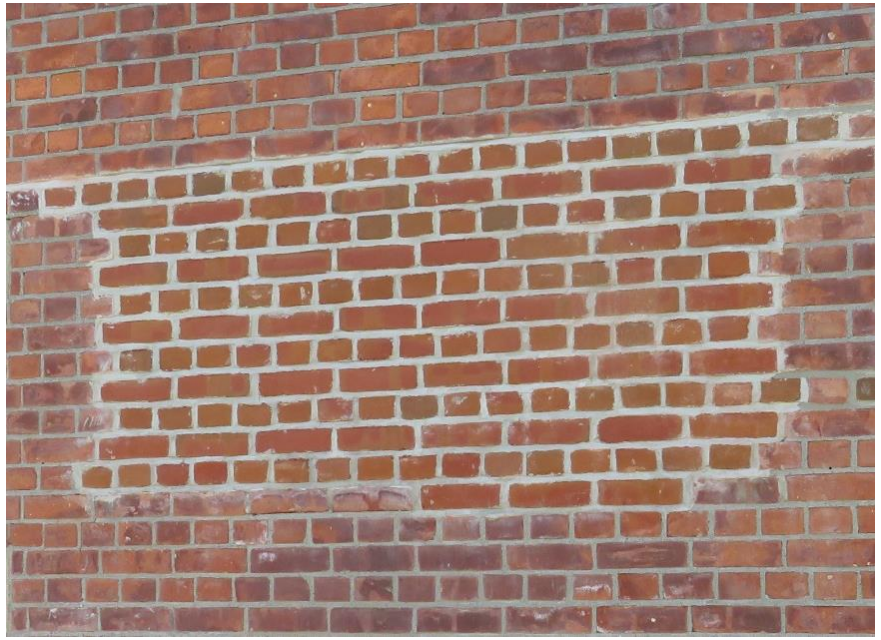
Mortar type based on substrate and intended exposure

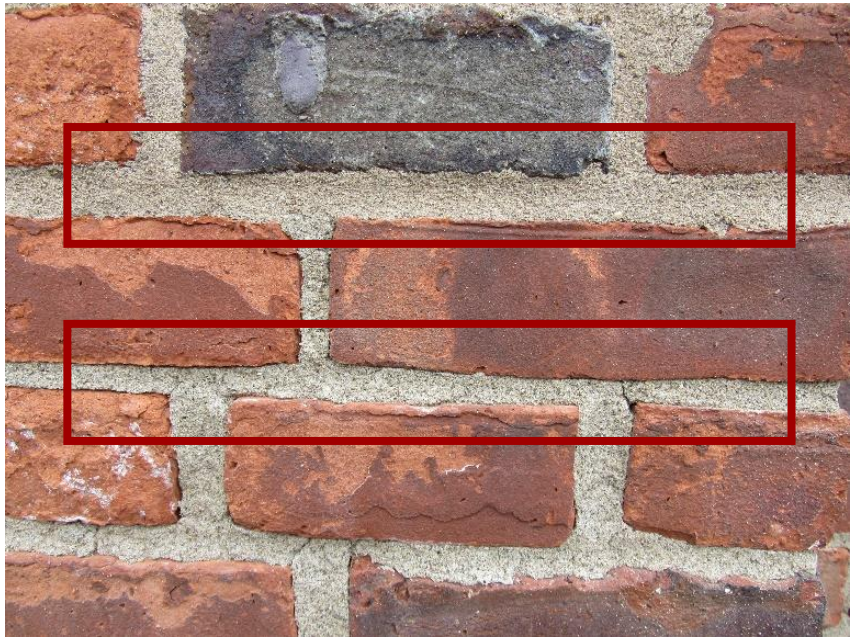
Masonry material	**Exposure**		
	Sheltered	**Moderate**	**Severe**
Very durable: granite, hard-cored brick, etc.	O	N	S
Moderately durable: limestone, durable stone, molded brick	K	O	N
Minimally durable: soft hand-made brick	“L”	K	O
Concrete blocks or CMU		N	S

NPS, Preservation Brief 2 – Repointing mortar joints in historic masonry buildings

Mortar design guidelines (VII)

Test panels for color match and durability:





Mortar design guidelines (VIII)

- Execution – Tooling
- Surface mottling – Construction evaluation, batch to batch uniformity, ASTM C 780

Conclusions

- No single mortar is the ‘right’ answer
- Optimization of any one property is usually at the cost of another – ASTM C270
- Field hardness tests - complementary information
- Rules of thumb
    a) New mortar must NOT be stronger than the existing mortar
    b) For older buildings (stone/brick), generally avoid mortar types M and S
- Repointing mortar is a sacrificial layer

Thank you

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