SHEAR STRENGTH OF CONCRETE BEAMS REINFORCED WITH GLASS FIBER REINFORCED POLYMER BARS WITHOUT STIRRUPS

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DEDICATION

For my beloved mother Azz Muftah and father Ali Omar,
and all people that help and supported me.
Also to my ever supporting supervisor Prof. Ir. Dr. Abdul Aziz Bin Abdul Samad

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ABSTRACT

The use of fiber reinforced polymer (FRP) bars as an alternative to steel bars for reinforced concrete (RC) structures is gaining acceptance among the structural engineers. The investigation of structure performance of FRP-RC members has become a critical issue. Extensive researches have been conducted to investigate the shear behavior of RC members with FRP bar. However, the shear strength design of FRP-RC beams is similar to that of RC beams with steel bar except that the mechanical properties of FRP bars which affect the shear strength design shall be considered. The focus of this research is to investigate the shear behavior of FRP-RC beams. A total of 18 RC beams were constructed and tested up to failure, the test beams included 10 GFRP-RC beams and 8 steel-RC beams. In order to realize the occurrence of the shear failure, all tested beams were designed without stirrups. The test variables were the reinforcement ratio (ρ), shear span to depth ratio (a/d), depth of beam (d), and concrete compressive strength (f_c'). The test results revealed that there is an effect of the variables on the shear behavior of the beams. Finite element model (FEM) was carried out to validate the experimental results conducted in the current investigation, resulting in a good agreement with experiments. The test results were compared with predictions provided by the different available codes, manuals, and design guidelines such as CSA S806-02, ACI 440.1R-06, JSCE (1997), ISIS M03-07 and theoretical models from Kazemi & Broujerdian (2006), Yousif (2015), Chowdhury *et al.* (2016) and Mihaylov (2016), in which it was observed from the statistical analysis that Kazemi & Broujerdian (2006) method showed a good consistency in its differences of percentage compared with other models, particularly for GFRP-RC beams. Based on the obtained experimental results, a proposed modification to the Kazemi & Broujerdian (2006) equation is presented and verified against test results available in the literature. It was found that the proposed equation is more accurate and consistent in predicting the shear strength of GFRP-RC beams.

ABSTRAK

Penggunaan bar polimer tetulang (FRP) sebagai alternatif kepada bar keluli untuk struktur konkrit bertetulang (RC) semakin diterima di kalangan jurutera struktur. Penyiasatan prestasi struktur anggota FRP-RC telah menjadi isu kritikal. Penyelidikan yang meluas telah dijalankan untuk menyiasat kelakuan ricih anggota RC dengan bar FRP. Walau pun reka bentuk kekuatan ricih rasuk FRP-RC adalah serupa dengan rasuk RC dengan bar keluli namun sifat mekanik bar FRP yang mempengaruhi reka bentuk kekuatan ricih hendaklah dipertimbangkan. Tumpuan penyelidikan ini adalah untuk mengkaji kelakuan ricih rasuk FRP-RC. Sebanyak 18 rasuk RC telah dibina dan diuji sehingga gagal, termasuk rasuk 10 GFRP-RC dan 8 rasuk keluli-RC. Untuk mengkaji kejadian kegagalan ricih, semua rasuk yang diuji direka tanpa tetulang ricih. Pemboleh ubah ujian adalah nisbah pengukuhan (ρ), nisbah rentang ricih dan kedalaman (a/d), kedalaman rasuk (d), dan kekuatan mampatan konkrit (f_c'). Keputusan ujian menunjukkan bahawa pemilihan pemboleh ubah telah memberi kesan terhadap kelakuan ricih rasuk. Model unsur terhingga (FEM) telah dijalankan untuk mengesahkan keputusan ujian yang telah dijalankan, menghasilkan keputusan yang baik dengan eksperimen. Keputusan ujian juga telah dibandingkan dengan ramalan dari pelbagai kod, manual, dan garis panduan seperti CSA S806-02, ACI 440.1R-06, JSCE (1997), ISIS M03-07 dan model teoretikal dari Kazemi & Broujerdian (2006), Yousif (2015), Chowdhury *et al*. (2016) dan Mihaylov (2016). Dari analisis statistik, kaedah ramalan Kazemi & Broujerdian (2006) telah menunjukkan konsistensi yang baik dalam peratusannya berbanding dengan model lain, terutamanya bagi rasuk GFRP-RC. Berdasarkan keputusan ujian yang diperolehi, pengubahsuaian terhadap persamaan Kazemi & Broujerdian (2006) telah dicadangkan dan seterusnya disahkan berdasarkan keputusan ujian dari kajian literatur. Didapati bahawa persamaan yang dicadangkan telah menunjukkan ketepatan dan konsistensi dalam meramalkan kekuatan ricih rasuk GFRP-RC.

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REFERENCES

ABAQUS Analysis User's Manual (2009) version 6.9, Dassault Systèmes Simulia Corp., *Providence, RI, USA*.

Abdalla, H. A. (2002). Evaluation of deflection in concrete members reinforced with fibre reinforced polymer (FRP) bars. *Journal of Composite Structures* 56 (2002), pp. 63-71.

Abdel-Baky, H., Ebead, U. A. & Neale, K. W. (2008). Numerical Aspects Concerning the Accuracy of Finite Element Simulations of Concrete Beams Strengthened in Flexure Using FRP Sheets. *International Conference on Advanced Composite Materials in Bridges Structures*. ACMBS-V, Winnipeg, Manitoba, Canada, September, pp. 22-24.

Abdul-Salam, B., Farghaly, A. & Benmokrane, B. (2016). Mechanisms of Shear Resistance of One-Way Concrete Slabs Reinforced with FRP Bars. *Construction and Building Materials Journal*, Vol. 127, pp. 959-970.

ACI Committee 224. (1986). *Cracking of Concrete Members in Direct Tension* (ACI 224.2R-86). American Concrete Institute, Detroit, Michigan, USA.

ACI Committee 318. (1995). *Building Code Requirements for Reinforced Concrete*. (318-95) and Commentary (318R-95), American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 318 (2002). *Building Code Requirements for Structural Concrete* (ACI 318-02) and Commentary. American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 318 (2005). *Building Code Requirements for Structural Concrete* (ACI 318-05) and Commentary. American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 318 (2008). *Building Code Requirements for Structural Concrete* (ACI 318-08) and Commentary. American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 318 (2014). *Building code requirements for structural concrete and commentary* (318 RM). A report by ACI committee 318 (ACI 318M-14). Farmington Hills (Mich.): American Concrete Institute, Farmington Hills, Michigan, USA.

