Effect of Formulation Parameters on Adhesive Properties of Tile Adhesive Mortars

Çimsa Cement Research and Application Center

August , 2017

ÇİMSA
ÇİMENTO SANAYİ VE TİCARET A.Ş.

Interfacial Resistance Between Tiles and Polymer Modified Cement Mortars

The factors affecting interfacial resistance between tiles and polymer modified cement mortars are:

- Ceramic tile water absorption,
- Cement amount and composition,
- The amount and type of polymer,
- Installation procedures,
- Water /cement ratio.

Latex Polymers

- They are generally vinyl acetate-based (VA) with polyvinyl alcohol (PVA) that is sprey driying agent.

- They are added in dry mix as an organic binder. They provide excellent adhesion to different substrates; such as concrete, sceramic, wood, vitrified glass by their hydroxyl groups on their side chains.

- Both polyvinyl alcohol and vinyl acetate-based (VA) are subjected to hydrolize in the presence of water. The protect these organic bonds, they are copolymerized with hydrophobic polymer usually with ethylene or vinyl versatate (VeoVa).

Effect of Chemistry of the Redispersible Latex Powder (RDP) in Use

- To investigate effect of chemistry of the RDP ,the same amount (2wt%) VA/Veova or EVA-based redispersible powder(RDF) were used.

Table 2
Mortar mix design with two RDPs at 2 wt% dosage.

Raw materials	wt%
Cement type II–V	36.8
Siliceous sand (50–100 mesh, 150–300 μm)	55.5
$CaCO_3$	5.17
Modified hydroxyethyl methyl cellulose, viscosity of 15,000 mPa s	0.33
Calcium formate	0.2
VA/VeoVA or EVA-based RDP	2
Water	23

- No sagging was observed on both mortars prepared with VA/Veova or EVA-based RDF.
- The measured viscosities were of 76,000 and 70,000 mPa s, indicating that workability does not change with different types of polymeric powdered resin.

Effect of Chemistry of the Redispersible Latex Powder (RDP) in Use

- The mortar formed with VA/VeoVA performed extremely well at 20 min and bond strength three times higher than the minimal requirement of 75 psi (0.52 MPa) because of hydrophobic side chain of the VeoVA copolymer.

- After particle coalescence and film formation, water evaporation during the 28 days decreases and provides better hydration of cement at early age, promoting mechanical anchoring of the C-S-H gel from cement's hydration into the porosity of the tile.

