Slant Shear Strength Of Fibre Reinforced Polyvinyl Acetat (PVA) Modified Mortar

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1. Introduction

1. Sustainability is a major issue affecting the design and performance requirements of concrete [1]. The issue challenges the concrete industry to create concrete with minimum exploitation to non-renewable natural resources, less impact to environment, cost-efficient of production, etc.
2. Creation of durable concrete could be a key factor to meet such challenges. Durable concrete promotes a longer service life of the constructed infrastructures with a minimum maintenance throughout their entirely life span. It means durable concrete can aids in reducing the consumption of natural resources.
3. Concrete in combination with steel reinforcement is widely utilised as a structural material. This material is considered to be a durable material. Under normal condition, it is expected that reinforced concrete (RC) structures can have a service life of at least 50 years [2]. However, there may be such situations where deterioration of RC structures could occur at a faster rate resulting in a service life of less than 20 years [3]. The situations challenge engineers to seek innovative solutions to prevent the deterioration and offer methods to extent the service life of the deteriorated RC structures. Accordingly, many materials have been developed specifically to protect, repair and rehabilitate this deterioration issue.

2. Theory

1. The bond strength of the matrix of TRC (i.e. fibre reinforced PVA modified mortar) to the substrate concrete was determined by the slant shear test method in accordance with BS 6319: Part 4 [25]. Figure 2 illustrates the composite prism specimen made from substrate concrete and fibre reinforced PVA modified mortar for the purpose of determining the slant hear strength
2. The size of slant shear specimens was 55x100x250 mm3. The composite prisms were produced with a bond line at 30^o to the vertical. The composite prisms were produced by the following sequence: first, substrate concrete was cast to form a half of the prism with a bond line at 30^o to the vertical. After 28 days, fibre reinforced PVA modified mortar was cast on the remaining half of the prism to form composite prism. No preparation on the bond plane of the substrate concrete was made before casting the layer of fibre reinforced PVA modified mortar. Once the layer of fibre reinforced PVA modified mortar was cast, the specimens were left in the room temperature until the day of testing. The slant shear test was carried out at 3rd and 28th days after casting of the fibre reinforced PVA modified mortar. The slant shear strengths were calculated using Equation 1

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$$f'_{cr} = \frac{P}{A} cos\alpha . sin\alpha \qquad \mathbf{1}$$

where f'_{cr}, P, A, α is slant shear strength, maximum applied load, horizontal area of specimen and bond line (30^o), respectively (see Figure 2).

3. Methodology

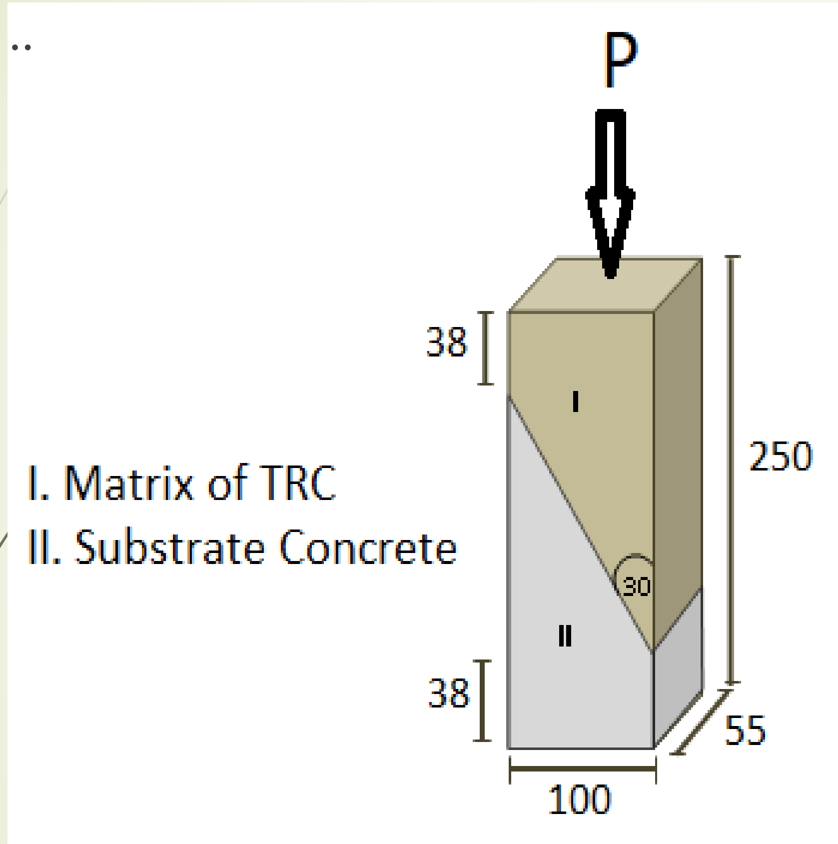

Fig. 2. Composite prism specimen for determining slant shear test under compressive loading

