Experimental Study of Rainfall and Splashes Acting on the Surface of a Concrete Structure

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1 INTRODUCTION

Concrete has an excellent structural performance and durability, but is affected by early deterioration when is subjected to a marine environment. The most common cause of deterioration is corrosion of the reinforcement steel, with a subsequent sapling of concrete. This deterioration is caused by two agents, the rainwater, and the salt that flies with the waves of the sea until reaching the concrete structure. Once the salt and rainwater reach the surface of the concrete structure, moisture and salt infiltrates into the structure. The corrosion on the steel bars is rotten and causes cracks in the concrete. However, the amount of moisture and sea salt are not the same in all the surfaces of the structure. Therefore, it is necessary to know certainty the distribution of moisture and sea salt. In order to supply this problem, this research aims to study and evaluate the distribution of moisture and sea salt on the surface of two different sections of vehicular bridge, simulating the environment acting in this structure. Within this environment, there is rainwater and sea salt that comes with the waves, rainwater and sea salt that reach the concrete surface, humidity and salt that runs through the structure by gravity and finally, as time passes, the evaporation of water with the sun.

2 EXPERIMENTAL METHOD

2.1 Whole Experimental Facilities

Fig. 1 shows the experimental facilities used in all the experiments, composed for wind generator system, rainfall generator system and two reinforcement concrete specimens.

2.2 Wind Reproduction

For the reproduction of the wind, a frame of ½ inch steel tubes was constructed, measuring 140mm (length) × 100mm (width) × 2500mm (height) and divided every 500mm by wooden boards, such as it is shown in **Fig.1**. The structure is made up of 12 fans, distributed 2 for each table. Each fan contains an electric power of 405 / 560W.

For wind speed measurement, 6 wind receiver fans were used, each with its data logger. The receiving fans were placed in the middle of the base of Specimens A and B with the help of metal arms, each with a height of 15mm, 50mm, 100mm, 150mm, 200mm, and 250mm.

In each specimen the wind speed was measured at 6 different distances, 250mm, 500mm, 1000mm, 2000mm, 3000mm and 4000mm, starting from the front of the specimen as reference 0mm. In all cases the wind speed was recorded for a period of 5 minutes.

2.3 Rainfall Reproduction

For the reproduction of the rain, 3 frames were constructed, of the same material and caliber as the frame of the fans. The measurements are 210mm (length) ×

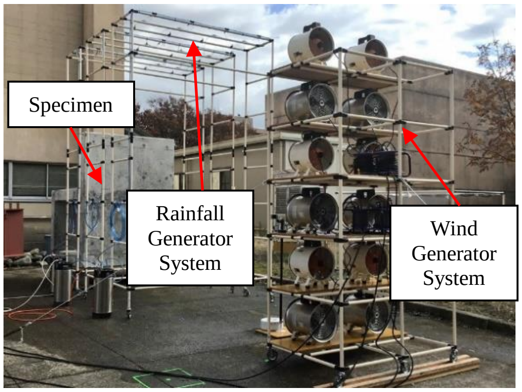

Fig. 1. Whole Experimental Facilities

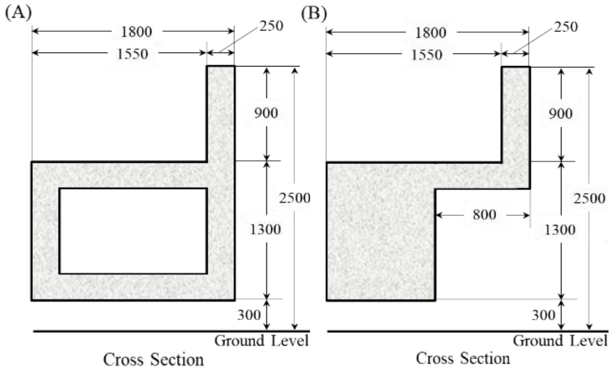

Fig. 2. Specimens A and B Dimensions (mm)

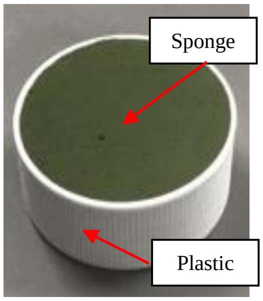

Fig. 3. Hydrophilic Sponges

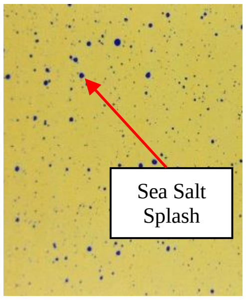

Fig. 4. Water Sensitive Paper

Fig. 5. Surface Rainfall Amount Experiment

Fig. 6. Surface Splashes Amount Experiment

700mm (width) × 3700mm (height), shown in **Fig. 1**. Four cone nozzles were placed on top of each frame, which have the function of simulating rain. The water was raised with the help of pressure tanks, one tank per structure.

To measure the amount of rainfall, a plastic cylinder and hydrophilic sponges were used inside, as shown in **Fig. 3**. The distribution of the devices was as follows: on the front of each specimen 33 of them and 3 more at the top, shown in **Fig. 5**.

