Evaluation of high temperature effect on shear bond strength between PMM and concrete by using bi-surface shear test

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1. INTRODUCTION

As Polymer Modified Mortar (PMM) is known as good material for its low permeability, high bond strength and thin construction thickness, it is now widely used for repairing and strengthening. Overlaying on bottom slab surface is one of a popular construction method for strengthening using PMM by spraying or trowelling. It is also known that it can be executed without blocking traffic and considering weather condition. In this method, S. Tuneoka et al indicates shear stress is dominant state of stress for debonding failure which is the most undesirable failure mode, because it induces significant decrease of strength. Therefore, it is very important to consider shear bond strength at interface between PMM and substrate concrete. However, the kinds of research considering environmental condition like temperature and humidity and so on have not been developed well. This research focused on high temperature effect, considering actual environment which can rise up to in some region with hot and arid climate.

2. EXPERIMENTAL PROGRAM

2.1. Test Method

Shear bond strength is influenced by various factors, for example, test method, surface roughness preparation and type of material, etc. Nevertheless many test methods have developed until now to evaluate shear strength precisely, standard test method for measuring shear strength has not been developed. This research adopted bi-surface shear test, which was proposed by A. Momayez et al (2004) and is of characteristics for easy fabrication and less scatter of data. In this research, composite specimens were fabricated as cube, that is 200 x 200 x 200 mm as shown in Fig.1.

2.2. Fabrication of the specimens

Specimens were fabricated by the following procedures. First, surface roughness was prepared by sand blasting. Roughness average (Ra) was 0.50 mm with cut off value of 80 mm. After that, each substrate moisture conditions were made by following the method shown in Chap.4.2, and then, primer and PMM were applied. Specimens were left in air for one day after primer application.

3. MATERIAL

3.1. Concrete

High early strength portland cement, fine sand and coarse aggregate were used in this research. The details of mix proportion are summarized in Table 1. Measured compressive strength of 64 and 94 days curing was 48.7N/mm^2 and 48.4N/mm^2.

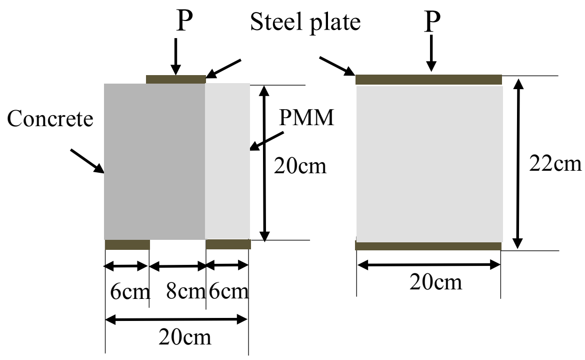

Fig.1 Overview of bi-surface shear specimen

Table 1 Mix proportion of concrete

G_{max} (mm)	W/C (%)	s/a (%)	Unit weight（kg/m^3）			
			W	C	S	A
20	50	47	163	350	896	1001

3.2. PMM

Two type of PMM which contained Poly Acrylic Ester (PAE) were used in this research and defined as Type D and Type M. The compressive strength of 28 and 58 days curing was 48.3N/mm^2 and 29.8N/mm^2 respectively.

4. PARAMETER

4.1. HIGH TEMPERATURE

The oven temperature was controlled at 60℃, which is the environmental temperature as possible maximum in some area. Three exposure periods to high temperature were considered in this research: 0 day, 1 day, 30 days.

4.2. MOISTURE CONDITION

Dry substrate specimens were made by leaving them in the basement of laboratory for one week, and wet substrate specimens were prepared by keeping them in water tank for one week. The specimens were removed from the water tank 24 hours before applying primer.

5. RESULTS AND DISCUSSIONS

5.1. Influence of exposure period to high temperature

Fig.2 shows shear bond strength decreases significantly after short duration exposure to high temperature in most specimens. From Fig.3, the strength decreased more than 50% at all the specimens except for wet M1 specimen. As

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there was no significant change between 1 day and 30 days, it can be said influence of high temperature was dominant at short exposure period.

5.2. Influence of substrate moisture condition

Substrate moisture condition effect is evaluated by comparing shear bond strength as shown in Fig.4. All the dry substrate specimen types except for D0 specimen showed higher shear bond strength than the wet specimen. From this fact, it can be considered that the bond strength through the primer can work better with dry substrate condition as known in practice.

5.3. Behavior of failure mode

In this research, failure mode was classified as shown in Fig.5. It shows cohesive failure, adhesive failure and partially cohesive and adhesive failure. As Table 2 shows, the failure mode of Type M PMM repaired specimens tends to be shifted to adhesive failure when substrate concrete was wet regardless of whether they were under high temperature or not.