4. Result & Analysis

3.1 Slant shear strength

The slant shear strength of the fibre reinforced PVA modified mortars is presented in Figure 3. As expected, the 28-d slant shear strength is higher than the 3-d slant shear strength. This characteristic is true for all mixes of fibre reinforced PVA modified mortars. The 3-d slant shear strength represents only about 33-50% of the 28-d slant shear strength. It also clearly shows that the slant shear strength is increased with respect to the increase of PVA content. The improvement of bonding with PVA content could be a result of diffusion of polymer matrixes that are mutually intertwined at the interface [22]. Furthermore, formation of PVA films may occur on the bond plane that close the entrapped air voids on this interface and bridge the two composite components.

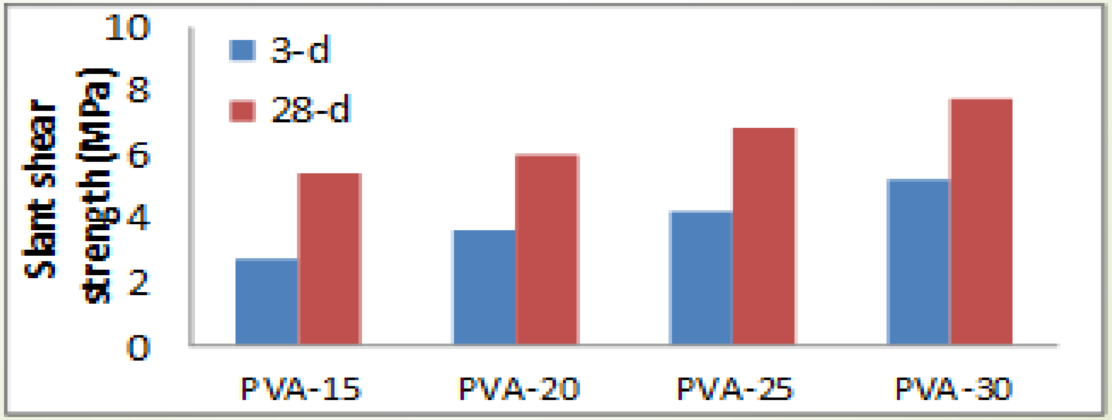

Fig.3. Slant shear strength of the fibre reinforced PVA modified mortars

The 3-d slant shear strength of the fibre reinforced PVA modified mortar will rise up to91% when the PVA content is increased from 15% to 30%. If it is measured at 28-d, the increase of slant shear strength will be around 43%. The significant difference of the slant shear strength increase with respect to the age of fibre reinforced PVA mortar may be related to the balance contribution of bond due to the hydration progress and PVA. At early age, the cement-based material is still in the process of developing bond to the substrate concrete in line with the progress of hydration. Hence, the contribution of PVA to improve the bonding is significant to the overall development of bond strength. On the other hand, at later age the hydration is nearly completed and so the ultimate bond strength due to hydration is practically attained. Consequently, the relative contribution of PVA on the bond strength is less weighty to the overall development of bond strength

Failure modes of the slant shear test

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Fig. 4. Failure modes observed in this investigation: mortar failure (left), interface failure (middle), and double failure (right)

Table 2. Failure modes of the slant shear test

Age	Spec. id	Spec. #	Failure mode
3-d	PVA-15	1	interface failure
		2	interface failure
		3	interface failure
	PVA–20	1	interface failure
		2	interface failure
		3	interface failure
	PVA-25	1	interface failure
		2	interface failure
		3	interface failure
	PVA-30	1	interface failure
		2	interface failure
		3	concrete, mortar & interface failure

Table 2. Failure modes of the slant shear test (…..continued)