Effect of Chemistry of the Redispersible Latex Powder (RDP) in Use

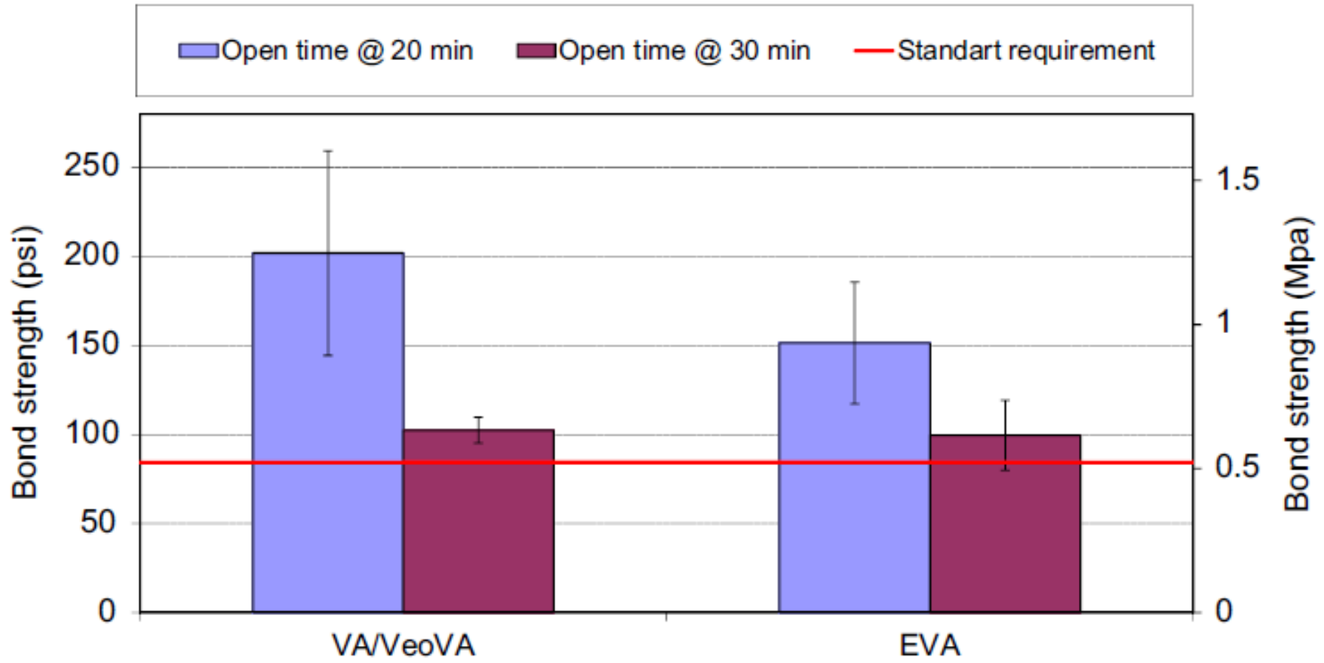

Fig. 1. 20 and 30 min open time bond strength measured at 28 days on the mortars proportioned with 2 wt% of either a VA/VeoVA or a EVA-based redispersible powder.

Effect of Chemistry of the Redispersible Latex Powder (RDP) in Use

- The polymer –cement co-matrix is created rapidly due to the film formation upon C-S-H gel is faster with EVA. On the other hand, delayed film formation upon C-S-H gel with the VA/Veova copolymer co-matrix formation at an early age (1day) is observed .

- As seen figure 2, EVA based mortars exhibits higher initial shear stress (1 day) when compared with VA/ VeoVA based showing lower initial shear stress but a higher gain in mechanical properties with time.

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Effect of Chemistry of the Redispersible Latex Powder (RDP) in Use

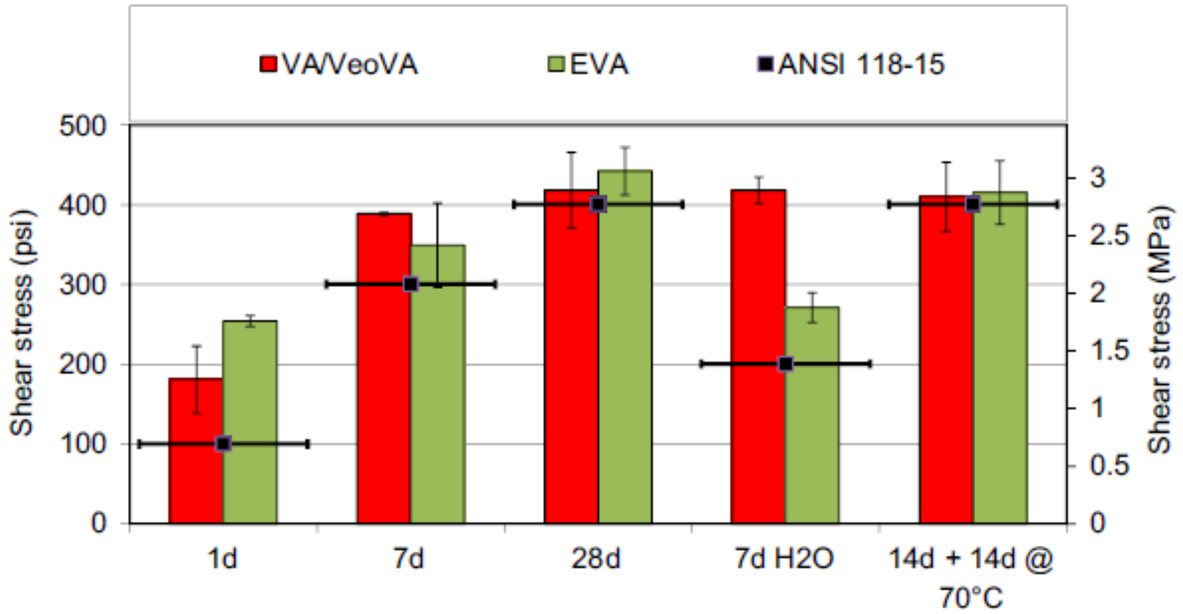

Fig. 2. Ceramic tile to tile shear stress values on the mortars proportioned with 2 wt% of either a VA/VeoVA or a EVA-based redispersible powder.

