Local Material Samboja Sand in East Kalimantan: Utilization with Fiber Reinforced Polymer Jacketing as an Effort to Increase the Concrete Strength

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Abstrak

Balikpapan sebagai pintu gerbang Kalimantan Timur merupakan kota yang sedang berkembang pesat. Kebutuhan akan beton dengan kuat tekan yang lebih tinggi dapat timbul pada masa yang akan datang pada proyek-proyek besar di Balikpapan. Tujuan dari penelitian ini adalah untuk mendapatkan inovasi pemanfaatan material lokal pasir Samboja sebagai campuran beton dengan penambahan Fiber Reinforced Polymer sehingga dihasilkan peningkatan kekuatan beton. Dalam penelitian ini digunakan 18 benda uji dengan 3 kelompok (original, partly jacketing dan fully jacketing) dan 6 variasi (AN, ANC2, ANC3, ANC5, ANC6 dan ANCF). AN: beton normal, ANC2: beton dengan tebal CFRP 2 cm, ANC3: beton dengan tebal CFRP 3 cm, ANC5: beton dengan tebal CFRP 5 cm, ANC6: beton dengan tebal CFRP 6 cm, ANCF: beton dengan tebal CFRP keseluruhan. Besar kuat tekan beton rata-rata adalah 16,06 MPa; 21,89 MPa; 17,36 MPa; 25,48 MPa; 25,86 MPa dan 26,04 MPa untuk benda uji AN, ANC2, ANC3, ANC5, ANC6 dan ANCF. Prosentase kenaikan kuat tekan beton untuk benda uji ANC2, ANC3, ANC4, ANC5 dan ANC6 adalah 36,47%; 8,24%; 58,82% dan 61,18% terhadap benda uji AN.

Kata Kunci : Fiber Reinforced Polymer (FRP), Jacketing, Kuat Tekan Beton dan Material Lokal

Abstract

Balikpapan, as the gate of East Kalimantan province, grows rapidly within decade. The need of concrete that has higher strength can appear in large construction projects in Balikpapan. This research aim to get innovation of implementing Samboja Sand in concrete with the addition of Fiber Reinforced Polymer, as a result the higher concrete strength can be achieved. This study used 18 specimens with 3 groups: original, partly jacketing and fully jacketing, and 6 variations: (AN, ANC2, ANC3, ANC5, ANC6 and ANCF). AN: normal concrete, ANC2: concrete with additional CFRP 2 cm in width, ANC3: concrete with additional CFRP 3 cm in width, ANC5: concrete with additional CFRP 5 cm in width, ANC6: concrete with additional CFRP 6 cm in width, ANCF: concrete with CFRP fully jacketing. The results of the study are as follow: average concrete strength are 16,06 MPa; 21,89 MPa; 17,36 MPa; 25,48 MPa; 25,86 MPa dan 26,04 MPa for AN, ANC2, ANC3, ANC5, ANC6 and ANCF specimens. The percentage of concrete strength increment for specimen ANC2, ANC3, ANC4, ANC5 and ANC6 are 36,47%; 8,24%; 58,82% and 61,18% compared to AN specimen.

Key words: Fiber Reinforced Polymer (FRP), Jacketing, Concrete Strength and Local Material

1. Background

Balikpapan which is East Kalimantan gate is a rapid growing city. As an industrial city, it has a large number of construction projects such as housing and transportation sectors. The need of concrete that has higher strength can appear in the future for those projects in Balikpapan. This situation is not well supported, because the high budget for sending materials from other places. As a result, it demands the academic local people to find a solution in regard with local materials utilization for fulfill the need of construction projects these days. Previous study about local material used in concrete, Samboja Sand, proved that it fulfills criterias to be construction material (Sunarno, 2009). Furthermore, one of additives that can be added to concrete in order to increase its strength is Fiber Reinforced Polymer (FRP). FRP that was be used in this study is Carbon Fiber Reinforced Polymer (CFRP).

