EVALUATION OF BOND STRENGTH BETWEEN NORMAL CONCRETE AND HPFRC

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- METHODOLOGY
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INTRODUCTION

BACKGROUND OF STUDY

- High performance fiber reinforced concrete(HPFRC) can be applied as repair material because of its properties which is low permeability and it outstanding mechanical properties that may be lead to increasing the adhesion forces between the concrete over layers.
- In recent research, researcher use a surface preparation method and it showed that surface preparation give the best bond strength result
- Curing can also improve ultimate compressive strength, improves resistance to abrasion and reduce surface dusting. Curing allows more water to be made available for the hydration reaction of concrete cement paste that will leads to better strength of concrete

PROBLEM STATEMENT

- HPFRC proposed to be used as repair material for deterioration of concrete structure
- A bond strength between old and new concrete is necessary to be a good bond strength
- Curing and surface preparation method help to achieve excellent bond strength between HPFRC with the surface of normal concrete

OBJECTIVE

To study the effect of surface preparation method (sandblasting, grooves, drill holes) on the bond strength between normal concrete and HPFRC

To study the effect of two different curing method (ambient curing, water curing) on the bond strength between normal concrete and HPFRC

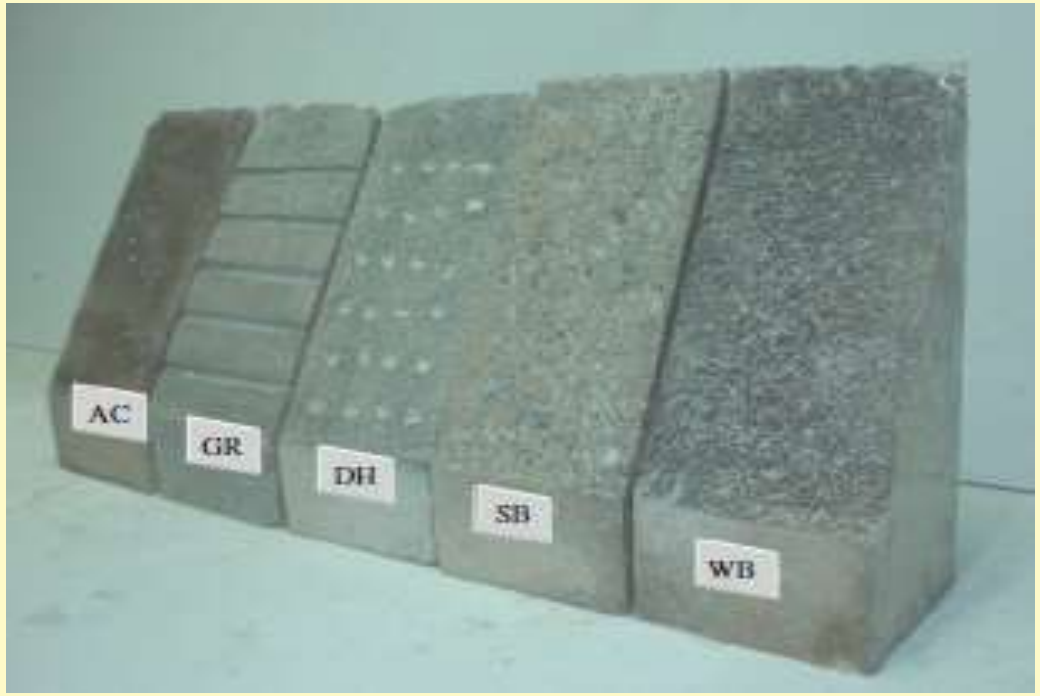
LITERATURE REVIEW

CURING METHOD

Author	Title	Key	Remark
Tayeh, B. A., Bakar, B. H. A., Johari, M. A. M., & Lei, Y. (2012)	Mechanical and permeability properties of the interface between normal concrete substrate and UHPFC overlay.	Water curing Steam curing	• Normal concrete has been cured by using water curing method at room temperature 27±2°C for two days • Undergo surface preparation, then cured for 28 days.
Al-Hallaq (2014)	Bond, I., Between, S., & Over, C. (n.d.). Improving Bond Strength Between Concrete Over Layers	Water curing	• Normal concrete was left in the mold and coated by plastic sheet for seven days. • Normal concrete was removed from mold and left at room temperature (23 ± 4 °C) for 120 days
Gnanavenkatesh, S., Arun, M., & Arunachalam, N. (2014)	Effects on Concrete Strength by Three Types of Curing Methods	• Immersion curing, • Wet gunny bag curing • Accelerated warm water curing	• Normal concrete grade that has been used in this study are M20 and M40 • Immersion curing achieved high compressive strength for both grade.