ACI-ASCE Committee 445 on Shear and Torsion. (1998). Recent Approaches to Shear Design of Structural Concrete. *Journal of Structural Engineering, ASCE*, 124 (12), pp. 1375-1417.

ACI Committee 440. (2003). *Guide for the Design and Construction of Concrete Reinforced with FRP Bars*. (ACI 440.1R-03), American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 440. (2004). *Guide Test Methods for Fiber-Reinforced Polymers (FRPs) for Reinforcing or Strengthening Concrete Structures*. (ACI 440.3R-04), American Concrete Institute, Farmington Hills, Michigan, USA.

ACI Committee 440. (2006). *Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars*. (ACI 440.1R-06), American Concrete Institute, Farmington Hills, Michigan, USA.

Ahmed, E. (2009). *Shear Behaviour of Concrete Beams Reinforced with Fibre-Reinforced Poylmer (FRP) Stirrups*. PhD Thesis, Department of Civil Engineering, University of Sherbrooke, Sherbrooke, Québec, Canada, 291 p.

Ahmed, E. A., El-Salakawy, E. F. & Benmokrane, B. (2010). Shear Performance of RC Bridge Girders Reinforced with Carbon FRP Stirrups. *Journal of Bridge Engineering*, ASCE, Vol. 15(1), pp. 44.54.

Alam, S. (2010). *Influence of Different Parameters on Shear Strength of FRP Reinforced Concrete Beams Without Web Reinforcement*. PhD Thesis, Memorial University of Newfoundland, Canada, p. 293.

Alam, M. & Hussein, A. (2011). Experimental investigation on the effect of longitudinal reinforcement on shear strength of fiber reinforced polymer

reinforced concrete beams. *Canadian Journal of Civil Engineering*, Vol. 38(3), pp. 243-251.

Alam, M. S. & Hussein, A. (2012). Effect of Member Depth on Shear Strength of High-Strength Fiber-Reinforced Polymer-Reinforced Concrete Beams. *Journal of Composites for Construction, ASCE*, Vol. 16(2), pp. 119-126.

Alam, M. S. & Hussein, A. (2013). Size Effect on Shear Strength of FRP Reinforced Concrete Beams without Stirrups. *Journal of Composites for Construction, ASCE*, Vol. 17(4), pp. 507-516.

Alam, M. S. & Hussein, A. (2013). Unified shear design equation for FRP reinforced concrete members without stirrups. *Journal of Composites for Construction*, Vol. 17(5), pp. 575-583.

Alkhrdaji, T., Wideman, M., Belarbi, A. & Nani, A. (2001). Shear Strength of GFRP RC Beams and Slabs. *Proceeding of the International Conference, Composites in Construction-CCC 2001*, Porto/Portugal, pp. 409-414.

Andermatt, M. F. & Lubell A. S. (2013). Behavior of Concrete Deep Beams Reinforced with Internal Fiber-Reinforced Polymer-Experimental Study. *ACI Structural Journal*, Vol. 110 (4), pp. 585-594.

Arslan, G. (2008). Cracking Shear Strength of RC Slender Beams without Stirrups. *Journal of Civil Engineering and Management*, Vol. 14(3), pp. 177-182.

ASCE-ACI Committee 426 (1973). The Shear Strength of Reinforced Concrete Members. *Journal of Structural Division, ASCE*, Vol. 99, pp.1091-1187.

Ascione, L., Mancusi, G. & Spadea, S. (2010). Flexural Behaviour of Concrete Beams Reinforced With GFRP Bars. *An International Journal for Experimental Mechanics (strain)*, Vol. 46(5), pp. 460-469.

Ashish, P. P. & Kushal, J. P. (2015). Experimental Study on Deflection Behavior of One-Way Slab using GFRP Bars. *International Journal for Innovative Research in Science & Technology* (*IJIRST*), Vol. 1(2), pp. 271-274.

Ashour, A. F. (2006). Flexural and shear capacities of concrete beams reinforced with GFRP bars. *Construction and Building Materials*, Vol. 20(10), pp. 1005-1015.

Ashour, A. F. & Habeeb, M. N. (2008). Continuous concrete beams reinforced with CFRP bars. *Proceedings of the Institution of Civil Engineers-Structures and Buildings*, Vol. 161(6), pp. 349-357.

Ashour, A. F. & Kara, I. F. (2014). Size effect on shear strength of FRP reinforced concrete beams. *Composites Part B: Engineering, Vol.* (60), pp. 612-620.

ASTM D7205. (2006). *Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars.* American Society for Testing and Materials, Philadelphia, USA.

Bakis, C. E., Bank, L. C., Brown, V. L., Cosenza, E., Davalos, J. F., Lesko, J. J., Machida, A., Rizkalla, S. H. & Triantafillou, T. C. (2002). Fiber-Reinforced Polymer Composites for Construction-State-of-the-Art Review. *Journal of Composites for Construction*, Vol. 6(2), pp. 73-87.

Bank, L. C. (2007). *Composites for Construction: Structural Design with FRP Materials*. John Wiley & Sons, Inc, pp. 1-560.

Barris, C., Torres, L. I., Turon, A., Baena, M. & Catalan, A. (2009). An experimental study of the flexural behaviour of GFRP RC beams and comparison with prediction models. *Composite Structures*, Vol. 91(3), pp.286-295.

Bažant, Z. P. & Kim, J. K. (1984). Size Effect in Shear Failure of Longitudinally Reinforced Beams. *ACI Journal Proceedings*, Vol. 81(5), pp. 456-468.

Bažant, Z. P. & Sun, H. H. (1987). Size Effect in Diagonal Shear Failure: Influence of Aggregate Size and Stirrups. *ACI Materials Journa*, 84 (4), pp. 259-272.

Bažant, Z. P. & Kazemi, M. T. (1991). .Size effect on diagonal shear failure of beams without stirrups. *ACI Structural Journal*, Vol. 88(3), pp. 268-276.

Bažant, Z. P. & Yu, Q. (2005). Designing Against Size Effect on Shear Strength of Reinforced Concrete Beams Without Stirrups: II. Verification and Calibration. *(ASCE) Journal of Structural Engineering*, Vol. 131(12), pp. 1886-1897.

Bažant, Z. P., Yu, Q., Gerstle, W., Hanson, J. & Ju, J. W. (2007). Justification of ACI 446 Proposal for Updating ACI Code Provisions for Shear Design of Reinforced Concrete Beams. International Concrete, *ACI Structural Journal*, Vol. 105(4), pp. 512-515.