Effect of Cement Dosage at Constant W_{eff}/C Ratio

- **W_{eff}: mass of efficient water**
- No sagging was observed, and the measured viscosities were 76,000 and 100,000 mPa.s, respectively.

Table 3
Formulation with different cement dosages at constant *Weff/C* ratio.

Raw materials	Mix design 1, wt%	Mix design 2, wt%
Cement type II–V	36.8	32.82
Siliceous sand (50–100 mesh, 150–300 μm)	55.5	62.58
$CaCO_3$	5.17	2
Modified HEMC, viscosity of 15,000 mPa s	0.33	0.25
Starch ether	–	0.1
Calcium formate	0.2	0.3
VA/VeoVA-based RDP	2	2
Water	23	22

Effect of Cement Dosage at Constant W_{eff}/C Ratio

- In mix 2, The increase in viscosity with decreasing cement can be because of addition of starch ether. Hydrocolloids rate increases from mix 1(0.33 wt%) to mix 2 (0.35wt %)

- Due to the high hydrocolloids rate in mix 2, open time performance is better than mix 1

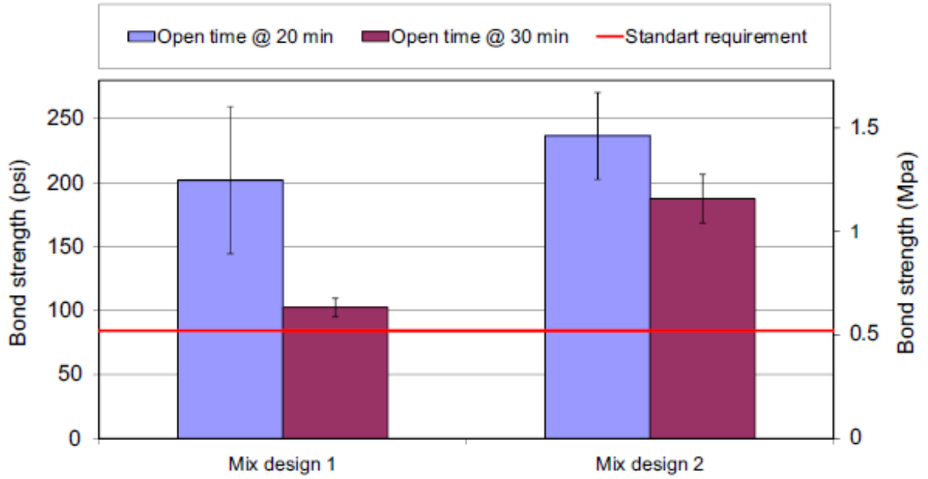

Fig. 4. 20 and 30 min open time bond strength measured at 28 days on the mortars proportioned with different cement dosage at constant *Weff*/C.

Effect of Cement Dosage at Constant Weff/C Ratio

- Higher shear stress values were obtained on the mix design 1 due to higher cement content at early ages (up to 7 days, independently of the curing conditions).

- At 28 days, shear stress values of two mortars exhibits similar in terms of co-matrix development both mortars' microstructure almost identical.