SURFACE PREPARATION

Author	Title	Key	Remark
Tayeh, B. A., Abu Bakar, B. H., Megat Johari, M. A., & Voo, Y. L. (2013a).	Evaluation of bond strength between normal concrete substrate and ultra high performance fiber concrete as a repair material.	• As cast without roughening (AC), • Sand blasting (SB), • Wire brushing(WB) • Drill holes (DR) • Grooves (GR)	• Sand blast has highest slant shear strength • Sand blasting specimen has acceptable bond strength according to The ACI Concrete Repair Guide
Safritt, M. (2015).	Bond Interface Strength between Ultra High Performance Concrete and Normal Concrete	• As cast without roughening • Sandblasting • Etched with hydrochloric acid.	• Sandblasting has highest slant shear strength and splitting tensile strength
Al-Hallaq (2014)	Bond, I., Between, S., & Over, C. (n.d.). Improving Bond Strength Between Concrete Over Layers	• casting substrata surface against steel formwork • mechanical wire brush for 10 min/m2 • Scarifying • Scabbling	• Scabbling method has highest split tensile test and slant shear test.
Júlio, E. N. B. S., Branco, F. A. B., & Silva, V. D. (2014).	Concrete-to-concrete bond strength. Influence of the roughness of the substrate surface.	• cast against steel formwork • surface prepared with steel brush • surface partially chipped • surface partially chipped plus water saturation 24hours • surface treat with sand blast.	• Result of slant shear test shows sand blast has highest slant shear strength among the others.


AC
GR
DH
SB
WB

Bond strength between normal concrete and HPFRC

Author	Title	Remark
Tayeh, B. A., Bakar, B. H. A., Johari, M. A. M., & Lei, Y. (2012)	Mechanical and permeability properties of the interface between normal concrete substrate and UHPFC overlay	Properties of UHPFRC is low permeability and it outstanding mechanical properties, have advanced and built up a core idea of using UHPFC to restore and strengthen zones where structures are presented to high mechanical loadings and in addition on account of extreme natural presentation conditions
Hussein, L., & Amleh, L. (2015).	Structural behavior of ultra-high performance fiber reinforced concrete-normal strength concrete or high strength concrete composite members	UHPFRC and normal strength concrete/high strength concrete bond strength between them was considerably high without addition of shear connector. UHPFRC has very high strength and very low permeability compared to normal strength concrete that make its suitable for be a new repair material
Askar, L. K., Tayeh, B. A., & Bakar, B. H. A. (2013).,	Effect of Different Curing Conditions on the Mechanical Properties of UHPFC,	UHPFRC has an outstanding mechanical and durability make it ideal for developing new solution to pressing concern on highway deterioration, repair and replacement and it widely used nowadays. It shows that UHPFRC has a good bond strength with normal concrete