Beer, F. P. & Johnson, E. R. (1992). *Mechanics of Materials*. Second Edition, McGraw-Hill, Inc, 1992.

Benmoktane, B., Chaallal, O. & Masmoudi, R. (1995). Glass fibre reinforced plastic (GFRP) reinforcement bars for concrete structures. *Construction and Building Materials*, Vol. 9(6), pp. 353-364.

Benmokrane, B., Wang, P., Ton-That, T. M., Rahman, H. & Robert, J. F. (2002). Durability of Glass Fiber-Reinforced Polymer Reinforcing Bars in Concrete Environment. *ASCE Journal of Composites for Construction*, Vol. 6 (3), pp. 143-153.

Bentz, E. C. (2000). *Sectional Analysis of Reinforced Concrete Members*. PhD Thesis, Graduate Department of Civil Engineering, University of Toronto, Toronto, Canada, pp. 184.

Bentz, E. C. & Collins, M. P. (2004). Development of the 2004 Canadian Standard Association (CSA) A23.3 shear provisions for reinforced concrete. *Canadian Journal of Civil Engineering*, Vol. 33(5), pp. 521-534.

Bentz, E. C. (2005). Empirical modeling of reinforced concrete shear strength size effect for members without stirrups. *ACI Structural Journal*, Vol. 102(2), pp. 232-241.

Bentz, E. C. & Buckely, S. (2005). Repeating A Classic Set of Experiments on Size Effect In Shear of Members without Stirrups. *ACI Structural Journal*, Vol. 102(6), pp. 832-838.

Bentz, E. C., Vecchio, F. J. & Collins, M. P. (2006). Simplified Modified Compression Field Theory for Calculating Shear Strength of Reinforced Concrete Elements. *ACI Structural Journal*, Vol. 103(4), pp. 614-624.

Bentz, E. C. & Collins, M. P. (2006). Development of the 2004 CSA A23.3 shear provisions for reinforced concrete. *Canadian Journal of Civil Engineering*, Vol. 33(5), pp. 521-534.

Bischoff, P. H. & Paixao, R. (2004). Tension Stiffening and Cracking of Concrete Reinforced with Glass Fibre Reinforced Polymer (GFRP) Bars. *Canadian Journal of Civil Engineering*, Vol. 31(4), pp. 579-588.

Brown, M. D., Bayrak, O. & Jirsa, J. O. (2006). Design for Shear Based on Loading Conditions. *ACI Materials Journal*, Vol. 103(4), pp. 541-545.

BS 8110-1:97. (1997). *Structural use of concrete-part 1: code of practice for design and construction*. British Standard Institution (BSI), Milton Keynes, London.

British Institution of Structural Engineers (BISE). (1999). *Interim guidance on the design of reinforced concrete structures using fiber composite reinforcement*. IStructE, SETO Ltd., London.

Carolin, A. (2003). *Carbon fibre reinforced polymers for strengthening of structural elements*. PhD Thesis, Division of Structural Engineering, Lulea University of Technology, Sweden. 194 p.

CEB-FIP. (1978). *CEB-FIP Model Code for Concrete Structures*. Comite Euro-International du Beton and Federation Internale de Ia Precontrainte, CEB.

CEN (2004). *Eurocode 2: Design of Concrete Structures: Part 1-1: General Rules and Rules for Buildings*. European Committee for Standardization. EN 1992-1-1. Bruss Belg Com Eur Norm.

Chang, K. & Seo, D. (2012). Behavior of One-Way Concrete Slabs Reinforced with GFRP Bars. *Journal of Asian Architecture and Building Engineering*, Vol. 11(2), pp. 351-358.

Choi, K. K., Park, H. G. & Wight, J. K. (2007). Shear Strength of Steel Fiber-Reinforced Concrete Beams without Web Reinforcement. *ACI Structural Journal*, Vol. 104(1), pp. 12-21.

Chowdhury, A. & Islam, M. (2015). Shear Strength Prediction of FRP-reinforced Concrete Beams: A State-of-the-Art Review of Available Models. *Journal of Civil & Environmental Engineering*, Vol. 5(5), pp. 1-10.

Chowdhury, A., Zahid, Z. I. & Islam, M. (2016). Development of Shear Capacity Prediction Model for FRP-RC Beam without Web Reinforcement. *Advances in Materials Science and Engineering*, Vol. 2016, Article ID 4356967, 19p.

CNR-DT 203/2006. (2006). *Advisory Committee on Technical Recommendation for Construction. Guide for the Design and Construction of Concrete Structures Reinforced with Fiber-Reinforced Polymer Bars*. Rome, Italy : CNR National Research Council, 2006.

Collins, M. P. & Mitchell, D. (1997). *Prestressed Concrete Structures*. Response Publications, Canada, 766 pp.

Collins, M. P. & Kuchma, D. A. (1999). *Advances in understanding shear performance of concrete structures*. Progress in Structural Engineering and Materials ;1:1-10.

Collins, M. P., Bentz, E. C., Quach, P. T., Fisher, A. W. & Proestos, G. T. (2015). *Advances in Understanding the Shear Response of Reinforced Concrete*. in New Zealand Concrete Industry Conference.

CSA A23.3-94. (1994). *Design of Concrete Structures for Buildings*. Canadian Standards Association, Rexdale, Toronto, Ontario, 220 p.

CSA S806-02. (2002). *Design and Construction of Building Components with Fibre Reinforced Polymers*. Canadian Standards Association, Rexdale, Ontario, 177p.

CSA A23.3-04. (2004). *Design of Concrete Structures*. Canadian Standards Association, Toronto, Ontario, 214 pp.

CSA S6-06. (2006). *Canadian Highway Bridge Design Code*. Canadian Standards Association, Rexdale, 800 pp.

CSA S806 (2012). *Design and construction of building components with fiber-reinforced polymers*. Mississauga, Ontario, Canada: (CSA S806-12) Canadian Standards Association.

Damin, D. (1993). Finite Element Analysis of Reinforced Concrete Structures II. *Proceeding of the International Workshop, edited by Isenberg, J., ASCE*, New York. USA

Deitz, D. H., Harik, I. E. & Gesund, H. (1999). One-Way Slabs Reinforced with Glass Fiber Reinforced Polymer Reinforcing Bars. *Proceedings of the 4th International Symposium, Fiber Reinforced Polymer Reinforcement for Reinforced Concrete Structures,* MI., pp. 279-286.