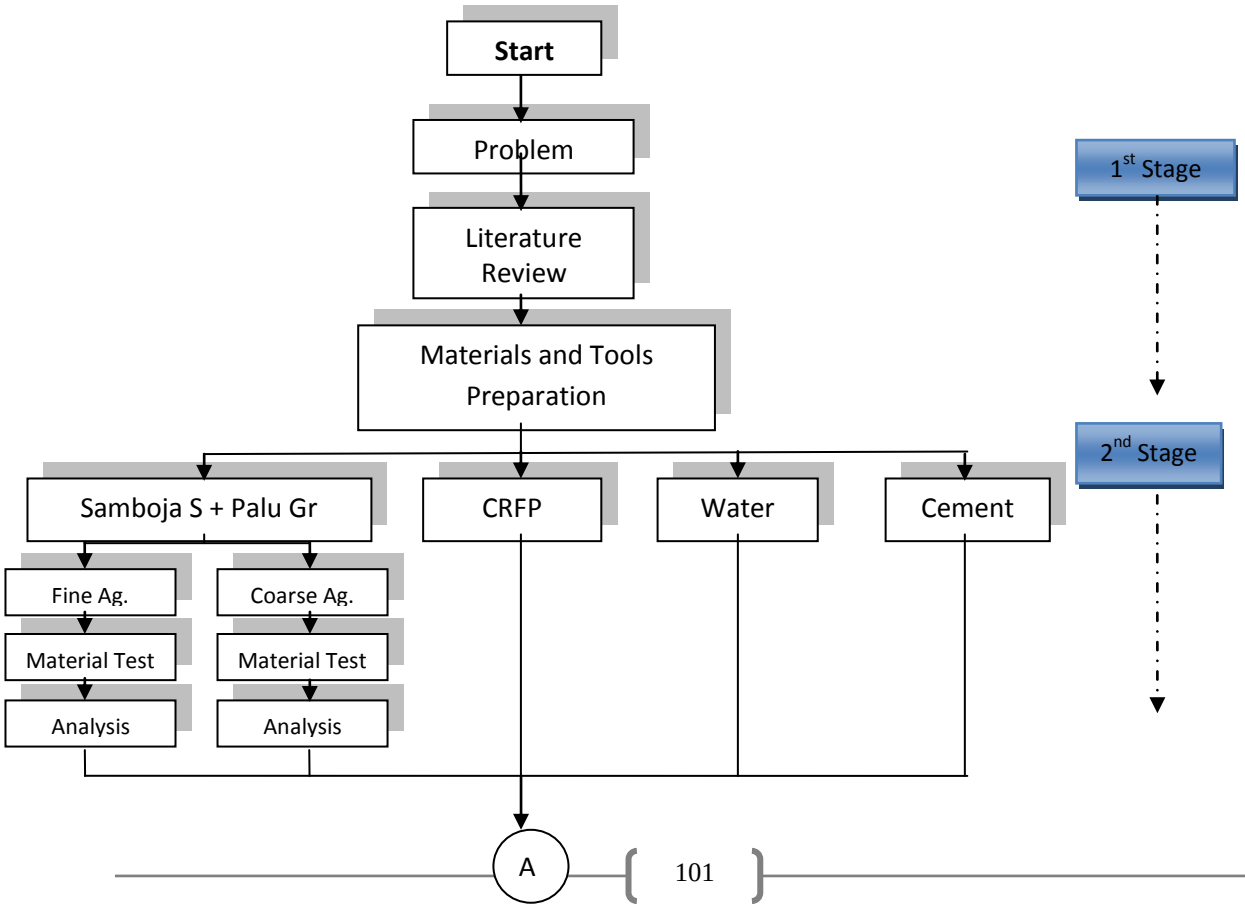
Carbon fiber is defined as fiber that contains at least 90% carbon weight. Fiber used is fiver graphite which has carbon more than 95% in weight. The most common material used for carbon are poliakrilonitril (PAN), petroleum, viscose rayon and certain fiber phenolic . Carbon fiber composit is suitable for application that must meet requirements such as strength, durability and fatigue resistance. Not like glass fiber, carbon also can be applied in high temperature and humid condition. The positive and negative aspects of CFRP can be seen as follow:

Table 1. Benefits and Drawbacks of CFRP (Gangarao, 2007)