SLANT SHEAR TEST

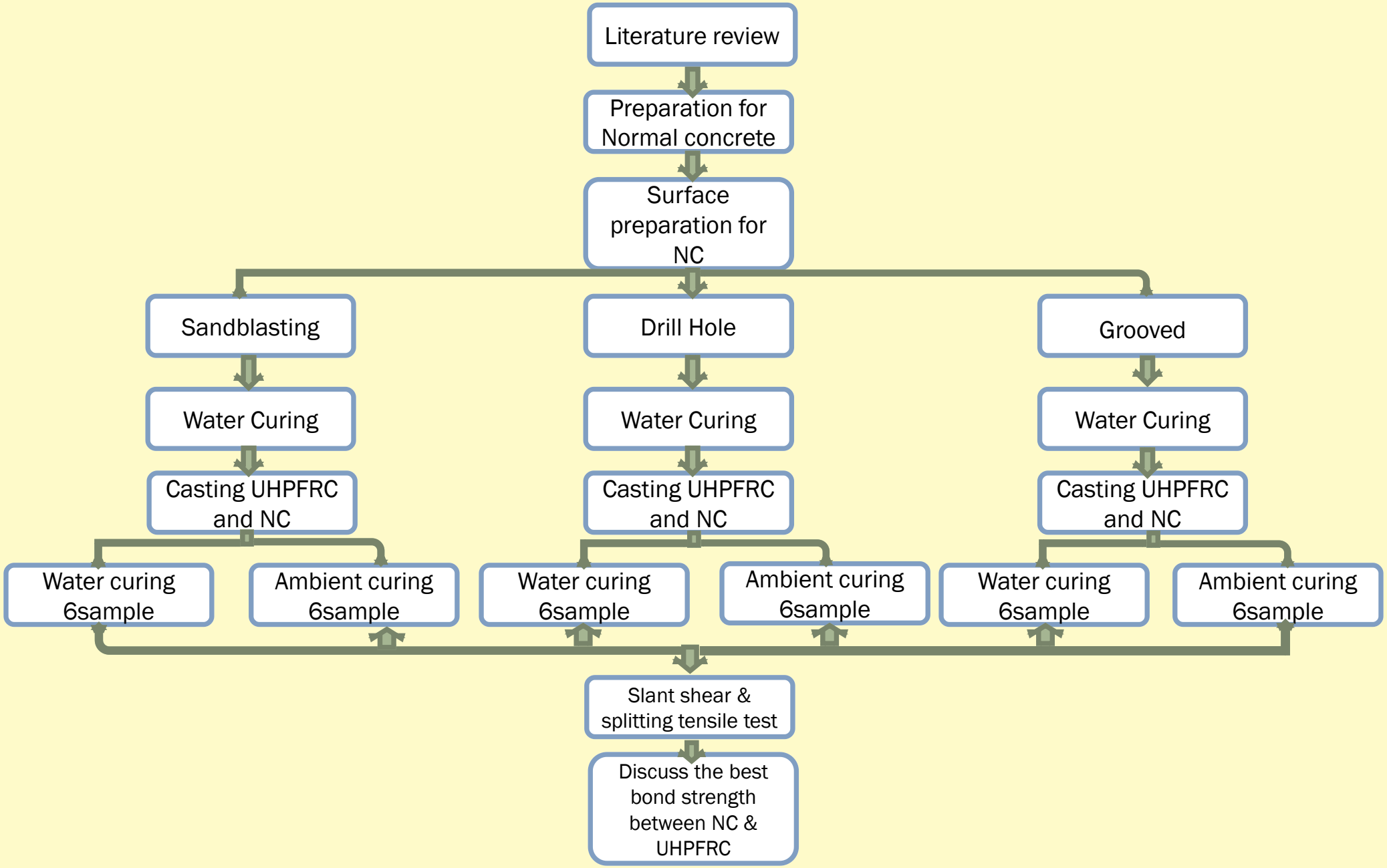
	Slant shear strength(MPa)					
Surface preparation References	As cast without roughening	Grooved	Drill Holes	Sandblast	Wire Brush	HCl etched
Tayeh et al., 2013	8.39	13.63	11.99	17.74	12.15	-
Tayeh et al., 2012	8.68	13.92	12.27	17.81	12.75	-
Saffrit 2015	11.96	-	-	14.68	-	11.89

SPLITTING TENSILE TEST

	Split tensile strength(MPa)					
Surface preparation References	As cast without roughening	Sandblasting	Wire brush	Grooved	Drill hole	HCl Etched
Tayeh et al., 2013	1.82	3.68	2.77	3.11	2.50	-
Tayeh et al., 2012	1.85	3.24	2.60	3.79	2.96	-
Saffrit, 2015	20.92	35.74	-	-	-	9.56

METHODOLOGY

FLOWCHART


Literature review
Preparation for Normal concrete
Surface preparation for NC
Sandblasting
Drill Hole
Grooved
Water Curing
Water Curing
Water Curing
Casting UHPFRC and NC
Casting UHPFRC and NC
Casting UHPFRC and NC
Water curing 6sample
Ambient curing 6sample
Water curing 6sample
Ambient curing 6sample
Water curing 6sample
Ambient curing 6sample
Slant shear & splitting tensile test
Discuss the best bond strength between NC & UHPFRC