Effect of Cement Dosage at Constant Weff/C Ratio

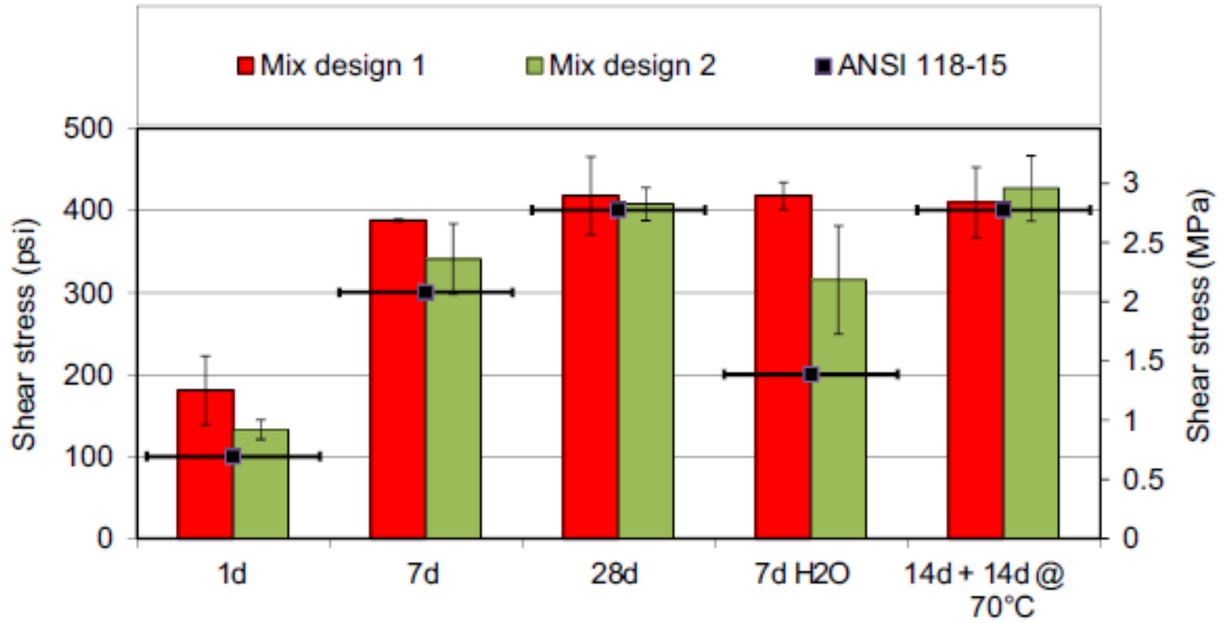

Fig. 5. Ceramic tile to tile shear stress values on the mortars proportioned with different cement dosages at constant *Weff/C*.

Effect of the Cellulose Ether Content

- Mortars viscosities measured as 38,000, 50,000 and 54,000 mPa.s from with cellulose ether dosage of 0.2 wt%, 0.25 wt% and 0.3 wt%, respectively.

Table 4
Formulation with different cement dosage at constant *Weff/C* ratio.

Raw materials	wt%
Cement type II–V	32.82
Siliceous sand (50–100 mesh, 150–300 μm)	To 100
$CaCO_3$	2
Modified HEMC, viscosity of 15,000 mPa s	0.2/0.25/0.3
Starch ether	0.1
Calcium formate	0.3
VA/VeoVA-based RDP	2
Water	22

Effect of the Cellulose Ether Content

- If hydrocolloids amount is low, too thin protective surface skin is formed on the top of the mortar. Therefore , enough water for hydration cannot be provided because of evaporation which results decrease in bond values.

- If hydrocolloids amount is high, thick hydrocolloid polymer film is formed on mortar. Adhesive performance will decrease due to reduction surface area between cement matrix and the back side of the tile.

Effect of the Cellulose Ether Content

- Maximum open time performance is observed on a mortar proportioned with optimum hydrocolloids rate (0.25 wt% of cellulose ether and 0.1 wt% of starch ether).

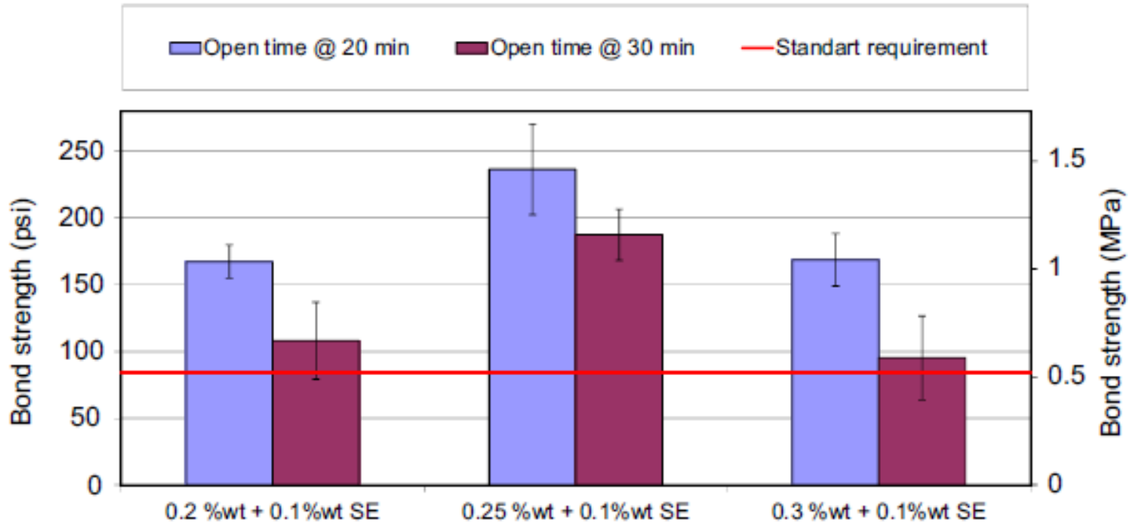

Fig. 7. 20 and 30 min open time bond strength measured at 28 days on the mortars proportioned with different cellulose ether dosages.

