DAFTAR PUSTAKA

ACI 440.1R-03. 2003. “Guide for the Design and Construction of Concrete Reinforced with FRP Bars.” *ACI committee 440* 88: 1–6.

ACI 440.1R-06. 2003. “Guide for the Design and Construction of Concrete Reinforced with FRP Bars Reported by ACI Committee 440.” *ACI committee 440*: 1–42.

ACI 440.2R-08. 2008. ACI committee 440 *Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structures*.

ACI Committee 318. 2008. 2007 American Concrete Institute *Building Code Requirements for Structural Concrete (ACI 318-08)*.

Adam, Maher A., Mohamed Said, Ahmed A. Mahmoud, and Ali S. Shanour. 2015. “Analytical and Experimental Flexural Behavior of Concrete Beams Reinforced with Glass Fiber Reinforced Polymers Bars.” *Construction and Building Materials* 84(July): 354–66.

Alsayed, S. H., Y. A. Al-Salloum, and T. H. Almusallam. 2000. “Performance of Glass Fiber Reinforced Plastic Bars as a Reinforcing Material for Concrete Structures.” *Composites Part B: Engineering* 31(6–7): 555–67.

ASTM D7205/D7205. 2006. “Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars.” *American Standard of Testing Materials* i.

ASTM E8/E8M-09. 2010. “Standard Test Methods for Tension Testing of Metallic Materials.” *American Standard of Testing Materials* (C): 1–27.

Baena, Marta, Lluís Torres, Albert Turon, and Cristina Barris. 2009. “Experimental Study of Bond Behaviour between Concrete and FRP Bars Using a Pull-out Test.” *Composites Part B: Engineering* 40(8): 784–97.

Baggio, Daniel, Khaled Soudki, and Martin Noël. 2014. “Strengthening of Shear Critical RC Beams with Various FRP Systems.” *Construction and Building Materials* 66: 634–44.

Balafas, I., and C. J. Burgoyne. 2010. “Environmental Effects on Cover Cracking Due to Corrosion.” *Cement and Concrete Research* 40(9): 1429–40.

Barris, C. et al. 2009. “An Experimental Study of the Flexural Behaviour of GFRP RC Beams and Comparison with Prediction Models.” *CompositeStructures*91(3):286–95.

Benmokrane, Brahim, O Chaallal, and R Masmoudi. 1995. “Glass Fibre Reinforced Plastic (GFRP) Rebars for Concrete Structures.” *Construction and Building Materials* 9(6): 353–64.

Bywalski, Czesław, Michał Drzazga, Mieczysław Kamiński, and Maciej Kaźmierowski. 2016. “Analysis of Calculation Methods for Bending Concrete Elements Reinforced with FRP Bars.” *Archives of Civil and Mechanical Engineering*.

Cai, Jingming, Jinlong Pan, and Xiangming Zhou. 2017. “Flexural Behavior of Basalt FRP Reinforced ECC and Concrete Beams.” *Construction and Building Materials* 142: 423–30.

CAN/CSA-S6-14. 2014. “Canadian Highway Bridge Design Code.” *CSA (Canadian Standards Association)*.

Chennareddy, Rahulreddy, and Mahmoud M. Reda Taha. 2017. “Effect of Combining Near-Surface-Mounted and U-Wrap Fiber-Reinforced Polymer Strengthening Techniques on Behavior of Reinforced Concrete Beams.” *ACI Structural Journal* 114(3). http://www.concrete.org/Publications/InternationalConcreteAbstractsPortal.aspx?m=details&i=51689443.

Djamaluddin, Rudy. 2013. “Flexural Behaviour of External Reinforced Concrete Beams.” *Procedia Engineering* 54: 252–60.

El-Nemr, Amr, Ehab A. Ahmed, Adel El-Safty, and Brahim Benmokrane. 2018. “Evaluation of the Flexural Strength and Serviceability of Concrete Beams Reinforced with Different Types of GFRP Bars.” *Engineering Structures* 173(December 2017): 606–19.