Carbon Fiber	
Benefit	**Drawback**
- High tensile strength-weight ratio - High tensile modulus-weight ratio - Low linear thermal expansion - High fatigue resistance	- Expensive - More fragile - Electrically conductive

2. Research Methodology

This research was done in Material Laboratory of Civil Engineering Department, Balikpapan State Polytechnic. The methodology used is described as follow:



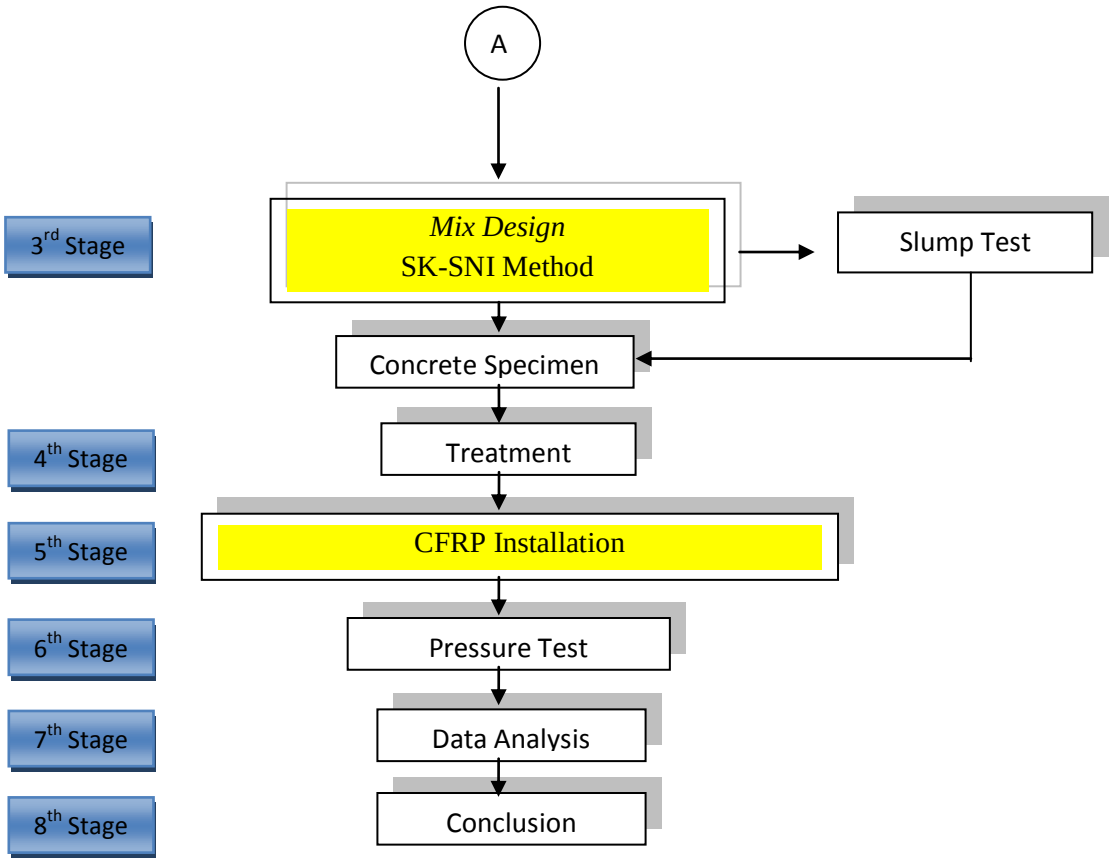


Figure 1. Research Flow

The study uses 18 cylinder specimens which have 30 cm in height and 15 cm in diameter. The making of specimen used manual method for mixing all materials by using pan and shovel. Specimens divide to 6 variations as described in table 2.

Table 2. Specimen Details

Specimen Groups	Variation Types	No. of Specimens	Name Code
Original	Normal Concrete	3	AN1 - AN3
Partly Jacketing	CFRP width : 2 cm	3	ANC21 - ANC23
	CFRP width : 3 cm	3	ANC31 - ANC33
	CFRP width: 5 cm	3	ANC51 - ANC53
	CFRP width: 6 cm	3	ANC61 - ANC63
Fully Jacketing	CFRP on all surfaces	3	ANCF1 - ANCF3
Total benda uji		**18**	

CFRP installed to the specimens of partly and fully jacketing was be done 7 days before the pressure test, to ensure the concretes have the optimum treatments, and to ensure CFRP applications were been well installed.