Desayi, P. & Krishnan, S. (1964). Equation for the stress-strain curve of concrete. *ACI Journal Proceed*, 61(3), March 1964, pp. 345-350.

Dhahir, M. K. (2017). Shear strength of FRP reinforced deep beams without web reinforcement. *Composite Structures*, Vol. 165(1), pp. 223-232.

Drucker, D. C. & Prager, W. (1952). Soil mechanics and plastic analysis for limit design. *Quarterly of Applied Mathematics*, Vol. 10(2), pp. 157-165.

Duranovic, N., Pilakoutas, K. & Waldron, P. (1997). Tests on Concrete Beams Reinforced with Glass Fibre Reinforced Plastic Bars. *Proceedings of 3rd International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures (FRPRCS-3)*, Japan Concrete Institute, Sapporo, Japan, Oct 1997. Vol. 2, pp. 479-486.

Elgabbas, F. M. (2016). *Development and Structural Testing of New Basalt Fiber-Reinforced-Polymer (BFRP) Bars In RC Beams and Bridge-Deck Slabs*. PhD Thesis, Sherbrooke University, Sherbrooke (Québec) Canada, p. 283.

El-Nemr, A., Ahmed, E. A & Benmokrane, B. (2010). Flexural Behavior and Serviceability of Normal- and High-Strength Concrete Beams Reinforced with Glass Fiber-Reinforced Polymer Bars. *ACI Structural Journal*, Vol. 110(6), pp. 1077-1088.

El-Salakawy, E. & Benmokrane, B. (2004). Serviceability of Concrete Bridge Deck Slabs Reinforced with Fiber-Reinforced Polymer Composite Bars. *ACI Structural Journal*, Vol. 101(5), pp. 727-736.

El-Sayed, A. K., El-Salakawy, E. F. & Benmokrane, B. (2005a). Shear Strength of One-Way Concrete Slabs Reinforced with Fiber-Reinforced Polymer Composite Bars. *ASCE Journal of Composites for Construction*, Vol. 9(2), pp. 147-157.

El-Sayed, A. K., El-Salakawy, E. F. & Benmokrane, B. (2005b). Shear Strength of Concrete Beams Reinforced with FRP Bars: Design Method. *ACI Structural Journal*, Vol. 230(3), pp. 955-974.

El-Sayed, A. K., El-Salakawy, E. F. & Benmokrane, B. (2006a). Shear Strength of FRP-Reinforced Concrete Beams without Transverse Reinforcement. *ACI Structural Journal*, Vol. 103(2), pp. 235-243

El-Sayed, A. K., El-Salakawy, E. F. & Benmokrane, B. (2006b). Shear Capacity of High-Strength Concrete Beams Reinforced with FRP Bars. *ACI Structural Journal*, Vol. 103(3), pp. 383-389.

El-Sayed, A. K. & Benmokrane, B. (2008). Evaluation of the new Canadian highway bridge design code shear provisions for concrete beams with fiber-reinforced polymer reinforcement. *Canadian Journal of Civil Engineering*, Vol. 35(6), pp. 609-623.

EN 1992-1-1 (2004). *Eurocode 2: Design of Concrete Structures-Part 1-1: General Rules and Rules for Buildings*. British Standards Institution, London, UK, pp. 230.

Erki, M. A. & Rizkalla, S. H. (1993). A sample of international production; FRP reinforcements for concrete structures. *Concrete international journal*, 1993, pp. 48-53.

Faza, S. S. & Gangarao, H. S. (1992). Pre-and post-cracking deflection behavior of concrete beams reinforced with fibre-reinforced plastic rebars. *Proceedings of the Second International Conference on Advanced Composite Materials for Bridges and Structures (ACMBS-II)*. Montreal, Canada, pp. 151-160.

Faza, S. S. & Gangarao, H. S. (1993). Theoretical and Experimental Correlation of Behavior of Concrete Beams Reinforced with Fiber Reinforced Plastic Reinforcement bars. *Fiber-Reinforced-Plastic Reinforcement for Concrete Structures-International Symposium, American Concrete Institute, Farmington Hills*, Mich., pp. 599-614.

fib, (2007). *FRP Reinforcement in RC Structures*. Fédération International Du Béton, Fib Task Group 9.3, Fib Bulletin 40, Lausanne, Switzerland, p. 147.

Filippo, S., Johan, S. & Giuseppe, M. (2015). Scatter in the shear capacity of slender RC members without web reinforcement: an overview study. *structural concrete, journal of the fib*, Vol. 17(1), pp. 11-20.

Genikomsou, A.S. & Polak, M.A., 2015. Finite element analysis of punching shear of concrete slabs using damaged plasticity model in ABAQUS. *Engineering Structures*, Vol. 98(1), pp.38-48.

Ghugal, Y. M. and Dahake, A. G. (2012). Flexural analysis of deep beam subjected to parabolic load using refined shear deformation theory. *Applied and Computational Mechanics*, Vol. 6 (2012), pp. 163-172.

Godat, A., Labossiere, P. & Neale, K. W. (2012). Numerical investigation of the parameters influencing the behaviour of FRP shear strengthened beams. *Construction and Building Materials*, Vol. 32(2012), pp. 90-98.

Gopalaratnam, V. S. & Shah, S. P. (1985). Softening Response of Plain Concrete in Direct Tension. *ACI Journal Proceedings*, Vol. 82(3). pp. 310-323.

Gross, S. P., Yost, J . R., Dinehart, D. W., Svensen, E. & Liu. N. (2003). Shear Strength of Normal and High Strength Concrete Beams Reinforced with GFRP Bars. *High performance materials in bridges, Proceedings of the International Conference, ASCE*, Kona, Hawaii, pp. 426-437.

Gross, S. P., Dinehart, D. W. & Yost, J. R. (2004). Experimental Test of High Strength Concrete Beams Reinforced CFRP Bars. *International Conference on, Advanced Composite Materials in Bridges and Structures, ACMBS-IV*, Calgary, Alberta, Canada, (8), pp. 20-23.

Halliwell, S. (2016). Technical papers: FRPs-the environmental agenda. *Advances in Structural Engineering*, Vol. 13(5), pp. 783-791.

Hollaway, L. C. (2010). A review of the present and future utilisation of FRP composites in the civil infrastructure with reference to their important in-service properties. *Construction and Building Materials*, Vol. 24(12), pp. 2419-2445.

