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Properties of Commercially Available, Ready-to-Use Mortars for the Restoration of Historic Renders and Masonry

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Abstract: There is a wide range of premixed, dry mortars, on the market, designed with the reconstruction of historic renders and masonry in mind. The use of such materials has some advantages, including good workability and standard quality, however, due to unknown composition, being a secret of a manufacturer, it is frequently impossible to predict their influence on the substrate and on the ageing. If the ready-to-use mortar is to be applied during the renovation of the historic masonry, it is necessary to know: how close the mortars' properties match the properties of the original material; will the repair be durable enough and will it degrade faster than the original material. Technical information, provided by the manufacturer, does not contain such data. The only parameters given, are the strength, porosity of hardened mortar and water vapour diffusion coefficient, however, it is not specified in which conditions these values were measured.

Within the project "Conditions and requirements of compatible care of the historical inorganic porous materials" the authors work on the development of a list of most important, so called critical properties of the mortars, that significantly affect the durability of the repair and as such must be followed in terms of the material compatibility. These properties can be divided into three different groups: a) properties related to the pore system, influencing the water and water vapour transport throughout the porous material, b) mechanical resistance and adhesion to the original substrate, c) response to the temperature variations.

In this study, we compare the key properties of six commercially available mortars, the compositions of which, according to what manufacturers claim, meet the demands of cultural heritage protection; some of them even comply with the WTA requirements. The following mortars were tested:

- WE – porous, air lime-based mortar, without cement, designed to render humid masonry, composed of stone or brick
- CE – mortar with the binder based on lime and pozzolana, without cement. Mortar is to be applied manually in the interior or exterior.
- EX – mortar belonging to CS II group (according to DIN EN 998 – 1), containing special admixtures, creating specific pore geometry
- BA – hydrophobic, porous, lime-trass render, with high water vapour permeability, for manual application
- RE – contains lime and trass, to be used as joint mortar. In a hardened state it has improved resistance against sulphates, low susceptibility to cracks formation and frost-mediated damage
- MA – mortar based on lime, eco-pozzolana and synthetic fibers, designed for structures made of natural stone, bricks or tuff

The size of samples was chosen to match the real thickness of the renders. Thus, the mechanical properties (flexural and compressive strength, Young modulus) and humidity transport-related properties (water accessible porosity and capillary absorption coefficient) were measured using 20x20x100mm samples. Water vapour permeability was measured using 12x70 round samples and the thermal expansion was measured on cylinders, 12x20mm. Samples of each mortar were prepared according to the guidelines provided by the manufacturer. The results obtained are shown in Table 1.

First of all, one can observe significant differences in mechanical properties of particular mortars. Together with mixing water content, that can vary slightly, within the range given by the manufacturer, this allows for adjustment of the render according to the strength of the substrate. Interestingly, it was found, that hydrophobic mortar, though slowly, still absorbs water. EX mortar, having relatively high porosity and low strength, is characterised by surprisingly low permeability. Such a combination of properties is rather disadvantageous. In contrast to this, BA mortar has similar strength, even higher porosity and very good permeability of water vapour. As regards higher strength renders, one would obviously choose MA, as it has low water absorption coefficient, relatively high water vapour permeability and favourable relation between strength and Young modulus. In conclusion, based on our experience and on the literature, we suggest to follow several simple rules:

- In the environment where frost can damage the object, stronger mortar is better than the weaker one, however it cannot be of higher strength than the substrate.
- The thermal expansion of the render should be similar to thermal expansion of the substrate, especially on the south and west façades.
- As water is always undesired in the masonry and even the hydrophobic render does absorb some water, porous renders with high pore size should be used where possible.

Table 1: The key properties of six commercially available mortars.

Mortar	Flexural strength (ČSN EN 12372) [MPa]	Compressive strength (ČSN EN 1926) [MPa]	Young's modulus (ČSN EN 14580) [GPa]	Porosity accesible to water (RILEM Test No.I.2. 1989) [vol. %]	Capillary absorption coeficient (ČSN 1925) [$kg.m^{-2}.hod^{-0,5}$]	Dry cup diffusion factor coefficient (ČSN EN ISO 12572) 0/33 μ [-]	Thermal expansion coefficient in tempereture range -20 +80°C [$\times 10^{-6}$ K^{-1}]
WE	4,5 ±0,4	9,0 ±0,7	2,3 ±0,6	29,0 ±0,3	4,0 ±0,1	22,2 ±2,0	between 5 and 6
MA	6,1 ±1,0	13,6 ±1,0	1,7 ±0,2	28,4 ±0,3	1,8 ±0,1	25,3 ±1,7	between 1 and 9
RE	6,1 ±0,7	10,8 ±0,7	2,2 ±0,4	29,9 ±1,0	3,8 ±0,2	26,4 ±1,2	between 7 and 19
BA	1,2 ±0,4	1,5 ±0,2	1,3 ±0,2	56,6 ±0,2	2,4 ±0,2	13,6 ±0,4	between -6 and 19
EX	1,2 ±0,1	2,0 ±0,2	2,9 ±1,0	46,9 ±0,6	4,2 ±0,3	12,7 ±1,0	between 0 and 19
CE	1,0 ± 0,2	1,6 ±0,2	1,6 ±0,4	31,6 ±0,6	5,3 ±0,6	16,0 ±0,5	between 5 and 23

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