Effect of the Cellulose Ether Content

- When the hydrocolloids rate is low, a full contact between the mortar and the tile takes place, leading to better shear stress values with at early ages (1 day).

- After 7 days, there is not enough water retaining admixture in the mixture to release enough water in order to permit good hydration, resulting in low shear stress values when mortar is cured either at room temperature or at 70 °C.

Effect of the Cellulose Ether Content

- When the hydrocolloids rate is high, 1 day shear stress value is low by retarding the hydration of cement (water entrapment), but this high amount of hydrocolloids will increase the 28 day shear stress values by gradually delivering water into the mortar when needed in order to continue the hydration reaction of the cement.

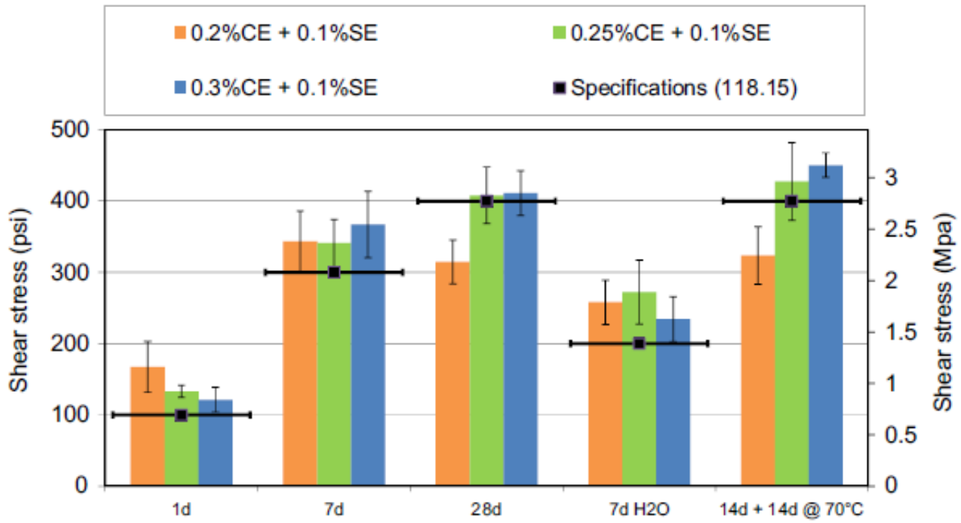

Fig. 8. Ceramic tile to tile shear stress values on the mortars proportioned with different cellulose ether dosages.

Effect of the Cellulose Ether Content

An optimum dosage of hydrocolloids should be found to balance these two effects, and this optimum value was seem to be 0.25 wt% of cellulose ether and 0.1% of starch ether in the tested mix design.

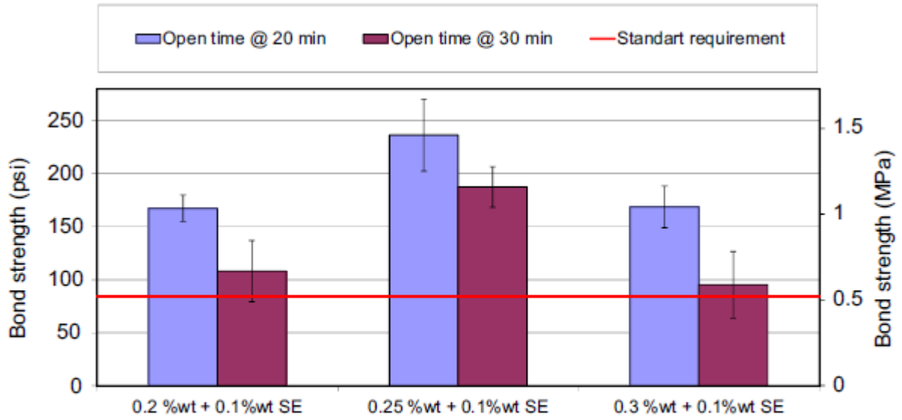

Fig. 7. 20 and 30 min open time bond strength measured at 28 days on the mortars proportioned with different cellulose ether dosages.

