IMPACT OF CHEMICAL INJECTION METHOD ON DISPERSION OF INJECTED AGENTS IN MASONRY

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Summary

Chemical injection of masonry is a very widely-used method for providing supplementary water-proofing of historic masonry. Like all branches of the construction industry, chemical injection of masonry is under pressure to achieve greater performance and speed together with maximum efficiency. Current norms and standards permit both pressure injection and non-pressure injection. Are these methods comparable in efficiency, or should we expect differing effects? A pilot experiment on model masonry pillars has been carried out at the Klokner Institute. This paper summarises the results of our experiments.

Key words: borehole, brick pillars, efficiency of injection, non-pressure injection, pressure injection

1 Introduction

Chemical injection of masonry is widely-used in the construction industry nowadays to provide water-proofing of masonry. This method is most commonly utilized for rehabilitating historic buildings, but it is also used for local reconstruction of new buildings. This method is relatively expensive in terms of materials and is labour-intensive. It is also relatively complicated and time-consuming. It is always necessary to make efforts to reduce costs. The logical option is to seek a less labour-intensive approach, to inject for a shorter period of time, using pressure injection.

This paper compares the efficiency and performance of pressure injection and non-pressure injection.

2 Aim of the experiments

Pilot injection tests were performed at the Klokner Institute. The tests were performed on two masonry pillars, using the pressure injection method and the non-pressure injection method with a hydrophobic solution based on potassium salts of methylsilikates. The aim of the tests was to provide a reference comparison of the dispersion of the injection solution in a masonry structure.

Attention was focused on the dispersion of the solution in the glost ware of the bricks near to the injection borehole. The tests should provide answers to the following questions.

Does the solution disperse into the brick structure?

Is it possible to determine the injection efficiency of brick glost ware by comparing the water absorption before and after injection?

Are there differences in efficiency between pressure injection and non-pressure injection?

3 Experiment methodology

3.1 Experiments on bricks

Before the masonry pillars were injected, basic tests were carried out on the bricks that were used. A summary of the properties is presented in Tab. 1.

Tab. 1 *Basic average properties of the tested bricks*

Properties Of The Bricks			
Density		1752	[kg/m^3]
Moisture absorption capacity, by weight		18.9	[% weight]
Moisture absorption capacity, by volume		33.11	[% volume]
Bending strength	normal	1.96	[MPa]
	saturated	1.39	[MPa]
	dried	1.72	[MPa]
Destructive compressive strength	normal	11.77	[MPa]
	saturated	10.64	[MPa]
	dried	13.96	[MPa]

3.2 Injection of masonry pillars

In both cases, the injection was performed in accordance with WTA regulation 4-4-04/D and in accordance with the technological regulations provided by the producer of the injection solution. The basic characteristics are presented in Tab. 2. Before injection, the surfaces of the pillars were insulated and were then left to dry thoroughly.

Tab. 2 *Basic characteristics of injection application*

Mark of borehole	**Average of borehole** [mm]	**Inclination of borehole** [°]	**Axis distance between boreholes** [mm]	**Injection pressure** [bar]	**Amount of injection solution** [l/m^2]
Pressure injection 1–7	20.0	30.0	120.0	2.0	20.0
Non-pressure injection 1–6					

3.3 Division of the segments

After injection, the brick pillars were divided into segments, which were then tested from the point of view of water absorption.

Each segment of rows D and J was divided into groups to represent a particular part of the brick glost ware according to its distance from the injection borehole. The average water absorption values were calculated for each group, and the values were analysed. Three bricks were taken from each row and evaluated for rows A-M, and 15 samples were evaluated in the analysis of local areas between the injection boreholes, for the pressure method and for the non-pressure method.

3.4 Water absorption tests

Dried segments were measured and weighed, and were then submerged in water for a period of 5 days and were left in this state to can absorb water. When they were removed from the container, they were submitted to gravimetric analysis and the water absorption was determined.

Water absorption is the ratio of the open pores absorbed water weight to the weight of a dried sample into constant weight.

4 Results of the experiment

The water absorption values were averaged and entered into the tables shown below. Tab. 3 shows the average water absorption values for each row (A–G for non-pressure injection, and H–M for pressure injection).