Hong, S. G. & Ha, T. (2013). Effective Capacity of Diagonal Strut for Shear Strength of Reinforced Concrete Beams without Shear Reinforcement. *ACI Structural Journal*, Vol. 109(2), pp. 138-148.

Hoult, N. A., Sherwood, E. G., Bentz, E. C. & Collins, M. P. (2008). Does the use of FRP Reinforcement Change the One-Way Shear Behavior of Reinforced Concrete Slabs?. *Journal of Composite for Construction, ASCE*, Vol.12(2), pp.125-133.

IS: 456 (2000). *Indian standard code of practice for plain and reinforced concrete for general building construction*. Bureau of Indian Standards, New Delhi, India.

ISIS-M03-01. (2001). *Reinforcing Concrete Structures with Fiber Reinforced Polymers.* The Canadian Network of Centers of Excellence on Intelligent Sensing for Innovative Structures, ISIS Canada, University of Winnipeg, Manitoba, Canada, 81p.

ISIS-M03-02. (2006). *An Introduction to FRP Composites for Construction: FRP Composites for Construction*. The Canadian Network of Centers of Excellence on Intelligent Sensing for Innovative Structures, ISIS Education Committee, Queen's University, Kingston, Canada, 27p.

ISIS-M03-07. (2007). *Reinforcing Concrete Structures with Fibre Reinforced Polymers.* The Canadian Network of Centers of Excellence on Intelligent Sensing for Innovative Structures, ISIS Canada, University of Winnipeg, Manitoba, Canada.

Islam, M. S. & Alam, S. (2013). Principal component and multiple regression analysis for Steel Fiber Reinforced Concrete (SFRC) beams. *International Journal of Concrete Structures and Materials*, Vol. 7(4), pp. 303-317.

Jankowiak, I., Kąkol, W. & Madaj, A. (2005). Identification of a continuous composite beam numerical model, based on experimental tests. *7th Conference on Composite Structures*, Zielona Góra, 2005, pp. 163-178.

Jankowiak, T. & Lodygowski, T. (2005). Identification of parameters of concrete damage plasticity constitutive model. *Foundations of Civil and Environmental Engineering.* Poznań University of Technology, Poznań, Poland. No.6, pp. 53-69.

Japan Society of Civil Engineers (1997). *Recommendation for Design and Construction of Concrete Structures using Continuous Fiber Reinforcing Materials.* Research Committee on Continuous Fibre Reinforced Materials, Machida, A., ed. Tokyo, Japan, 325 p.

Jung, S. & Kim, K. S. (2008). Knowledge-based prediction of shear strength of concrete beams without shear reinforcement. *Engineering Structures*, Vol. 30(6), pp. 1515-1525.

Kani, G. N. J. (1964). The Riddle of Shear Failure and its Solution. *ACI Journal*. Vol. 61(4), pp. 441-468.

Kani, G. N. J. (1967). How Safe are Our Large Reinforced Concrete Beams?. *ACI Journal*. Vol. 64(3), pp. 128-141.

Kani, G. N. J. (1969). A Rational Theory for the Function of Web Reinforcement. *ACI Journal*. Vol. 66(3), pp. 185-197.

Kani, M. W., Huggins, M. W. & Wittkopp, P. F. (1979). *Kani on shear in Reinforced concrete*. Dependent of Civil Engineering, University of Toronto, Canada.

Kara, I. F. (2011). Prediction of shear strength of FRP-reinforced concrete beams without stirrups based on genetic programming. *Advances in Engineering Software,* Vol. 42(6), pp. 295-304.

Kara, I. F. & Ashour, A. F. (2012). Flexural performance of FRP reinforced concrete beams. *Journal of Composite Structures*, Vol. 94(5), pp. 1616-1625.

Kawano, H. & Watanabe, H. (1997). Shear strength of reinforced concrete columns-Effect of specimen size and load reversal. *Proceedings of the Second Italy-Japan Workshop on Seismic Design and Retrofit of Bridges*, 1997, pp. 141-154.

Kazemi, M. T. & Broujerdianm, V. (2006). Reinforced concrete beams without stirrups considering shear friction and fracture mechanics. *Canadian Journal of Civil Engineering,* Vol. 33(2), pp. 161-168.

Khaja, M. N. & Sherwood, E. G. (2013). Does the shear strength of reinforced concrete beams and slabs depend upon the flexural reinforcement ratio or the reinforcement strain?. *Canadian Journal of Civil Engineering*, Vol. 40(11), pp. 1068-1081.

Kim, C. H. & Jang, H. S. (2014). Concrete shear strength of normal and lightweight concrete beams reinforced with FRP bars. *Journal of Composites for Construction, ASCE*, Vol. 18(2), pp. 1-9.

Kmiecik, P. & Kamiński, M. (2011). Modelling of reinforced concrete structures and composite structures with concrete strength degradation taken into consideration. *Archives of Civil and Mechanical Engineering*, Vol. 11(3), pp. 623-636.

Kong, P. Y. & Rangan, B.V. (1998). Shear strength of high-performance concrete beams. *ACI Structural Journal*, Vol. 95(6), pp. 677-688.

Kourosh, N. & Basiri, M. M. (2014). Prediction of shear strength of FRP reinforced concrete beams using fuzzy inference system. *Expert Systems with Applications*, Vol. 41(4), pp. 1006-1020.

Kupfer, H., Hilsdorf, H. K. & Rusch, H. (1969). Behavior of concrete under biaxial stresses, *ACI Journal Proceedings*, Vol. 66(8), pp. 656-666.

Kwadwo, A. A. & Mark, A. A. (2013). Characterization and Shear Strength Prediction of Reinforced Concrete Deep Beams-A Review. *International Journal of Science and Research (IJSR)*, Vol. 16(4), pp. 1789-1798.

Lee, J. & Fenves, G. (1998). Plastic-Damage Model for Cyclic Loading of Concrete Structures. *Journal of Engineering Mechanics*, Vol. 124(8), pp. 892-900.

Lee, S. & Lee, C. (2014). Prediction of shear strength of FRP-reinforced concrete flexural members without stirrups using artificial neural networks. *Engineering Structures*, Vol. 61, pp. 99-112.

Li, C. & Liu, X. (2007). Mechanical and thermal properties study of glass fiber reinforced polyarylene ether nitriles. *Materials Letters*, Vol. 61(11), pp. 2239-2242.

