EXTENT OF SALINITY MOVEMENT IN MULTIPLE AND SINGLE BRICK SAMPLES

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ABSTRACT

Brick structures in coastal areas are directly affected by the rise of ground water table containing high salinity due to climate change and as a result salinity movement occurs from bottom of the brick structures to top levels. The salinity movement causes the salts to be transported in the brick structures and causes considerable damage. This study investigates the salinity movement in long and short brick samples. The 20 brick samples of cross section 5cmx5cm with full brick length were prepared for experiment. Multiple brick sample contains three full brick placed vertically. Fourteen single brick sample contain one full brick placed vertically. The brick sample was protected by wax in specific outer faces and other faces were kept wax free for the evaporation of water. The samples of setup were kept into containers in vertically as the saline water of specific concentrations injects then the water absorbs through the base of the brick specimens and the salts ions were also transported to fill up bricks inner voids with salt crystals after evaporation. At the end of the run the salinity brick specimen was found out in the laboratory for each specimen at three different heights. The results shows, (i) Normal clay brick always evaporate more water than machine made brick. (ii) The salinity movement in almost all the specimens occurred from base portion to top and the salts accumulated more in the bottom part in most of the cases for the particular type of opening.

Keywords: *Multiple brick setup, single brick sample, salt water, salinity movement.*

1. INTRODUCTION

Brick structures in coastal areas are directly affected by the rise of ground water table containing high salinity due to climate change and as a result salinity movement occurs from bottom of the brick structures to top levels. The salinity movement causes the salts to be transported in the brick structures and causes considerable damage. Salinity movement is the movement of salts through porous masonry materials like bricks, stones, concrete etc through the moisture absorption of those materials. The salts are dissolved in the water absorbed by the materials and forms salt crystals inside the pores after evaporation. The salinity movement in bricks is a natural phenomenon caused by the moisture absorption in the brick pores. The moisture could be absorbed by the brick from outside environmental sources such as soil moisture, very humid weather and water bodies near the bricks. Salts like sodium chloride remain in dissolved ionic form in the water and when this water is absorbed by masonry materials such as bricks the salt ions are transferred to the brick internal structure and accumulates into salt crystals after evaporation (Suchorab and Widomski 2011). This leads to cause damages such as discoloration, efflorescence (McBurney and Parsons 1937), reduction in strength, durability, service life of load bearing walls, partition wall and fractures occurs. Goncalves et.al (2007) reported that salt aggravates dampness in masonry which was observed by monitoring the drying of masonry bricks specimens by means of magnetic resonance imaging technique. Ahl (2003) measured the rate of diffusion of salt in ceramic brick materials and it is seen that the diffusion contributes to the transport of salt ions in the brick structures.

Previous researches show different techniques and experiment in removing the salinity in brick clay (Sobuz et.al 2010) and masonry. Bakar et.al (2009) conducted an experiment over durability of fired clay brick masonry wall due to salt attack. They mentioned that masonry structures, when subjected to salt attack or exposed to aggressive environment during their service life may suffer degradation due to the formation of crystallization pressure as a result of the evaporation of soluble salt in clay masonry structures. Young (2008) conducted an experiment over salt attack and rising damp and found that rising damp is caused by capillary suction of the fine pores or voids that occur in all masonry materials. The deterioration of bricks caused by salt movement in the brick pores (Phillips and Zsembery 1982) has been an important issue in the recent time. Ibrahim et.al (2011) considered the attack of soluble salt is serious due to causing change and damage on masonry walls as composite materials .This kind of changes are strongly depends on the water level rise due to consequences of climate change and causes all the problems as described above. It is still important to know the amount of salt accumulation in bricks as the accumulated salt creates the long term problem (Kruschwitz 2007). Therefore, it is worthy to know the extent of salinity movement in the brick structures due to salt water intrusion as the consequence of climate change.

2. METHODOLOGY

The works include collection of bricks, preparation of bricks into specific specimen sizes according to experimental program, application of wax on the specific faces of specimens, setup of specimens in specific containers, injection of saline water into the containers, undoing of experimental samples from setups and determination of salinity of the brick specimens. Total 20 brick specimen was prepared according to the experimental program as shown in Table 1. The bricks chosen were of standard sizes and in good shape. Machine made brick and Normal fire clay brick were collected for specific setup as shown in Table 1.

Table 1: Experimental Program. Machine B = Machine made brick; NF B = Normal fired clay brick; S = single brick sample; MultiN = Multiple normal brick sample.

Ssample Identification	Brick Type	Setup Type	Concentration of saline water in mg/L	Dry Weight in gm	Time in Days
M0A	Machine B	S	0	1532	84
M0B	Machine B	S	0	1745	84
M0C	Machine B	S	0	1572	84
N0A	NF B	S	0	1324	50
N0B	NF B	S	0	1302	50
N0C	NF B	S	0	1373	50
M10A	Machine B	S	10000	1698	90
M10B	Machine B	S	10000	1576	90
M10C	Machine B	S	10000	1639	90
M35A	Machine B	S	35000	1630	84
M35B	Machine B	S	35000	1660	84
M35C	Machine B	S	35000	1628	84
N35A	NF B	S	35000	1452	56
N35B	NF B	S	35000	1292	56
MultiN10B	NF B Multi Bottom	Multi	10000	1259	90
MultiN10M	NF B Multi Middle	Multi	10000	1356	90
MultiN10T	NF B Multi Top	Multi	10000	1297	90
MultiN35B	NF B Multi Bottom	Multi	35000	1354	90
MultiN35M	NF B Multi Middle	Multi	35000	1348	90
MultiN35T	NF B Multi Top	Multi	35000	1435	90

This study investigates the salinity movement in multiple and single brick sample. The 20 brick samples of cross section 5cmx5cm with full brick length were prepared for experiment as shown in Figure 1a. Two setups were performed with multiple bricks. Each of this setup contains three full brick placed vertically in plastic containers into the square opening in container lids as shown in Figure 1b. Wax were applied on all four sides of bottom two brick sample to prevent evaporation from them and the top one was wax free to allow evaporation from all faces.