El-nemr, Amr, Ehab Ahmed, and Brahim Benmokrane. 2013. “Flexural Behavior and Serviceability of Normal and High Strength Concrete Beams Reinforced with Glass Fiber Reinforced Polymer Bars.” *ACI Structural Journal* (110): 1077–88.

Jabbar, Shahad AbdulAdheem, and Saad B.H. Farid. 2018. “Replacement

of Steel Rebars by GFRP Rebars in the Concrete Structures." *Karbala International Journal of Modern Science* 4(2): 216–27.

Jaeger, GL, G Tadros, and AA Mufti. 1997. "The Concept of the Overall Performance Factor in Rectangular-Section Reinforced Concrete Beams." In *In: Proc of 3rd Int Symp on Non-Metallic (FRP) Reinforcement for Concrete Structures*, Sapporo, Japan, 551–58.

Maranan, Ginghis, Allan Manalo, Karu Karunasena, and Brahim Benmokrane. 2015. "Bond Stress-Slip Behavior: Case of GFRP Bars in Geopolymer Concrete." *Journal of Materials in Civil Engineering* 27(1): 04014116.

Mousa, Magda I. 2016. "Effect of Bond Loss of Tension Reinforcement on the Flexural Behaviour of Reinforced Concrete Beams." *HBRC Journal* 12(3): 235–41.

Nawi, Edward G. 1998. *Beton Bertulang (Suatu Pendekatan Dasar)*. Bandung: PT. Rafika Aditama.

Osman, Bashir H., Erjun Wu, Bohai Ji, and Suhaib S. Abdulhameed. 2016. "Effect of Reinforcement Ratios on Shear Behavior of Concrete Beams Strengthened with CFRP Sheets." *HBRC Journal*: 1–8.

Park, T., and R. Pauly. 1974. *Reinforced Concrete Structure*. JOHN WILEY & SONS.

Priestley, M J N, G M Calvi, and M J Kowalsky. 2008. "Displacement Based Seismic Design of Structures.Pdf." *Earthquake Spectra* 24(2): 555.

Rolland, Arnaud et al. 2018. “Experimental Investigations on the Bond Behavior between Concrete and FRP Reinforcing Bars.” *Construction and Building Materials* 173: 136–48.

Ruan, Xiangjie et al. 2019. “Flexural Behavior and Serviceability of Concrete Beams Hybrid-Reinforced with GFRP Bars and Steel Bars.”

Saba, A. M.; Sallam, H. E. M; Shahin H. H; Abdel-Raouf H. 2016. “Arrest Of Peeling Cracks In Strengthened RC Beams By Replacing Concrete Cover.” In *Proceedings of the 4th ICCAE Conf.*,.

Salleh, Norhafizah, Abdul Rahman Mohd. Sam, Jamaludin Mohd Yatim, and Mohd. Firdaus bin Osman. 2014. “Flexural Behaviour of Reinforced Concrete Beam with Glass Fiber Reinforced Polymer (GFRP) Bar Strengthened with Carbon Fiber Reinforced Polymer (CFRP) Plate.” *Advanced Materials Research* 1051: 748–51.

Sathyamoorthy.S. 2011. “Rebar Industry in India – A Peek into Emerging Trends in Value Added Rebar.” *Frost & Sullivan Market Insight*. https://www.frost.com/prod/servlet/market-insight print.pag?docid=246233426 (November 9, 2011).

Seo, Soo yeon, Ki bong Choi, Young sun Kwon, and Kang seok Lee. 2016. 10 International Journal of Concrete Structures and Materials *Flexural Strength of RC Beam Strengthened by Partially De-Bonded Near Surface-Mounted FRP Strip*. Elsevier Ltd.

Shaw, Ian, and Bassem Andrawes. 2017. “Repair of Damaged End

Regions of PC Beams Using Externally Bonded FRP Shear Reinforcement." *Construction and Building Materials* 148: 184–94.