Age	Spec. id	Spec. #	Failure mode
28-d	PVA-15	1	concrete, mortar & interface failure
		2	concrete, mortar & interface failure
		3	concrete, mortar & interface failure
	PVA–20	1	concrete, mortar & interface failure
		2	concrete, mortar & interface failure
		3	concrete, mortar & interface failure
	PVA-25	1	concrete, mortar & interface failure
		2	interface failure
		3	concrete, mortar & interface failure
	PVA-30	1	concrete, mortar & interface failure
		2	concrete, mortar & interface failure
		3	concrete, mortar & interface failure

3.2 Correlation of slant shear strength and compressive strength

The compressive strength of the fibre reinforced PVA modified mortars is presented in Figure 5. It seems that the compressive strength of these mortars has a similar trend to their slant shear strength. An increase of PVA content will increase the compressive strength in a similar manner to that of slant shear strength. For this reason, a correlation between the two strengths has been established as shown in Figure 6. Based on this figure, it is found that the slant shear strength is about 24% of the compressive strength.

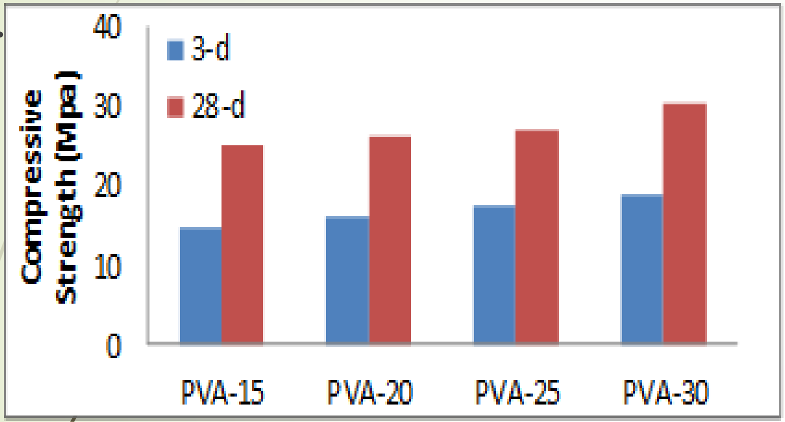

Fig. 5. Compressive strength of fibre reinforced PVA modified mortar

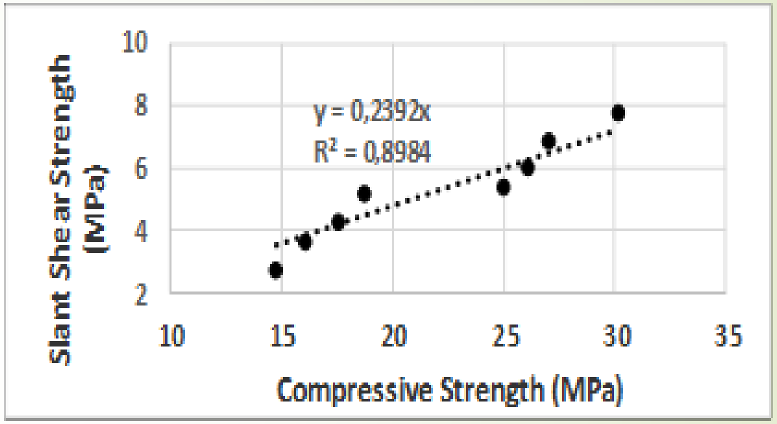

Fig. 6. Correlation between slant shear strength and compressive strength of fibre reinforced PVA modified mortar

5. Conclusions

- This study shows that the amount of PVA affects the bond strength of the fibre reinforced PVA modified mortar to the substrate concrete. The higher the amount of the PVA content, the higher the bond strength. It is also noticed that the effect of PVA is weightier at early age when the contribution of bond due to the cement hydration has not yet attained its ultimate value.
- At early age, the failure modes of the slant shear test are dominated by the interface failure.
- It is likely that at early age the fibre reinforced PVA modified mortar has not developed sufficient bond to the substrate concrete. At later age, however, a maximum cement hydration of the fibre reinforced PVA modified mortar is practically attained and the mortar has developed sufficient bond to the substrate concrete. Consequently, the failure modes of the slant shear test at later age are dominated by double failure.
- This investigation shows that at the 3-d slant shear strengthen fibre reinforced PVA
- Modified mortar to the substrate concrete only represents about 33-50% of the 28-d slant shear strength. It is also confirmed that linear relationship (by a factor of 0.24) can be established to correlate between the slant shear strength and the compressive strength.

THANK YOU