Li, W. & Leung, C. K. (2016). Shear Span–Depth Ratio Effect on Behavior of RC Beam Shear Strengthened with Full-Wrapping FRP Strip. *Journal of Composites for Construction*, Vol. 20(3), pp. 1-14.

Liu, R. & Pantelides, C. P. (2013). Shear strength of GFRP reinforced precast lightweight concrete panels. *Journal of Construction and Building Materials*, Vol. 48(2013), pp. 51-58.

Lubell, A. S., Sherwood, E. G., Bentz, E. C. & Collins, M. P. (2004). Safe shear design of large wide beams. *Concrete International*, Vol. 26(1), pp. 66-78.

Lubliner, J., Oliver, J., Oller, S. & Oñate, E. (1989). A plastic-damage model for concrete. *International Journal of Solids and Structures*, Vol. 25(1989), pp. 299-329.

Lundqvist, J. (2007). *Numerical analysis of concrete elements strengthened with carbon fiber reinforced polymers*. Luleå University of Technology.

Machial, R., Alam, M. S. & Rteil, A. (2010). Shear strength contribution of transverse FRP reinforcement in bridge girders. *IABSE-JSCE Joint Conference on Advances in Bridge Engineering-II*, August 8-10, 2010, Dhaka, Bangladesh, pp. 504-511.

Machial, R., Alam, M. S. & Rteil, A. (2012). Revisiting the shear design equations for concrete beams reinforced with FRP rebar and stirrup. *Materials and Structures*, Vol. 45(11), pp. 1593-1612.

MacGregor, J. (1997). *Reinforced Concrete: Mechanics and Design*. 3rd Edition, Prentice Hall, Englewood Cliffs, N.J., 939p.

MacGregor, J. G. & Bartlett, F. M. (2000). *Reinforced Concrete: Mechanics and Design*. First Canadian Edition.

MacGregor, J. & Wright, J. K. (2005). *Reinforced Concrete Mechanics and Design*. 4th. ed. New Jersey: Pearson Prentice Hall, pp. 209-216.

Mohamed, N., Farghaly, A. S., Benmokrane, B., & Neale, K. W. (2014). Experimental Investigation of Concrete Shear Walls Reinforced with Glass Fiber–Reinforced Bars under Lateral Cyclic Loading. *Journal of Composites for Construction*, Vol. 18(3), pp. 1-11.

Mahmoud, K. A. A. (2015). *Shear Behaviour of Continuous Concrete Beams Reinforced with GFRP Bars*. PhD Thesis, University of Manitoba Winnipeg, Manitoba, Canada, p. 275.

Mahroug, M. E. (2013). *Behaviour of Continuous Concrete Slabs Reinforced With FRP Bars*. PhD Thesis, School of Engineering, Design and Technology (EDT), University of Bradford, UK, p. 177.

Majewski, S. (2003). *The mechanics of structural concrete in terms of elasto-plasticity.* Silesian Polytechnic Publishing House, Gliwice, 2003.

Malm, R. (2006). *Shear cracks in concrete structures subjected to in-plane stresses*. PhD Thesis, Royal Institute of Technology (KTH), 2006, Stockholm, Sweden.

Mara, V., Haghani, R. & Harryson, P. (2014). Bridge decks of fibre reinforced polymer (FRP): A sustainable solution. *Construction and Building Materials*, Vol. 50(2014), pp. 190-199.

Marí, A., Cladera, A., Oller E. & Bairán, J. (2014). Shear design of FRP reinforced concrete beams without transverse reinforcement. *Composites Part B: Engineering*, Vol. 57(2014), pp. 228-241.

Matta, F., Nanni, A., Galati, N. & Mosele, F. (2007). Size Effect on Shear Strength of Concrete Beams Reinforced with FRP Bars. Proc. *6th International Conference on Fracture Mechanics of Concrete and Concrete Structures (FraMCoS-6)*, June 17-22, 2007, Catania, Italy, Taylor & Francis, Vol. 2, pp.1077-1084.

Matta, F., El-Sayed, A. K., Nanni, A. & Benmokrane, B. (2013). Size effect on concrete shear strength in beams reinforced with fiber-reinforced polymer bars. *ACI Structural Journal*, Vol. 110(4), pp. 617-628.

Michaluk, C. R., Rizkalla, S. H., Tadros, G. & Benmokrane, B. (1998). Flexural Behaviour of One-Way Concrete Slabs Reinforced by Fiber Reinforced Plastic Reinforcements. *ACI Structural Journal*, Vol. 95(3), May-Jun 1998, pp. 353-364.

Mihaylov, B. I. (2016). Two-Parameter Kinematic Approach for Shear Strength of Deep Concrete Beams with Internal FRP Reinforcement. *Journal of Composites for Construction*, Vol. 21(2), pp. 1-11.

Minelli, F., Conforti A., Cuenca, E. & Plizzari, G. (2014). Are steel fibres able to mitigate or eliminate size effect in shear?. *Materials and Structures Journal*, Vol. 47(3), pp. 459-473.

Mizukawa, Y., Sato, Y., Ueda, T. & Kakuta, Y. (1997). A study on the shear fatigue behavior of concrete beams with FRP rods. *Proceedings of 3rd International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures (FRPRCS-3)*, Vol.2, Sapporo, Japan, Oct 1997, pp. 309-316.

Nanni, A. (2003). North American design guidelines for concrete reinforcement and strengthening using FRP: principles, applications and unresolved issues. *Construction and Building Materials*, Vol. 17(6-7), pp. 439-446.

NCHRP. (2005). *Simplified Shear Design of Structural Concrete Members*. Report #549, National Cooperative Highway Research Program, University of Illinois, Urbana, Illinois, US.

Nawy, E. D. (2003). *Reinforced Concrete: A Fundamental Approach*. Prentice Hall. Fifth Edition, New Jersey: Pearson Education, Inc.

Nehdi, M., El-Chabib, H. & Said, A. A. (2007). Proposed shear design equations for FRP-reinforced concrete beams based on genetic algorithms approach. *Journal of Materials in Civil Engineering*, Vol. 19(12), pp. 1033-1042.

Niranjan, B. R. & Patil, S. S. (2012). Analysis of R.C Deep Beam by Finite Element Method. *International Journal of Modern Engineering Research (IJMER)*. Vol. 2(6), Nov.-Dec. 2012, pp. 4664-4667.

Niwa, J. (1983). Design Equation for Shear Capacity of Deep Beams based on FEM analysis. *2nd Colloquium on Shear Analysis of RC Structures*, Proceedings of Japan Concrete Institute (JCI), pp. 119-126.