SNI 1974. 2011. Badan Standardisasi Nasional Indonesia *Cara Uji Kuat Tekan Beton Dengan Benda Uji Silinder*.

SNI 2052. 2014. "Baja Tulangan Beton." *Badan Standardisasi Nasional Indonesia*.

SNI 2491. 2014. *Metode Uji Kekuatan Tarik Belah Spesimen Beton Silinder*.

SNI 2847. 2002. "Tata Cara Perhitungan Struktur Beton Untuk Bangunan Gedung." *Badan Standardisasi Nasional Indonesia*.

———. 2013. Badan Standardisasi Nasioanal Indonesia *Persyaratan Beton Struktural Untuk Bangunan Gedung*.

SNI 4431. 2011. "Cara Uji Kuat Lentur Beton Normal Dengan Dua Titik Pembebanan." *Badan Standardisasi Nasional Indonesia*.

Thériault, Michèle, and Brahim Benmokrane. 1998. "Effects of FRP Reinforcement Ratio and Concrete Strength on Flexural Behavior of Concrete Beams." *Journal of Composites for Construction* 2(1): 7–16.

Torres-Acosta, Andrés A., Sergio Navarro-Gutierrez, and Jorge Terán-Guillén. 2007. "Residual Flexure Capacity of Corroded Reinforced Concrete Beams." *Engineering Structures* 29(6): 1145–52.

Veljkovic, Ana, Valter Carvelli, Marcin Michal Haffke, and Matthias Pahn. 2017. "Concrete Cover Effect on the Bond of GFRP Bar and Concrete

under Static Loading." *Composites Part B: Engineering* 124.

Vijay, P. V., and GangaRao, H. V. S. 1996. "Unified Limit State Approach Using Deformability Factors in Concrete Beams Reinforced with GFRP Bars." In *Proceedings of the Fourth Materials Engineering Conference, ASCE*, Washington, DC, 657–65.

Wang, Lei et al. 2015. "Effects of Stirrup and Inclined Bar Corrosion on Shear Behavior of RC Beams." *CONSTRUCTION & BUILDING MATERIALS* 98: 537–46.

Wang, Xianlin et al. 2019. "Effect of Concrete Cover on the Bond-Slip Behavior between Steel Section and Concrete in SRC Structures." *Construction and Building Materials* 229: 116855.

LAMPIRAN

Lampiran 1. Perhitungan beban lentur dan beban geser balok BK

Prosedur perhitungan	Nilai	Satuan
Langkah -1		
Momen dan Gaya geser maksimum berdasarkan model pembebanan pada **Gambar 15**.		
M = 0.6P+0.96	-	kNm
D = 0.5P+1.293	-	kN
Langkah -2		
Momen nominal balok BK berdasarkan **Gambar 16**.		
Mutu beton (f'c)	24.5	MPa
Mutu baja (fy)	378.36	MPa
A_s (3D13)	380.03	mm^2
Luas tulangan seimbang $A_{sb} = \beta_1 \frac{f'_c}{f_y} bd \left(\frac{510}{600 + f_y} \right)$	919.49	mm^2
Tinggi blok tekan, $a = \frac{A_s . f_y}{0.85 f'_c b}$	46.03	mm
Momen nominal penampang, $M_n = A_s \cdot f_y \left(d - \frac{a}{2} \right)$	27.411	kNm
Berdasarkan pada langkah-1, didapatkan beban lentur (P_{lentur})	44.08	kN
Gaya geser yang terjadi (V_{max}) berdasarkan beban lentur (P_{lentur})	22.17	kN
Langkah-3		
Gaya geser nominal balok BK berdasarkan **Gambar 15**.		
Kontribusi beton, $V_c = \frac{\sqrt{f'_c}}{6} b_w d$	26.44	kN
Kontribusi tulangan (ϕ8-100), $V_s = \frac{A_v f_y d}{s}$	41.75	kN
Gaya geser nominal ($V_n = V_c + V_s$)	68.19	kN
Berdasarkan pada langkah-1, didapatkan beban Geser (P_{geser})	133.79	kN