6. CONCLUSIONS

1) PMM repaired concrete is very much sensitive to high temperature and showed significant decrease in shear bond strength after short duration exposure of 1 day. After one day there was no significant strength reduction until 30 days exposure.

2) Substrate wet condition makes shear bond strength lower than dry one. The possible reason is that the bond strength through the primer can work better with dry substrate condition as known in practice.

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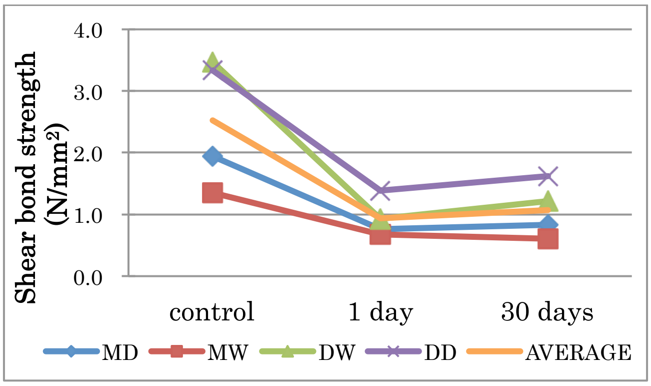

Fig.2 Shear bond strength and exposure

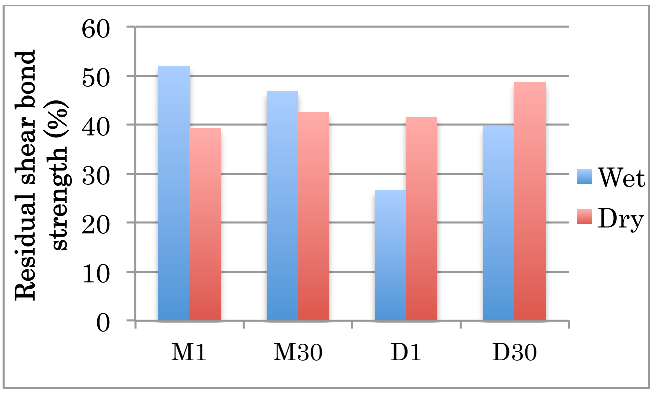

Fig.3 Residual shear bond strength after exposure to high temperature

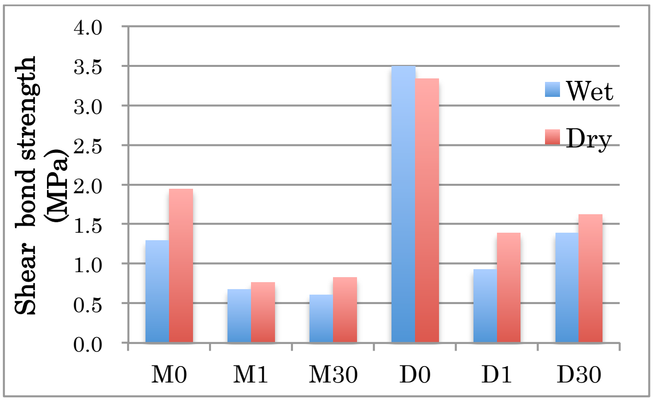

Fig.4 Comparison of strength based on substrate moisture condition

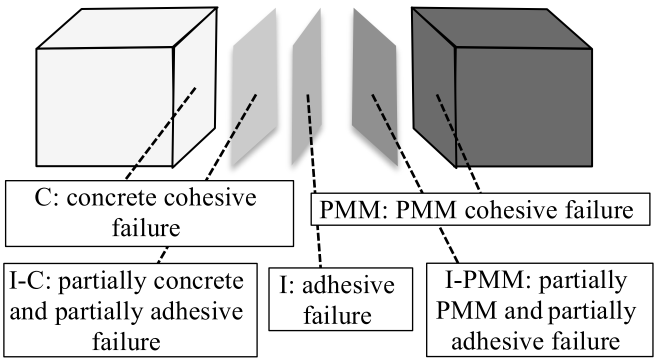

Fig.5 Classification of failure mode

Table 2 failure mode of each specimen group

Specimen group	Percentage of area at failure surface (%)			failure mode
	Concrete	Interface	PMM	
MWL	1	48	50	I-PMM
MDL	1	1	98	PMM
MWH1	0	37	63	I-PMM
MDH1	0	0	100	PMM
MWH30	0	61	39	I-PMM
MDH30	0	1	99	PMM
DWL	5	87	8	I
DDL	4	86	10	I
DWH1	0	99	0	I
DDH1	2	97	1	I
DWH30	1	86	12	I
DDH30	0	65	35	I-PMM