Nkurunziza, G., Ahmed, D., Patrice, C. & Benmokrane, B. (2005). Durability of GFRP bars: a critical review of the literature. *Progress in Structural Engineering and Materials*, Vol. 7(4), pp. 194-209.

Nour, A., Massicotte, B., Yildiz, E. & Koval, V. (2007). Finite Element Modelling of Concrete Structures Reinforced with Internal and External Fibre-Reinforced Polymers. *Can. J. of Civil Engineering*, Vol. 34(2007), pp. 340-354.

Oller, E., Marí, A., Bairán, J. M. & Cladera, A. (2015). Shear design of reinforced concrete beams with FRP longitudinal and transverse reinforcement. *Composites Part B: Engineering*, Vol. 74(15), pp. 104-122.

Pantiledes, C. P., Besser, B. T. & Liu, R. (2012). One-Way Shear Behavior of Lightweight Concrete Panels Reinforced with GFRP Bars. *ASCE Journal of Composites for Construction*, Vol. 16(1), pp. 2-9.

Pecce, M., Manfredi, G. & Cosenza, E. (2000). Experimental response and code models of GFRP RC beams in bending. *Journal of Composites for Construction*, Vol. 4(4), pp. 182-190.

Pilakoutas, K. (2000). *Composites in concrete construction*. Failure Analysis of Industrial Composite Materials, McGraw- Hill, London, UK.

Pilakoutas, K., Guadagnini, M., Neocleous, K. & Taerwe, L. (2007). *Design guidelines for FRP reinforced concrete structures*. Proceedings of the Advanced Composites in Construction, University of Bath, Bath, UK.

Pillai, S. U. & Menon, D. (2003). *Reinforced Concrete Design*. Tata McGraw-Hill Publishing Company Ltd., New Delhi, India.

Popovics, S. (1973). A numerical approach to the complete stress strain curve for concrete. *Cement and concrete research*, Vol. 3(5), pp. 583-599.

Ramadass, S. & Thomas, J. (2013). Shear strength prediction of concrete beams reinforced with FRP bars using IS: 456-2000. *American Journal of Engineering Research (AJER)*, Vol. 1(2013), pp. 43-48.

Ramadass, S. & Thomas, J. (2014) Experimental investigation on the shear strength of concrete beams longitudinally reinforced with GFRP bars. *International Journal of Engineering Research and Applications (IJERA)*, pp. 82-86.

Rao, G. A. & Sundaresan, R. (2012). Evaluation of size effect on shear strength of reinforced concrete deep beams using refined strut-and-tie model. *Indian Academy of Sciences*, Vol. 37(1), pp. 89-105.

Park, H. G., Choi, K. K. & Wight, J. (2006). Strain-Based Shear Strength Model for Slender Beams without Web Reinforcement. *ACI Structural Journal*, Vol. 103(6), pp. 783-793.

Razaqpur, A. G., Isgor, O. B., Greenaway, S. & Selley, A. (2004). Concrete Contribution to the Shear Resistance of Fiber Reinforced Polymer Reinforced Concrete Members. *ASCE Journal of Composites for Construction*, Vol. 8(5), pp. 452-460.

Razaqpur, A. G. & Isgor, O. B. (2006). Proposed Shear Design Method for FRP-Reinforced Concrete Members without Stirrups. *ACI Structural Journal*, Vol. 103(1), pp 93-102.

Razaqpur, A. G. & Isgor, O. B. (2010). Shear Strength of Reinforced Concrete Elements Brackets with FRP. *In: Proceedings of AIAS, 39th National Congress of Italian Association of Stress Analysis*, Calabria, Italy.

Razaqpur, A. G. & Spadea, S. (2015). Shear Strength of FRP Reinforced Concrete Members with Stirrups. *Journal of Composites for Construction*, Vol. 19(1), pp. 1-15.

Rebciz, K. S. (1999). Shear Strength Prediction for Concrete Members. *Journal of Structural Engineering, ASCE*, Vol. 125(3), pp. 301-308.

Reineck, K. H. (1990). *Mechanical model for the behaviour of reinforced concrete members in shear*. PhD Thesis, University of Stuttgart.

Reineck, K. H. (1991). Ultimate Shear Force of Structural Concrete Members without Transverse Reinforcement Derived from a Mechanical Model. *ACI Structural Journal*, Vol. 88(5), pp. 592-602.

Reineck, K. H. (1999). Modelling of members with transverse reinforcement. *IABSE Colloquium on Structural Concrete*, IABSE Rep., Zurich, 62, pp. 481-488.

Said, M., Adam, M. A., Mahmoud, A. A. & Shanour, A. S. (2016). Experimental and analytical shear evaluation of concrete beams reinforced with glass fiber reinforced polymers bars. *Construction and Building Materials*, Vol. 102, Part 1, 15 Jan. 2016, pp. 574-591.

Shenoi, R. A., Moy, S. S. J. & Hollaway, L. C. (2002). Advanced Polymer Composites for Structural Applications in Construction. *Proceedings of the first international conference*, held at Southampton University, UK, on 15-17 April, 2002.

Sherwood, E. G. (2008). *One-Way shear behaviour of large, lightly-reinforced concrete beams and slabs*. Ph.D. Thesis, Department of Civil Engineering, University of Toronto, 567pp.

Shioya, T., Iguro, M., Nojiri, Y., Akiyama, H. & Okada, T. (1990). Shear Strength of Large Reinforced Concrete Beams. *ACI Special Publication*, SP118-12, pp. 259- 280.

Singh S. B. (2015). *Analysis and Design of FRP Reinforced Concrete Structures*. McGraw Hill Education, Technology & Engineering, New Delhi, India, 5 Feb 2015, p. 352.

Sivagamasundari, R. & Kumaran, G. (2012). Experimental study on the behaviour of concrete one way slabs reinforced with GFRP reinforcements under constant and variable amplitude. *International Journal Of Civil And Structural Engineering.* Vol. 2(2), pp. 547-569

Słowik, M. (2014). Shear failure mechanism in concrete beams. *Procedia Materials Science*, Vol. 3(2014), pp. 1977-1982.

Sonobe, Y. (1997). Design Guidelines of FRP Reinforced Concrete Building Structures. *Journal of Composite for Construction, ASCE*, Vol. 3(1), pp. 90-115.