Fourteen single brick setup contain one full brick placed vertically in plastic containers. The brick sample was protected by wax in three specific outer faces and other face and top were kept wax free for the evaporation of water. The specimens were kept into containers in vertically as the saline water of specific concentrations injects then the water absorbs through the base of the brick specimens as shown in Figure 2. The injected water contain selected salinity as 0 mg/L, 10000 mg/L, and 35000 mg/L as shown in Table 1. At the end of the run the salinity brick specimen was found out in the laboratory for each specimen at three different heights.

(a) brick samples of cross section 5cmx5cm (b) multiple bricks setup

Figure 1. Brick sample preparation and multiple brick setup

After the run was observed for 50 to 90 days according to the experimental program where the saline water of different concentrations was injected in the plastic boxes at different intervals of time, it was undone in a systematic way. The brick samples were first taken out of the containers and the saline water left in the container was removed after measuring. After drying, the waxes from the specific sides of each sample were removed carefully by using a knife. Each of the 20 brick specimens after the removal of wax was cut into approximately three equal cubic pieces as shown in Figure 2a. After cutting total 60 small pieces of cubic shape were obtained from those 20 specimens, three pieces for each short setup and 9 pieces for each long setup

Each of the 60 cubic pieces was crushed to small pieces in such a way that they were in granular form, which provides highest extraction as shown in Figure 2a. The crushed samples were dried in a oven. After drying for 24 hours at a temperature of 100-105^{o}C, the samples were then soaked in saline free water for 24 hours. Silver Nitrate Titration was done to measure the salinity of extracted samples in mg/L then converted to g/kg of bricks.

(a) approximately three equal cubic pieces (b) granular form

Figure 2. Sample preparation for salinity measurement.

3. RESULT & DISCUSSION

The comparison of intake rate of water by brick samples during the course of time 50 to 90 days has been done. Normal clay brick (N) always evaporate more water than machine made brick (M) as normal brick has more pores. It can be seen from Table 2 that the average evaporation rate of normal clay brick (N0) is 27.6 ml/day and that of machine made brick (M0) is 21.2 ml/day. N35 and M35 also show similar results. The evaporation rate is higher in low saline water intake than high saline water intake. For machine made brick M10 (10000 mg/L salt water intake) and M35 (35000 mg/L salt water intake) the evaporation rate was 22 ml/day and 18.7 ml/day. It means the specimen injected with 10000 mg/l concentration of saline water gave the highest intake and evaporation rate than the specimen injected with 35000 mg/l concentration of saline water because of the concentration being higher and the salt movement in the specimen took some time. The salinity movement in almost all the specimens occurred from base portion to top height and the salts accumulated more in the bottom in most of the cases for the particular type of opening, which were the top and one face. It is seen that the salinity accumulation in bricks increases with the increase in salinity concentrations in the water absorbed by the bricks. Such as M10 accumulate 57 gm than M35 accumulate 131.77 gm as single sample. Again Multiple sample MultiN10 accumulate 31.85 gm than MultiN35 accumulate 99.68gm at similar duration and test condition. Therefore, brick structures near coastal will be more vulnerable by saline attack due to sea level rise in consequence of climate change.

Table 2 Evaporation rate and salt intake in multiple (three) and single brick samples

Setup	Saline injected, ml	Evaporation rate (ave.)	Salt content in gm				
			Bottom	Middle	Top	Total	Average/ *sum
M0A	1850	22	3.83	5.11	0.02	8.96	
M0B	1730	21	8.73	4.07	0.05	12.85	
M0C	1760	21(21.2)	2.10	4.72	0.01	6.82	9.54
N0A	1350	27	1.99	2.12	0.01	4.11	
N0B	1420	28	4.34	3.47	0.02	7.83	
N0C	1370	27 (27.6)	8.70	1.37	0.04	10.11	7.35
M10A	1850	21	34.81	26.04	0.20	61.04	
M10B	1970	22	30.21	17.34	0.16	47.70	
M10C	2090	23 (22)	33.87	28.14	0.19	62.19	57.0
M35A	1620	19	56.51	66.29	0.31	123.10	
M35B	1550	18	81.34	63.63	0.45	145.42	
M35C	1590	19 (18.7)	65.93	60.51	0.36	126.80	131.77
N35A	1050	19	28.07	31.94	0.14	60.15	
N35B	1100	20 (19.5)	51.68	103.36	0.22	155.26	107.71
MultiN10B	2030	23	0.84	1.05	0.00	1.89	
MultiN10M	-	-	12.88	13.33	0.06	26.27	
MultiN10T	-	-	2.59	1.08	0.01	3.69	*31.85
MultiN35B	1740	19	11.06	13.09	0.05	24.20	
MultiN35M	-	-	47.85	20.22	0.22	68.29	
MultiN35T	-	-	3.35	3.83	0.02	7.19	*99.68

4. CONCLUSIONS

- Normal clay brick always evaporate more water than machine made bricks in similar condition.
- The salinity movement in almost all the specimens occurred from base portion to top and the salts accumulated more in the bottom part in most of the cases for the particular type of opening.
- It is seen that the salt accumulation in bricks increases with the increase in salinity concentrations in the water absorbed by the bricks. Therefore, brick structures near coastal will be more vulnerable by saline attack due to sea level rise in consequence of climate change.

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