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O 53. BEHAVIOR OF SILLE STONE AGAINST ACID RAIN

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ABSTRACT: The structures in which human activities are carried out and we are in at any time are reacting with the increasing acid rain and acids caused by different reasons. Building materials lose their chemical and physical properties as a result of reactions with acids. Sille stone, which has quarries in the Sille district of our Konya province, is a building material that has been used since ancient times. The resistance of this building material, which is still preferred in housing construction in today's conditions, against acid rain, although it has been encountered in various historical artifacts carried from different cultures and civilizations until today, was discussed in this study. The pH value of rainwater varies between 5.6 and 6 and shows acidic properties. It has been observed that the pH value of acid rains fell below 5 and decreased to 3 in some places in the world. Sulfuric acid, nitric acid, carboxylic acid and their mixtures, which are frequently encountered in acid rain, were used in this study. 7x7x7 samples were taken from the stone quarries in Sille district. 1 molar concentration were prepared to examine the behaviour of Sille stone as a result of the reaction of these stones in seasonal acid rains. The samples were kept in natural and acidic environments by being varnished with stone varnish as they came out of the quarry. In this way, the protection of stone varnish against acid rains was also analysed.

Keywords: Acid rain, Nitric acid, Sille stone, Citric acid, Sulfuric acid.

1. INTRODUCTION

Palta (2020) examined the effect of boric acid on self-compacting concrete. They produced the concrete themselves. 6 samples were obtained by adding a reference sample and 0.5%, 1.0%, 1.5%, 2.0%, 2.5% boric acid by weight to the concrete water, respectively. Diffusion Table, V-Funnel, L-Box, U-Box tests from Fresh Concrete Tests were performed on these 6 samples produced. Compressive strength and bending strength experiments were carried out to compare the changes in the mechanical properties of the obtained samples. Additionally, SEM and XRD analyzes were performed to observe structural characterization changes. When SEM images were examined, boric acid accelerated the formation of C-S-H gels by binding C-H to itself over time, and with the effect of this, an increase in compressive strength was achieved over time. Thus, with the addition of boric acid, a new C-S-H gel was formed and the structure was made more impermeable and durable. With the addition of 2.5% boric acid, the gaps and pores began to increase significantly. Micro crack formation was also observed. As a result of this situation, the increase in compressive strength decreased compared to the control sample. In the XRD analysis, when looking at the XRD peaks, especially after the 0.5% Boric acid additive rate, the dominant peak intensities seen at approximately 30^{o} started to increase effectively. The low peak intensity of 0.5% Boric acid additive ratio can be associated with the decrease in particle size and pores. It can be said in the SEM image of the sample with 0.5% boric acid that the particles are smaller compared to other samples. SEM and XRD analysis results support the increase in compressive strength, especially in the concrete sample with 0.5% Boric acid added. When a general evaluation was made, it was seen that Self-Compacting Concrete could be produced by adding boric acid.

Reddy studied three different regions in the northeastern United States in 1988. The aim of this research is to examine the effects of dry and wet deposition states of acid on stone separately. As a result of the experiments and observations, it was revealed that the stagnation on the stone surface is proportional to the amount of precipitation. In other words, the amount of precipitation that falls on the stone will increase the dissolution on the stone surface proportionally. This research has shown that the result is proportional to the hydrogen ion arriving on the stone surface (Reddy, 1988).

Charola (1987) have studied limited the pollutants that cause acid rain to only sulfur oxides. He limited the stones he examined to quartz, which is a stable mineral form. As a result of his research, he attributed the deterioration of calcareous stone to two main reasons. The first is the chemical dissolution of calcite, and the second is the damage caused by the salts formed during dissolution crystallising again in the stone pores. The first case explains the deterioration in the surface details of buildings and monuments, and the second case explains the causes of structural damage to the stone.

In 2005, Tecer examined the effects of SO2 and NOx resulting from environmental pollution on carbonate rocks. He examined the results of the effects of air pollutants on historical structures whose main component is CaCO3. Effects of Sulfur Dioxide, effects of Nitrogenides, Effects of Carbon Dioxide, effects of Acid Rain, effects of Particulate Matters on carbonate rocks is examined in the study.

Bravo (2005) had experiments to observe the dissolution that occurs when limestone is exposed to acid rain. As a result of the studies, it was determined that 85% of the precipitation in this region is acidic and the limestone building material in this region is dissolved by acid rain and as a result, it erodes over time and loses its shape and resistance.

2. MATERIALS AND METHODS

Air pollution, which has become one of today's important environmental problems with the rapid increase in industrialization brought about by advanced technology, causes acid rain. The aim of this thesis is to examine the effect of acid rain on the Sille stone, a geological heritage reserve in the Sille district of Konya. The changes in physical and chemical properties of Sille stone were examined. Additionally, it was aimed to reduce this effect and the Sille stones were covered with stone varnish. The change in strength and chemistry of Sille stones coated with stone varnish compared to unvarnished Sille stones was compared.

In this study, nitric acid (HNO_3) prepared as 1 molar for Sille stone for 6 months, were applied to Sille stones in water, nitric asid, source and in the atmosphere environment, coated with stone varnish and uncoated. It was kept for 6 months. Mechanical and chemical changes of Sille stones during seasonal transitions were analyzed over a 6-month period.