MIX PROPORTION FOR NORMAL CONCRETE

Material	Course Aggregate	Fine Aggregate	Portland Cement	Water
Proportion (kg) for $1m^3$	590	1090	470	235
Proportion (kg) for $0.041m^3$	24.19	44.69	19.27	9.64

MIX PROPORTION FOR HPFRC

Constituent	Type of material	Proportion(kg)
Portland cement	Type CEM1- strength class 52.5R	12
Fine aggregate	150-300μm	0.6
	300-600 μm.	1.5
Water	Potable water	2.4
Superplasticizer	polycarboxylate ether based (PCE)	0.6
Silica fume	Micro Silica	6.0
Steel fiber	6mm	1.21
	14mm	0.4

Prismatic beam 100mm x100mm x 300mm

Cylinder 100mmx 200mm

Sandblasting

Drill Hole

Grooved

Sandblasting

Grooved

Drill Hole

Preparation of HPFRC

Fine sand size 300-600 μm

Silica fume

Sand 150-300 μm and cement

Steel fiber 6mm & 14mm

Water

Superplasticizer

Testing

Slant Shear Test

ASTM-C822 (1999). Standard Test Method for Bond Strength of Epoxy-Resin System Used with Concrete by Slant Shear

Splitting Tensile Test

ASTM C496: Splitting Tensile Strength of Cylindrical Concrete Specimens

RESULT AND DISCUSSION

Bond Strength Between Normal Concrete and HPFRC

- Slant Shear Strength

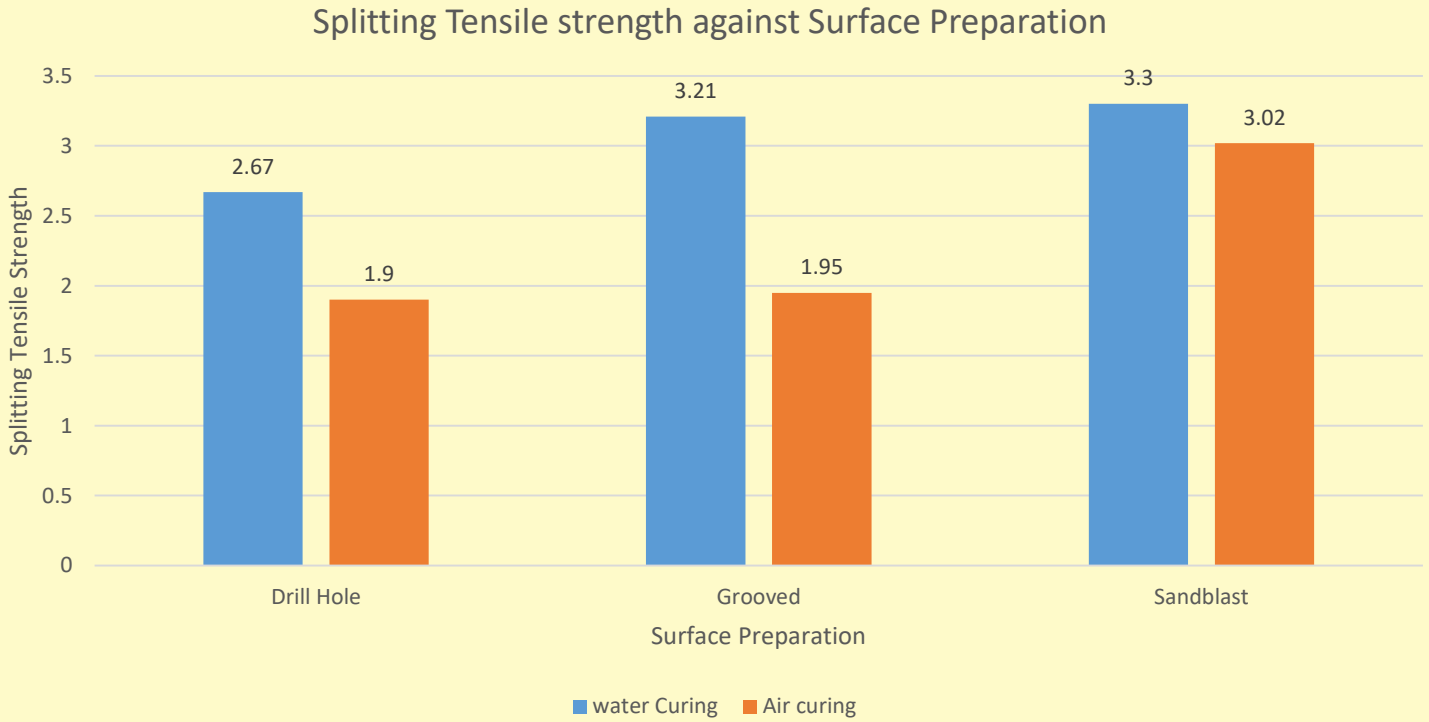
Surface treatment	Curing method	Sample	Shear Stress S(MPa)	Average S_{av} (MPa)	Failure mode
Grooved	Water curing (WC)	GV1	11.32	12.30	C
		GV2	13.30		C
		GV3	12.28		C
	Air Curing (AC)	GV1	13.66	10.64	C
		GV2	7.90		C
		GV3	10.35		C
Drill hole	Water curing (WC)	DH1	12.46	10.90	B
		DH2	9.20		C
		DH3	11.05		C
	Air Curing (AC)	DH1	10.84	9.29	B
		DH2	6.03		B
		DH3	11.00		C
Sandblast	Water curing (WC)	SB1	15.94	15.16	C
		SB2	13.02		C
		SB3	16.51		D
	Air Curing (AC)	SB1	16.29	11.42	C
		SB2	10.02		C
		SB3	7.96		C