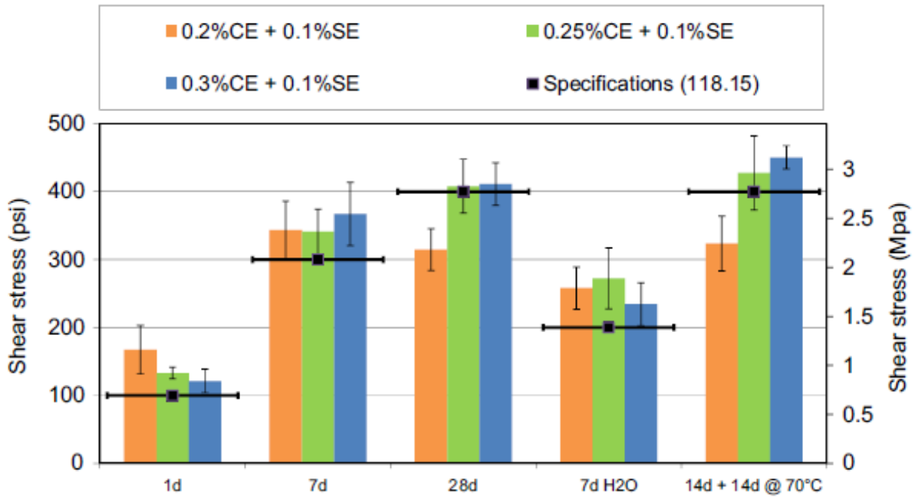

Fig. 8. Ceramic tile to tile shear stress values on the mortars proportioned with different cellulose ether dosages.

Effect of the RDP Content

- Viscosities decreased with increase of RDP value from 2 to 3 (wt%) due to plasticizing effect of RDP in fresh mortar.

- Also due to water retention efffect of RDP, the wetting ability was slightly enhance with increase in wt% of RDP. (%70 of covarage embedded in the CTA 30 min).

Table 6
Fresh characteristics obtained on mortars made with variable RDP content.

wt% of RDP	2	2.75	3.5
Viscosity (mPa s)	100,000	96,000	94,000
Specific gravity (g/cm^3)	1.65	1.64	1.64
Wetting ability @ 20 min (%)	75.00	70.0	80.00
Wetting ability @ 30 min (%)	70.00	70.0	75.00

Table 5
Formulation with variable RDP content.

Raw materials	wt%
Cement type II–V	32.82
Siliceous sand (50–100 mesh, 150–300 μm)	To 100
$CaCO_3$	2
Modified methyl hydroxyethyl cellulose, viscosity of 15,000 mPa s	0.25
Starch ether	0.1
Calcium formate	0.3
VA/VeoVA-based RDP	2/2.75/3
Water	22

Effect of the RDP Content

- All of the materials (RDP, starch ether and cellulose ether) effect hydration reactions. Therefore there is a adsorption competition between them.

- Increase in RDP content causes decrease in open time performance as seen figure 10.

- Optimum shear stress value is gathered with 2.75%wt. RDP.