2.1. Used materials

The main material of this study is Sille stone which is stated that the required sample size for the pressure test on TS1926 natural stones should be 7x7x7 cm3. For this reason, in this study, which will last 6 months, the size of a sample of Sille stone will be a cube of 7x7x7 cm3. Compressive strength test is performed on at least 5 test samples for each environment (TS 1926). Additionally, 1 test sample is required for chemical experiments. In this case, 5+1 unvarnished and 5+1 varnished test samples are required for each environment.

	varnished	unvarnished
Referans	5+1	5+1
Nitric Acid	5+1	5+1
Atmosphere	5+1	5+1
Water	5+1	5+1
Total	48	

3. DISCUSSION and RESULTS

3.1. Pressure Test

Compressive strength is the maximum stress that occurs in concrete under the effect of axial pressure load and the resistance it shows to avoid breaking. The reasons why the most commonly used strength is compressive strength; the test applied to determine compressive strength is simpler than the tests applied to determine other types of strength. The compressive strength value has an important role in building designs. If the compressive strength is known, one can have an idea about the other strength values of the samples and make comments.

The pressure test was prepared depending on TS 1926 conditions and its procedure. Sille stone was prepared as cube samples with dimensions of 7x7x7 cm3. Before placing the sample on the compression device with adjusted loading speed, it was checked that the surface on which the sample would be placed was clean and smooth. The sample was carefully placed on the testing device in the center of the loading bed so that the load would act exactly in the middle and axially. After the placement process was completed, loading was started and the maximum force withstood by the sample was measured from the device. The compression test was carried out with the compression device in the civil engineering laboratory of Necmettin Erbakan University.

Comments were made on the behavior of the samples under load with the pressure test, which is a mechanical experiment. As a result of the compression test performed without waiting for the Sille stone when it was first removed from the its source originally, the strength was measured as 30.91 MPa. The compression test result of the Sille stone samples, which were varnished and kept for the varnish to dry, was measured as 25.61 MPa as seen in Table 1.

Table 1. Compressive strength of Sille stone, taken from the its source, with and without varnish.

	Sample No	7*7*7 Cubic (KN)	Compressive strength (MPA)	Average (MPA)
Unvarnished	1	133,95	27,34	30,91
	2	177,44	36,21	
	3	128,57	26,24	
	4	162,26	33,11	
	5	154,98	31,63	
Varnished	1V	84,93	17,33	25,61
	2V	154,36	31,50	
	3V	109,13	22,27	
	4V	135,54	27,66	
	5V	143,44	29,27	

As can be seen from the Figure 1, applying varnish prevented oxygen from passing through. For this reason, the strength in varnished samples was lower than in unvarnished samples. As can be seen from the figure, it was observed that the compressive strength is increasing in all environments compared to the strength when they first came out of the quarry. This is a sign that the strength of quarried samples increases when exposed to oxygen. Applying varnish prevented oxygen from passing through. For this reason, the strength in varnished samples was lower than in unvarnished samples.

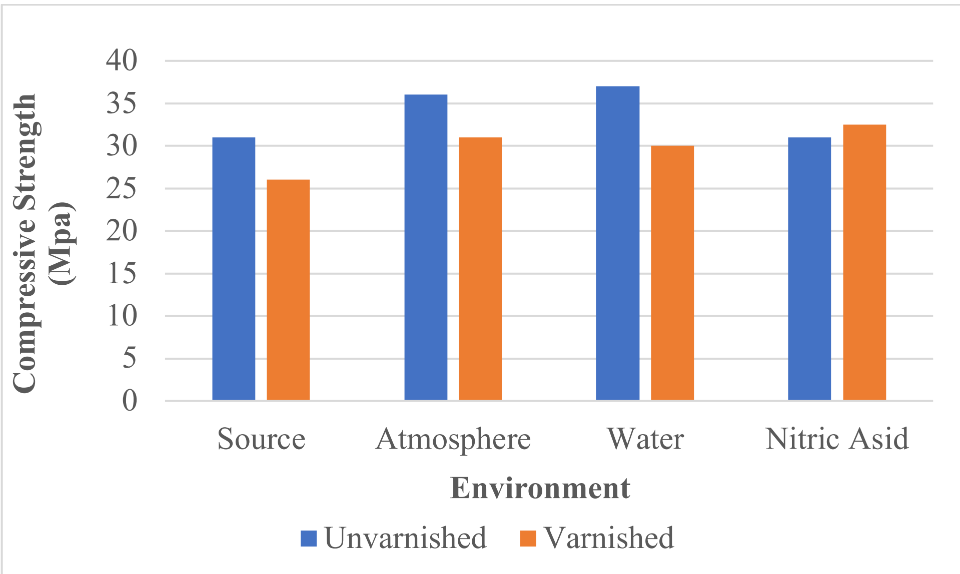

Figure 1. Compressive Strength of samples

Over time, both physical and chemical transformations occur in Sille stone. The physical transformation of the stone occurs when the quarried Sille stone turns into a lower energy state as the pressure on it decreases. Chemical transformation of the stone is the changes in compressive strength as a result of chemical reactions in Sille stone samples kept in different environments.

4. RESULTS

- The transformation began to negatively affect the sample by destroying it, and a decrease in compressive strength occurred in the 6th month.
- It has been observed that the improvement in mechanical properties is slower in Sille stone samples varnished and kept in atmosphere, water and acid environments. However, it has been determined that Sille stone samples behave more stable over time.
- It is thought that not varnishing the stones used in houses and buildings intended to be built using Sille stone at the beginning, but varnishing them after a certain period of time, will be effective in increasing the compressive strength. Determining this period clearly experimentally may be the subject of future studies.
- In order to examine the transformations in the chemical and physical properties of Sille stone in more detail, more detailed findings can be detected and evaluated by selecting a single aging environment and performing strength tests over a longer period of time and at shorter intervals.

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