- Sandblasting surface preparation method gives the highest shear strength as compared to another two surface preparation.
- The slant shear strength was affected by the roughen surface of specimen.
- The more roughen surface preparation, the higher the bond strength between the normal concrete and UHPFRC

- Water curing shows higher result than ambient curing for each surface preparation.
- Water curing type allows more water to be made available for hydration reaction of concrete cement paste since this method require the concrete specimen to be immersed into water

Splitting Tensile Strength

Surface treatment	Curing method	Sample	Tensile Stress T(MPa)	Average T_{av} (MPa)	Failure mode
Grooved	Water curing (WC)	GV1	3.98	3.21 (Excellent)	C
		GV2	2.79		B
		GV3	2.85		C
	Air Curing (AC)	GV1	1.12	1.95 (very good)	B
		GV2	2.23		B
		GV3	2.49		B
Drill hole	Water curing (WC)	DH1	2.90	2.67 (Excellent)	B
		DH2	1.88		B
		DH3	3.22		B
	Air Curing (AC)	DH1	2.04	1.90 (very good)	B
		DH2	2.19		B
		DH3	1.63		B
Sandblast	Water curing (WC)	SB1	4.06	3.30 (Excellent)	C
		SB2	3.01		C
		SB3	2.83		C
	Air Curing (AC)	SB1	3.15	3.02 (Excellent)	C
		SB2	3.34		C
		SB3	2.57		C



- Sandblasting has the higher splitting tensile strength and drill hole is the lowest.
- The more roughened surface of specimen, the higher the bond strength.
- According to Springkel (2000), the bond strength between normal concrete and UHPFRC in this study is in the range of very good to excellent.
- Water curing gives higher result of bond strength.

CONCLUSION

CONCLUSION

- The result of slant shear test and splitting tensile test proved that the bond strength between normal concrete and UHPFRC is significantly depends on the surface preparation method of the specimen. The higher the surface roughened the higher the bond strength. In this study, sandblast is the highest bond strength achieved.
- The slant shear result shown that sandblasting is the highest compared to other to surface preparation method. The bond strength of sandblasting is acceptable of the bond requirement at 28 days as specified by the ACI guideline (Chynoweth,1996).
- The bond strength between normal concrete and HPFRC in this study is in the range of very good to excellent. The splitting tensile test shown that sandblasting method is the highest compared to another two surface preparation method.
- Curing method also influence the bond strength of the composite concrete. In this study, water curing gives the higher result compared to air curing

THANK YOU ☺