Effect of the RDP Content

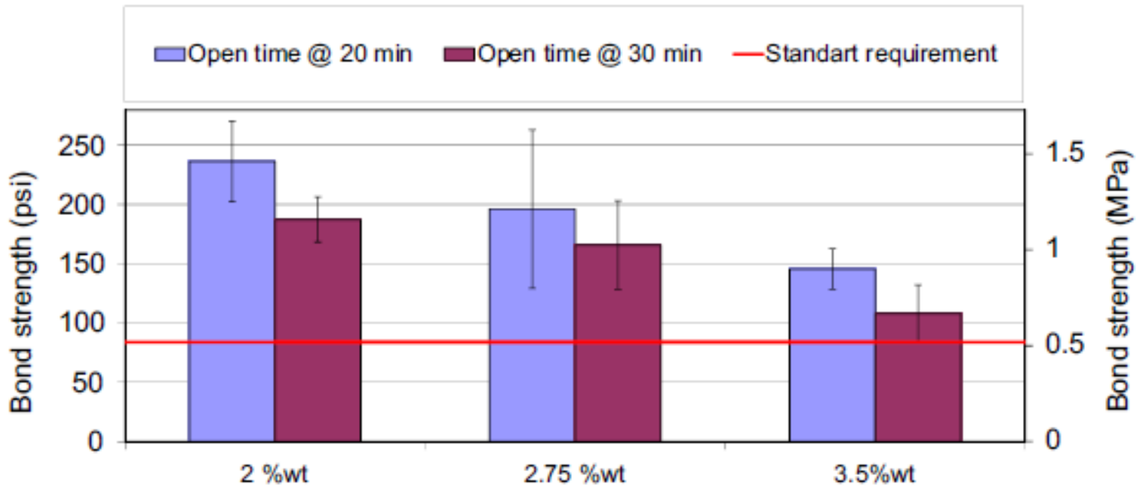

Fig. 10. 20 and 30 min open time bond strength measured at 28 days on mortar proportioned with variable RDP rate.

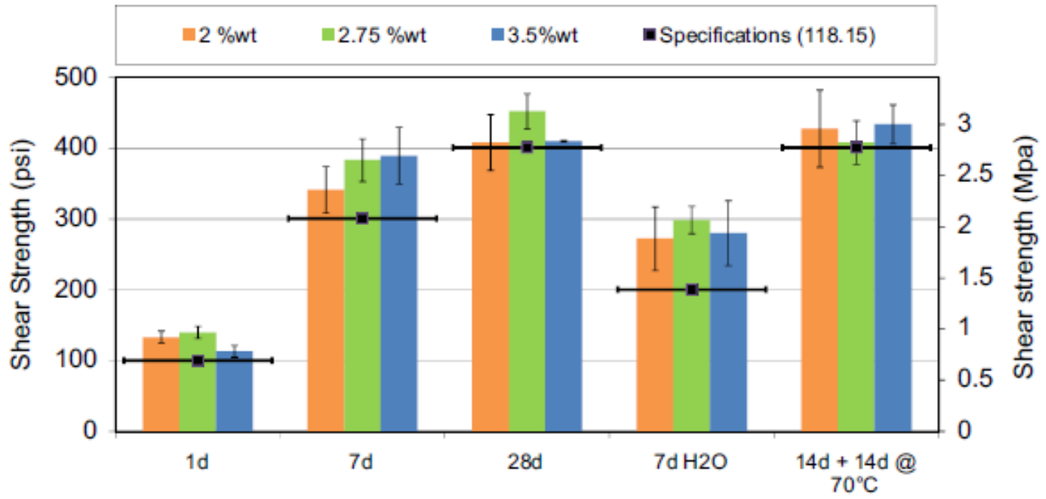

Fig. 11. Shear stress values on ceramic tiles on the lowered cement content mortars proportioned with variable RDP rate.

Effect of the RDP Content

- In general; the higher polymer to cement ratio, the better bond strength.
- Maximum polymer to cement ratio is between 5% and 10% irrespective to the polymer type.
- Polymer dosage of 2.75 wt% , polymer to cement ratio 8.38 wt%, in accordance with literature. Therefore, it is normal to get an overall maximum slant shear value when the RDP dosage is of 2.75 wt%, corresponding to a polymer to cement rate of 8.38 wt%

Conclusions

- The chemistry of the redispersible powder in use will affect only shear stress values at early ages when samples are dry cured.

- VA/VeoVA based RDPs enhance the wet shear stress of cementitious tile adhesives due to their long α-alkyl side chain.

- A decrease in cement content can be incorporated into the mix design with no detrimental impact on the overall performances of the mortar when the ratio of efficient water to cement is kept constant.

Reference

- j.Y. Petit, B.Comelli, R. Perrin, E.Virguin, Effect of formulation parameters on adhesive properties of ANSI 118-15 and 118-11 compliant tile adhesive mortars , International Journal of Adhesion & Adhesive, 66(2016)73–80.

For Further Information…

Cement Research and Application Center

Toroslar Mah. Tekke Cad.

33013 Yenitaşkent- MERSİN TÜRKİYE

T: +90 324 241 23 37

C: +90 531 373 97 70

F: +90 324 454 00 52

e-mail : m.sucu@cimsa.com.tr

t.delibas@cimsa.com.tr