Once the ventilation system and the rain generator were switched on, the time in which the experiment was carried out was 4 and a half minutes for both specimens.

2.4 Splashes Reproduction

For this experiment a special equipment was used which throws tiny drops of water, simulating the drops of water and salt that reach the surface of the structure with the air. The method used for conducting the experiment was the use of the water sensitive papers, shown in **Fig. 4**. The distribution of this papers was as follows: on the front of each specimen 11 of them, as shown in **Fig 6**. Without making use of the rain generator, the time during which the experiment was conducted was approximately 2 to 3 seconds for both specimens.

2.5 Specimens Configuration

As specimens, 2 reinforcement concrete structures of a section of a full-scale vehicular bridge were used. Slab type and T beam type bridge profiles were selected, to which the specimen names A and B were attributed respectively, as shown in **Fig. 2**.

3 EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Wind Velocity

In this experiment, the speeds of 6 points with different heights and at different distances from the front of the specimen were obtained. The results shown in **Fig. 7** and **Fig 8**. are the results of the distance of 250mm. If we see the two graphs, wind speeds vary depending on the shape of the structure. Obtaining the maximum of the air velocity as the low and high part of each specimen and in the center the minimum values.

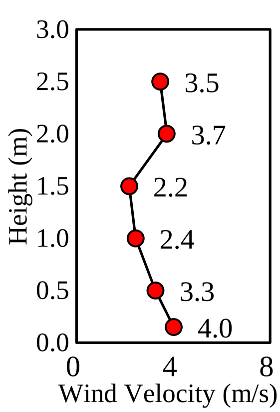

Fig. 7: Wind Velocity vs. Height (Specimen A)

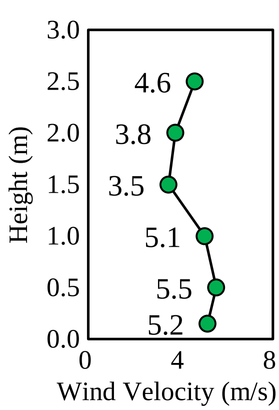

Fig. 8: Wind Velocity vs. Height (Specimen B)

3.2 Surface Rainfall Amount

In this experiment, the amounts of rainfall were obtained for each specimen, as we can see in **Fig. 9** and **Fig. 10**. For a better understanding of the results, we divided in three columns the hydrophilic sponges. The left row as blue, the center row with red and the right row with green. If we see the graph of specimen A, we see that at the top it was the highest concentration of water and as it went down, the amount of water decreases. On the other hand, in specimen B, we can see that it also shows in the upper part a greater concentration of water. Also, under the step the water did not reach the concrete surface. However, in the lower part of the structure it was observed that up to 45cm above, the water could reach the structure.

3.3 Surface Splashes Amount

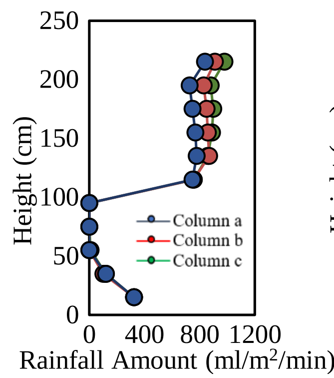

Fig. 9. Rainfall Amount vs. Height (Specimen A)

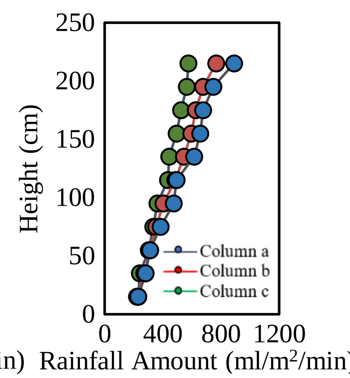

Fig. 10. Rainfall Amount vs. Height (Specimen B)

Fig. 11. shows the surface splashes amount data of Specimen B, obtaining by the pixel counting. On the top step, the highest moisture concentration was found at the height of 135cm with 4.61 l/m2 and in the bottom step in the height of 35cm with 7.59 l/m2. With these data, we can corroborate that in this structure shape, there is an area where the splashes did not reach the surface of the structure.

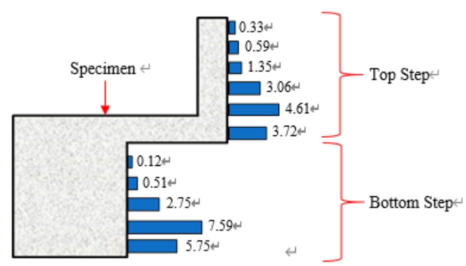

Fig. 11. Surface Splashes Amount (l/m^2/)

4 CONCLUSIONS

It was demonstrated that the adhesion amount of rainfall and splash particles to the surface is affected by the shape of the structure and wind condition. In cases with wind, the adhesion amount of rainfall is greater than the no wind cases. The adhesion amount of rainfall and splashes particles to surface of the structures can be estimated by results. Finally, it was possible to demonstrate that the adhesion amount of rainfall and splashes is not the same in all places of the concrete structure.