Concrete pressure tests were done in order to know the strength of concretes that contain Samboja

Sand and Palu Gravel with additional CFRP jacketing. The tests were be done when the concrete aged 28 days with the variations of the CFRP width are 2 cm, 3 cm, 5 cm, 6 cm and full jacketing. The specimens are 3 cylinders for each variation. Figure 2 to figure 4 show the specimens used in the research.

Figure 2. Original Specimen AN

(a)

(b)

(c)

(d)

Figure 3. Partly Jacketing Specimens : (a) ANC2; (b) ANC3; (c) ANC5; dan (d) ANC6

Figure 4. Fully Jacketing ANCF Specimen

3. Result and Discussion

The pressure test results for 6 specimen variations can be seen in table 3.

Table 3. Concrete Pressure Test Result

Specimen Group	Variation Type	Specimen	Weight (kg)	P (KN)	Concrete Strength f'c (MPa)	Ave. Concrete Strength (MPa)
Original	Beton normal	AN1	12,62	300	16,99	16,04
		AN2	12,36	230	13,02	
		AN3	12,41	320	18,12	
Partly Jacketing Concrete	Tebal CFRP : 2 cm	ANC21	12,48	340	19,25	21,89
		ANC22	12,62	420	23,78	
		ANC23	12,70	400	22,65	
	Tebal	ANC31	12,59	340	18,12	17,36

	CFRP : 3 cm	ANC32	12,65	300	16,99	
		ANC33	12,62	300	16,99	
	Tebal CFRP : 5 cm	ANC51	12,40	300	16,99	25,48
		ANC52	12,66	500	28,31	
		ANC53	12,56	400	22,65	
	Tebal CFRP : 6 cm	ANC61	12,51	450	25,48	25,86
		ANC62	12,53	450	25,48	
		ANC63	12,50	470	26,61	
Fully Jacketing Concrete	Tebal CFRP keseluruhan	ANCF1	12,82	470	26,61	26,04
		ANCF2	12,79	450	25,48	
		ANCF3	12,63	400	22,65	

It can be seen from table 3 the average concrete strength are 16,04 MPa; 21,89 MPa; 17,36 MPa; 25,48 MPa; 25,86 MPa and 26,04 MPa The ANC3 specimen has lower concrete strength compared to ANC2, even though it still has higher concrete strength compared to AN, which is 17,36 MPa. This happened because the lack of accuracy when the pressure test was been done regarding the center of the cylinder was not in line with the center of the pressure machine. Furthermore, the low concrete strength of ANC3 specimen, especially ANC32 and ANC33 were impacted by the broken of CFRP overlap due to less accuracy when it was installed.

(a)

(b)

(c)

Figure 5. Pressure Test Results : (a) Original; (b) Partly jacketing; dan (c) *Fully Jacketing*

For specimens with fully and partly jacketing, the damage occurred after the CFRP broken off. In specimen with fully jacketing can be seen that the concrete inside CFRP have already damaged, but it still restrained by the CFRP.

