EFFECTIVENESS OF DIFFERENT SURFACE COATINGS ON REPAIR MORTAR AGAINST ABRASION OF CONCRETE IN HYDRAULIC STRUCTURES

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1. INTRODUCTION

Water abrasion is a natural challenge in concrete hydraulic structures resulting from the abrasive effects of waterborne silt, sand, gravel, rocks, and other debris circulated over a concrete surface [1]. Abrasion results in the deterioration of concrete and can eventually expose the reinforcement to corrosion [2]. Thus, apart from section loss, durability could be a major issue in hydraulic structures made of reinforced concrete [3]. Abraded concrete surfaces of hydraulic structures often require to be repaired to avert further deterioration [4]. Repair mortar, plain or with additives is often used depending on the desired output [3].

This study focuses on investigating the effectiveness of three different coatings (two Silane type and one Silicate type) as a protective layer on repair mortar. The study adopts an experimental approach by preparing four sets of mortar specimens. One set will be uncoated while the other three sets will be coated with different surface coatings. The specimens will then be subjected to underwater abrasion according to ASTM C1138 standard [5] and the data obtained compared for the uncoated specimen and the coated specimens to show whether the coatings are effective as a protective layer on repair mortar against abrasion.

Silane type and silicate type coatings used in this study are meant for improving the quality of the surface layer composition and contributing to greater durability [6]. This experimental study will be conducted at three rotational speeds of 700, 1050 and 1500 rpm to check on the correlation between rotation speed and rate of abrasion weight loss.

2. METHODOLOGY (The Standard C1138 Underwater Abrasion Test Method)

The ASTM C1138 underwater abrasion test method will be used in this study [5]. This is a standard abrasion test method to evaluate the relative abrasion resistance of underwater concrete/mortar surfaces subjected to the action of waterborne materials like silt, sand, gravel, rocks, and other debris. The method will include a cylindrical steel tank in which the specimen of approximately 300 mm diameter and 100 mm thickness will be inserted and tested. The tank diameter will be slightly larger than the diameter of the test specimen (+6mm) to simplify the inserting and lifting of the specimen. Fig. 1 shows the fabricated apparatus used in this study as per the test apparatus layout shown in Fig. 2 according to ASTM C1138 requirements.

On the surface of the specimen as shown in Fig. 3, 70 steel balls with 3 different diameters of approximately 13, 19, and 25 mm weighing 1850g as shown in Fig. 4 will be placed to simulate the erodent waterborne particles. The tank will be filled with water up to 200 mm depth above the sample. The water will then be rotated at a specified rotational speed of 700, 1050, and 1500 rpm using a rotating agitation paddle fixed onto an electric bench drill machine. Here the standard rotational speed of ASTM C1138 is 1200rpm. However, from the literature review, most researches increase or decrease by 400rpm from the standard to compare the effects of low and high rotation speeds for various specimens under test.

Figure 1: Fabricated test apparatus used in this study

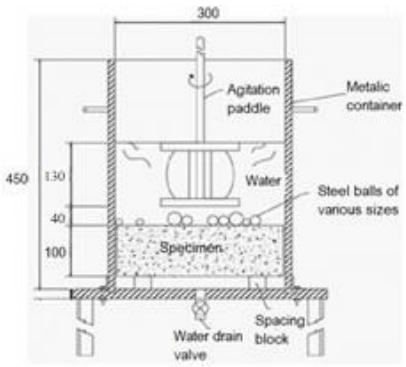

Figure 2: Test apparatus layout as per ASTM C1138 [5]

Figure 3: Specimen with abrasive charges placed on the surface

Figure 4: 1850g, weight of 70 abrasive charges

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The coatings will be applied by brushing on mortar specimens to full application quantities as per the manufacturer's recommendations. Details for the application and specimens used in this study are shown in Table 1. 300 mm diameter and 100 mm depth cylindrical mortar specimens will be cast and cured for 28 days and used to conduct the abrasion tests and the details of the mortar mix proportions are shown in Table 2.