Tab. 3 *Average analysed water absorption for each row*

Mark of row of non-pressure / pressure injection	**Average maximum of water absorption of used bricks**	**Average maximum of water absorption [% weight]**		**Average rate of saturation [%]**		**Reduction of saturation rate (injection efficiency) [%]**	
	before injection	after injection		after injection		after injection	
	[% weight]	non-pressure injection	pressure injection	non-pressure injection	pressure injection	non-pressure injection	pressure injection
A/H		15.5	13.9	81.9	73.4	18.1	26.6
B/CH		18.8	15,6	99.7	82.7	0.3	17.3
C/I		3.3	9.1	17.4	48.1	82.6	51.9
D/J	18,9	5.6	9.7	29.6	51.3	70.4	48.7
E/K		9,.2	14.7	48.4	77.7	51.6	22.3
F/L		12.9	15.5	68.2	81.8	31.8	18.2
G/M		15.2	15.9	80.4	84.4	19.6	15.6
Average						**39.2**	**28.7**

Tab. 3 shows the average water absorption values for segments from row D (non-pressure injection) and row J (pressure injection), divided into groups according to distance from the injection borehole.

Tab. 4 Average analysed water absorption for each segment

Localization of segments	**Average maximum of water absorption of used bricks**	**Average maximum of water absorption [% weight]**		**Average rate of saturation [%]**		**Reduction of saturation rate (injection efficiency) [%]**	
	after injection	after injection		after injection		after injection	
	[% weight]	non-pressure injection	pressure injection	non-pressure injection	pressure injection	non-pressure injection	pressure injection
Distance from borehole: 0–20 mm	18.9	4.7	6.3	25.0	33.3	75.0	66.7
Distance from borehole: 20–50 mm		5.3	8.5	28.0	45.0	72.0	55.0
in axis distance between boreholes		6.3	8.2	33.3	43.4	66.7	56.6

The average water absorption values for the three reference bricks that were saturated by the injection solution are shown in Tab. 4. The longer sides of the bricks were immersed into the solution to a depth of 20 mm for 3 hours.

Tab. 5 Average water absorption of reference bricks saturated in the injection solution

Number of brick	**Average maximum of water absorption of used bricks after absorption of injection solution**	**Average maximum of water absorption of used bricks after absorption of injection solution**	**Average rate of saturation**	**Reduction of saturation rate (efficiency of injection solution)**
	[% weight]	[% weight]	[%]	[%]
1	18.9	2.3	12.2	87.8
2		2.14	11.3	88.7
3		2.14	11.3	88.7
Average				**88.4**

On the basis of our experiments and the water absorption values for the tested samples, we can state that:

- The average injection efficiency (reduction in saturation rate) for bricks from all rows of brick pillars with non-pressure injection was 39.2 % with range of values 0.3–82.6 %, as the case may be 28,7 %, with values ranging between 17.3–51.9 %,
- The average efficiency of the injection solution absorbed into the bricks when they were immersed was 88,4 %, with values ranging between 87.8–88.7 %,
- The average efficiency of non-pressure injection in the borehole was 75 %, and the average efficiency of pressure injection in the part from borehole was 66.7 %,
- The average efficiency of non-pressure injection at a distance of 20–50 mm from the injection borehole was 72 %, and the average efficiency of pressure injection at a distance of 20–50 mm from the injection borehole was 55 %,

- The average efficiency of non-pressure injection in the axis distance between the injection boreholes was 66.7 %. The average efficiency of pressure injection in the axis distance between the injection boreholes was 56.6 %.

5 Conclusion

On the basis of our experiments, we can state that injecting brick pillars according to the methodology presented in section 2 by filling injection boreholes with a hydrophobic solution based on potassium salts of methylsilikates ensured that the injection solution was absorbed into the pore structure of the bricks. The experiments proved that there were noticeable differences in water absorption in segments of brick glost wares before and after injection. This method can therefore be applied for determining injection efficiencies. Injection efficiency can be defined as the reduction in the water absorption rate of brick glost ware, i.e. the reduction in the ratio of partial and maximum water absorption. Our experiments have shown that the efficiency in the borehole axis for the surroundings studied here range between 55–75 %. The experiments also showed that non-pressure injection achieves higher efficiency than pressure injection. When the injection solution was absorbed to a height of 20 mm, the injection solution efficiency was about 88 %.

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References

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[2] Czech Technical Standard P 73 0606 Structure waterproofing – Coating waterproofing

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[4] Regulation WTA 4-4-04/D: Injection of masonry against capillary moisture

[5] Regulation WTA 4-4-96/D: Injection of masonry against capillary moisture

[6] (Czech Technical Standard 72 2603 – Testing of brick products. Determination of weight, specific weight and absorbed water