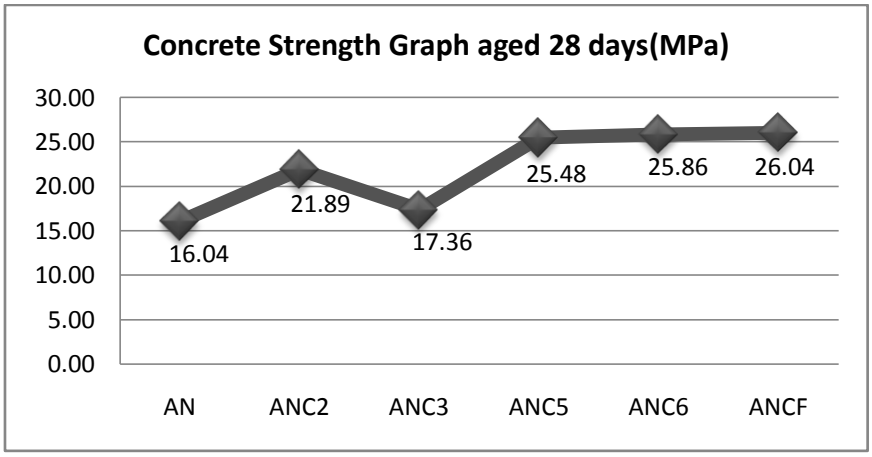


Figure 5. Concrete Strength aged 28 days

Graph 5 illustrates that with additional CFRP, the concrete strengths tend to increase.

The wider the CFRP, the higher the concrete strength increase

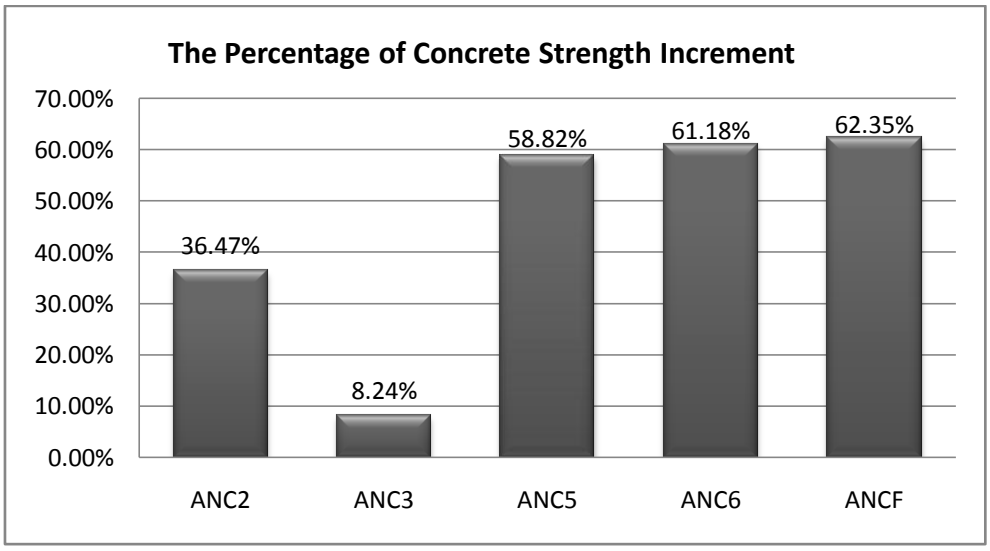


Figure 6. Percentage of Concrete Strength Increment

Figure 6 shows the percentage of the concrete strength increment. The average increments compared to original specimen are 36,47%; 8,24%; 58,82%; 61,18% and 62,35% for the specimens ANC2, ANC3, ANC5, ANC6 and ANCF respectively. With the additional CFRP installed to the specimen give the increment 36.47%, while the increments between partly jacketing do not show any significant differences. Generally, it can be seen that the width of the CFRP will impact the concrete strength. Speciment with fully jacketing has concrete strength increment significantly which is 10 MPa or increase 62.35 % compared to original concrete.

In this circumstance, CFRP has function as external confinement, so when pressure tests have been done, the cracks of the specimens were still endured by the CFRP. Although CFRP contributes the concrete strength increment, it still needs internal confinement to be optimum. So that, other

research may be done to know the CFRP impact in specimen with internal confinement.

4. Conclusion

Based on the research that has been done in regard to Samboja Sand application, in State Polytechnic of Balikpapan Laboratory, with adding CFRP jacketing for increase concrete strength, it can be summed up as follow:

1. Adding CFRP partly jacketing can increase the concrete strength.
2. The percentage of the concrete strength increment for ANC2, ANC3, ANC4, ANC5 and ANC6 specimens are 36,47%; 8,24%; 58,82% and 61,18% respectively, compared to AN specimen.
3. The increment of concrete strength for CFRP fully jacketing is higher compared to those with partly jacketing. The percentage of the increment is 62,35% compared to AN specimen.

5. Aknowledgement

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