Sooriyaarachchi, H., Pilakoutas, K. & Byars, E. (2005). Tension Stiffening Behaviour of GFRP-Reinforced Concrete. *7th International Symposium on Fibre Reinforced Polymer Reinforcement for Reinforced Concrete Structures (FRPRCS-7)*, New Orleans, Louisiana, USA, *ACI special publication* SP-230-55.

Sooriyaarachchi, H., Pilakoutas, K. & Byars, E. (2007). Model for Tension Stiffening for Deflections of GFRP-RC. *8th International Symposium on Fibre Reinforced Polymer Reinforcement for Reinforced Concrete Structures (FRPRCS-8)*, University of Patras, Patras, Greece, July 16-18.

Swamy, N. & Aburawi, M. (1997). Structural Implications of Using GFRP Bars as Concrete Reinforcement. *Proceedings of the Third International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures (FRPRCS-3)*, Japan Concrete Institute, Sapporo, Japan, Vol. 2(1997), pp. 503-510.

Svetlana, B. & John, J. (2006). *Reinforced Concrete Design: A Practical Approach*. Pearson Education Canada, Toronto. 743p.

Tan, K. & Lu, H. (1999). Shear behavior of large reinforced concrete deep beams and code comparisons. *ACI Structural Journal*, 1999, Vol. 96(5), pp. 836-845.

Tariq, M. & Newhook, J. P. (2003). Shear Testing of FRP Reinforced Concrete Without Transverse Reinforcement. *Proceedings of CSCE Annual Conference of the Canadian Society for Civil Engineering 2003*, Moncton, NB, Canada, June 2003, 10p.

Taylor, H. P. J. (1972). Shear Strength of Large Beams. *ASCE Structural Division Journal Proceedings*, 98 (ST11), pp. 2473-2490.

Thamrin, R., Abdul Aziz Abdul Samad & Abdul Hamid, N. A. (2009). Evaluation On Shear Capacity And Tension Force Of Longitudinal Reinforcement Of RC Beams With FRP Bars. *Proceedings Of APSEC 2009 & EACEF 2009*. 2, pp. 424-430.

Thamrin, R., Abdul Aziz Abdul Samad, David, Y. E., Abdul Hamid, N. A. & Imohamed Ali .(2012). Experimental Study On Diagonal Shear Cracks Of Concrete Beams Without Stirrups Longitudinally Reinforced With GFRP Bars. *Proceedings fib Symposium, Composites and Hybrids.*, PRAGUE 2012.

Thomas, J. & Ramadass, S. (2016). Parametric Study of Shear Strength of Concrete Beams Reinforced with FRP Bars. *Journal of The Institution of Engineers (India): Series A*, Sep. 2016, Vol. 97(3), pp 273-284.

Teng, J. G., Chen, J. F., Smith, S. T. & Lam, L. (2002). *FRP Strengthened RC Structures*. England: John Wiley& Sons, Ltd.

Tottori, S. & Wakui, H. (1993). Shear Capacity of RC and PC Beams using FRP Reinforcement. *American Concrete Institute, ACI SP-138,* edited by A. Nanni and C.W. Dolan, pp. 615-631.

Toutanji, H. A. & Saafi, M. (2000). Flexural behavior of concrete beams reinforced with glass fiber-reinforced polymer (GFRP) bars. *ACI Structural Journal*, Vol. 97(5), pp. 712-719.

Tuakta, C. (2005). *Use of fiber reinforced polymer composite in bridge structures*. Master's Thesis, Massachusetts Institute of Technology, Massachusetts, US.

Tureyan, A. K. & Frosch, R. J. (2002). Shear Tests of FRP-Reinforced Concrete Beams without Stirrups. *ACI Structural Journal*, Vol. 99(4), Jul-Aug 2002, pp. 427-434.

Tureyan, A. K. & Frosch, R. J. (2003). Concrete Shear Strength: Another Perspective. *ACI Structural Journal*, Vol. 100(5), Sep - Oct 2003. pp 609-615.

Vecchio, F. J. (2001). Non-Linear Finite Element Analysis of Reinforced Concrete At the Crossroads?. *Structural Concrete, fib*, Vol. 2(4), pp. 201-212.

Walraven, J. & Lehwalter, N. (1994). Size effects in short beams loaded in shear. *ACI Structural Journal*, 1994, Vol. 91(5), pp. 585-593.

Wegian, F. M. & Abdalla, H. A. (2005). Shear Capacity of Concrete Beams Reinforced with Fiber Reinforced Polymers. *Composite Structures*, Vol. 71(1), pp. 130-138.

Wight, J. K. & MacGregor, J. G. (2009). *Reinforced Concrete: Mechanics and Design* (5th edition). Pearson Prentice Hall.

Wight, J. & MacGregor, J. (2011). Reinforced Concrete: Mechanics and Design. Eighth Edition, Pearson Education, Inc., Upper Saddle River, New Jersey 07458.

Wight, J. K. & MacGregor, J. G. (2012). *Reinforced Concrete: Mechanics and Design* (6th edition). Pearson Prentice Hall.

Yang, Y. (2014). *Shear Behaviour of Reinforced Concrete Members without Shear Reinforcement - A New Look at an Old Problem*. PhD Thesis, Delft University of Technology, Delft, Netherlands.

Yost, J. R., Gross, S. P. & Dinehart, D. W. (2001). Shear Strength of Normal Strength Concrete Beams Reinforced with Deformed GFRP Bars. *ASCE Journal of Composites for Construction*, Vol. 5(4), pp. 263-275.

Yousif, A. R. (2015). Prediction of Ultimate Shear Capacity of FRP-Reinforced Concrete Beams without Stirrups Using Neural Networks. *Zanco Journal of Pure and Applied Sciences*, Vol. 27(4), pp. 1-19.

Zararis, P. D. & Papadakis, G. C. (2001). Diagonal Shear Failure and Size Effect in RC Beams without Web Reinforcement. *Journal of Structural Engineering*, Vol. 127(7), pp. 733-742.

Zhang, T., Oehlers, D. J. & Visintin, P. (2014). Shear Strength of FRP RC Beams and One-Way Slabs without Stirrups. *Journal of Composites for Construction*, Vol. 18(5), pp. 1-15.

Zheng, Y., Li, C. H., Yang, J. B. & Sun, C. (2015). Influence of arching action on shear behaviour of laterally restrained concrete slabs reinforced with GFRP bars. *Composite Structures.* Vol. 132(2015), pp. 20-34.

Zsutty, T, (1986). Beam Shear Strength Prediction by Analysis of Existing Data. *ACI Journal*, Vol. 65(11), pp. 942-951.