Lampiran 2. Perhitungan beban lentur dan beban geser balok BFS dan BFTS

Prosedur perhitungan	Nilai		Satuan
	BFS	BFTS	
Langkah -1			
Momen dan Gaya geser maksimum berdasarkan model pembebanan pada **Gambar 15**.			
M = 0.6P+0.96	-	-	kNm
D = 0.5P+1.293	-	-	kN
Langkah -2			
Momen nominal balok berdasarkan **Gambar 16** dan **Gambar 17**			
Mutu beton ($f'c$)	24.5	24.5	MPa
Regangan ultimit beton (ε_{cu})	0.003	0.003	
Mutu *GFRP bar* (f_{fu})	632.16	632.16	MPa
Modulus elastisitas *GFRP bar* (E_{fl})	43900	43900	MPa
Luas tulangan, A_f (3D13)	380.03	380.03	mm^2
Rasio tulangan, $\rho_f = \frac{A_f}{b \cdot d}$	0.0119	0.0104	
Tegangan dalam tulangan, $f_f = \left[\sqrt{\frac{(E_f \varepsilon_{cu})^2}{4} + \frac{0.85\beta_1 f'_c}{\rho_f} E_f \varepsilon_{cu}} - 0.5 E_f \varepsilon_{cu}\right]$	382.4	412.2	MPa
Momen nominal penampang, $M_n = \rho_f \cdot f_f \left(1 - 0.59 \frac{\rho_f \cdot f_f}{f'_c}\right) bd^2$	27.65	34.22	kNm
Berdasarkan pada langkah-1, didapatkan beban lentur (P_{lentur})	44.50	55.45	kN
Gaya geser yang terjadi (V_{max}) akibat beban lentur (P_{lentur})	22.37	27.85	kN

berlanjut

Lanjutan Tabel 3

Langkah-3			
Gaya geser nominal balok BFS dan BFTS berdasarkan **Gambar 16** dan **Gambar 17**			
Kontribusi beton, $V_c = \frac{2}{5}\sqrt{f'_c}bc$	8.56	9.19	kN
Dimana $c=kd$,	28.85	30.95	mm
$k = \sqrt{(\rho_f n_f)^2 + 2\rho_f n_f} - \rho_f n_f$	0.135	0.127	
Kontribusi tulangan (ϕ8-100), $V_s = \frac{A_v f_y d}{s}$	41.75	-	kN
Kontribusi *GFRP sheet*, $V_f = \frac{A_{fv} f_{fe} d_{fv}}{s}$	-	24.19	kN
dimana: $A_{fv} = 2.n.t_f.w_f$	-	130	mm^2
$f_{fe} = \varepsilon_f E_{f2}$	-	76.39	MPa
Modulus elastis *GFRP sheet* (E_{f2})	-	20900	MPa
Gaya geser nominal ($V_n=V_{c,f}+V_s$) atau ($V_n=V_{c,f}+V_f$)	50.32	33.38	kN
Berdasarkan pada langkah-1, didapatkan beban Geser (P_{geser})	98.06	64.19	kN

Lampiran 3. Tahapan pengecoran balok beton bertulang

(a). Beton Ready Mix

(b) Pengukuran Slump

(c) Penuangan beton ke bekisting

(d) Pemadatan beton

(e)Perataan permukaan balok

(f) Pengambilan sampel uji properti

Lampiran 4. Tahapan pemasangan *GFRP sheet*

(a) Permukaan dikasarkan dan tepi balok dibulatkan

(b) Pembersihan permukaan balok dari debu

(c) Marking posisi tulangan

(d) Pencampuran epoxy resin

(e) Pengolesan epoxy resin ke *GFRP sheet*

(f) Pembuatan acian dari epoxy resin + aerosol

(g) Menutup pori dengan acian epoxy resin+aerosol

(h) Pengolesan epoxy resin ke permukaan balok

(i) Penempelan *GFRP sheet*