The abrasion will be analyzed as a weight loss with time intervals of 1h for a total test time of 6hrs [1]. After each time step, the specimen will be removed from the water container, dried and weighed [5]. Then the abrasion weight loss and the rate of abrasion were calculated by equations (1) and (2).

$$Abrasion\ weight\ loss\ (g) = \left[\begin{Bmatrix} Weight\ of\ specimen \\ before\ testing \end{Bmatrix} - \begin{Bmatrix} Weight\ at\ the\ current \\ time\ step \end{Bmatrix}\right] \quad (1)$$

$$Rate\ of\ abrasion\ (g/h) = \frac{\left[\begin{Bmatrix} Abrasion\ weight\ loss\ of \\ current\ time\ step \end{Bmatrix} - \begin{Bmatrix} Abrasion\ weight\ loss \\ of\ previous\ time\ step(s) \end{Bmatrix}\right]}{No\ of\ time\ steps * 1h} \quad (2)$$

Table 1: Details of Test Specimens

Test Specimen	Description	Application rate (g/m^2)
No coating	No coating applied	n/a
Coating 1	Silicate	240
Coating 2	Silane Type 1	200
Coating 3	Silane Type 2	200

Table 2: Mortar Mix Proportions

W/C	S/C	Cement* (kg/m^3)	Sand** (kg/m^3)	Water (kg/m^3)
0.40	2.8	515	1441	206

***Ordinary Portland Cement**
**** Local land sand**

3. RESULTS AND DISCUSSIONS

Fig.5 shows the comparison of abrasion weight loss against rotation speed and shows that at higher rotation speeds of 1500rpm, the difference is noticeable and easy to compare. Fig.6 shows the abrasion weight loss against the testing time at 1500rpm and Table 3 shows the calculated percentage reduction of the rate of abrasion after 6hrs time step for the coated specimens at 1500rpm. According to these results, the coatings can be effective as a protective layer in repair mortar against abrasion.

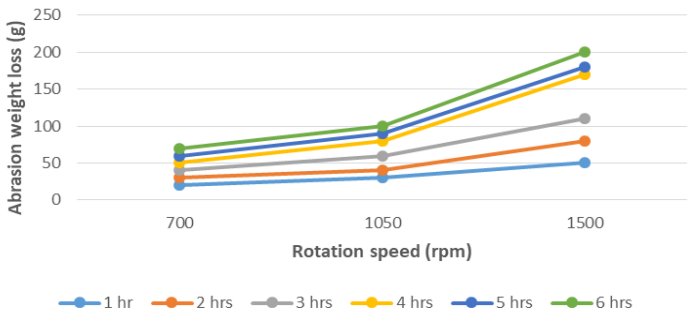

Figure 5: Comparison of abrasion weight loss against rotation speed (No coating specimen)

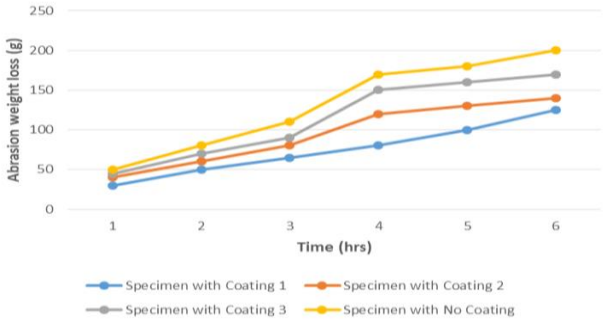

Figure 6: Comparison of abrasion weight loss against testing time (1500 rpm)

Table 3: Percentage reduction of rate of abrasion for the coated specimens against no coating specimen at 6hrs time step (1500rpm)

Specimens / Description	No coating	Coating 1	Coating 2	Coating 3
Rate of abrasion (g/h)	33	25	27	28
Reduction (%)	0	24	18	15

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