

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

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A thesis submitted in
fulfilments of the requirement for the award of the
Doctor of Philosophy in Civil Engineering

Faculty of Civil and Environmental Engineering
Universiti Tun Hussein Onn Malaysia

May, 2018

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



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

ACKNOWLEDGEMENT

I would like to thank all the parties who have given the co-operation to me in writing this thesis. I am sincerely great full to my supervisor, Prof. Ir. Dr. Abdul Aziz Bin Abdul Samad for his continuous support and guidance in this thesis. He has set a high standard for the conduct of this study and his valuable suggestions and guidance have provided me the motivation needed to complete this thesis.

I would also like to express sincere gratitude and appreciation to my co-supervisors Prof. Madya Dr. Noridah Binti Mohamad; Assoc Prof. Dr. Ghusen Mohammed Al-Kafri and Dr. Goh Wan Inn for constant guidance and inspiration, and advices throughout this thesis.

Finally, I thank my family and friends for their supports and encouragement. Their encouragement provided the often-needed motivation and inspirations for me to push through the hard times. I would also like to acknowledge the contributions of those who have helped either directly or indirectly in the completion of this thesis.

Thank You.

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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