FRPRCS11 – 11th International Symposium on Fiber Reinforced Polymer for Reinforced Concrete Structures

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The 11th International Symposium on Fiber Reinforced Polymer for Reinforced Concrete Structures (FRPRCS11), an event co-sponsored by IIFC, was held 26-28 June at the Vila Flor Cultural Centre of Guimarães City, in Portugal. Following peer review, 148 extended abstracts and full papers were accepted and published in the proceedings. Approximately 170 delegates representing 38 countries and 137 institutions were in attendance. The distribution of papers by theme is indicated in Table 1, where the tendency for a significant research effort on the "Reinforcement and strengthening performance of FRP systems" is clear, forming about one third of the accepted publications. The FRPRCS11 was composed of 20 sessions of 20 minutes presentations including about 5 minutes for discussion of each. The high technical/scientific level of the publications, and especially the enthusiastic and fruitful discussions which occurred during the presentations were highly remarked upon by the conference participants. Prof. Brahim Benmokrane and Prof. Stijn Matthys provided two stimulating keynote lecturers which provided extraordinary contribution to the motivation and enthusiasm of the delegates, and the scientific quality of FRPRCS11. The closing ceremony ended with the announcement of the chairman of the next FRPRCS conference, Prof. Zhishen Wu, who in 2015 will host FRPRCS12 in Nanjing, China.

Table 1 Distribution of FRPRCS papers.

Theme	Papers
reinforcement and strengthening	46
new FRP materials, systems and techniques	26
bond behaviour	22
durability	14
advanced numerical methods	13
codes, standards and guidelines	11
test methods	7
seismic strengthening	4
field applications	3
health monitoring	2

...detailed (and fruitful?) discussions of presented papers during breaks...

...celebrity photo opportunities...

...and the conference banquet.

The SC@UM Challenge

Hosted by FRPRCS11 and supported by IIFC and S&P, the SC@UM Challenge gathered researchers, practitioners and institutions in a reflection about CFRP strengthening applied to reinforced concrete (RC) structures. The motif was a T-shaped RC beam, which was pre-loaded to simulate service conditions and then strengthened with longitudinal and transverse NSM-CFRP laminates. The SC@UM Challenge was primarily directed to PhD students working in the field and required accurate predictions characterising the load-deflection response and failure mechanism of an RC beam after strengthening. The initiative was welcomed by many institutions and universities, with 19 teams from 11 countries initially registered to participate.

The Challenge

The strengthening scheme incorporated innovative features relative to the current state of the art, increasing the difficulty of the challenge and increasing curiosity about the outcomes. The competition comprised different stages following the production and characterization of all materials used. After the registration of all teams, the T-shaped RC beam specimens (Figures 1 and 2 in subsequent article) were cast and all materials – concrete, reinforcing steel, CFRP and adhesive – employed were characterised by their Young's modulus and strength. In addition, the load-deflection response of the RC beam during the pre-loading stage was provided to all participating teams to support their estimations and competition reports. The pre-loading of the RC beam was carried out 28 days after casting and consisted of imposing a total deflection of L/350 at a rate of 20 μm/s. The pre-cracked beam was then strengthened using 1.2 x 20 mm CFRP laminates adopting the Near Surface Mounted (NSM) technique for both the flexural and shear strengthening (Figure 1 in subsequent article). The exact dimensions and detailing of the CFRP strengthening were also made available to all teams, together with the accurate positioning of all transverse and longitudinal steel reinforcement elements.

The final competition reports delivered by all teams were composed of three elements: a full paper of approximately 10 pages containing the theoretical background and discussion of their predicted results, a brief presentation summarizing the main results, and a file containing their predicted load-deflection response. Eight teams were able to complete the challenge, submitting their reports and complying with the competition rules. One week after the submission deadline, approximately 90 days after casting, the CFRP strengthened RC T-beam was tested to failure at an imposed deflection rate of 20μm/s (see Figures 1 and 2, this article). The event was broadcast live to the jury members, who were responsible for verifying that all the procedures complied with the competition rules. The jury chairman was Mauricio Guadagnini from the Sheffield University. The jury members were Kent Harries from IIFC, Filipe Dourado from S&P and Eduardo Pereira from ISISE-University of Minho.

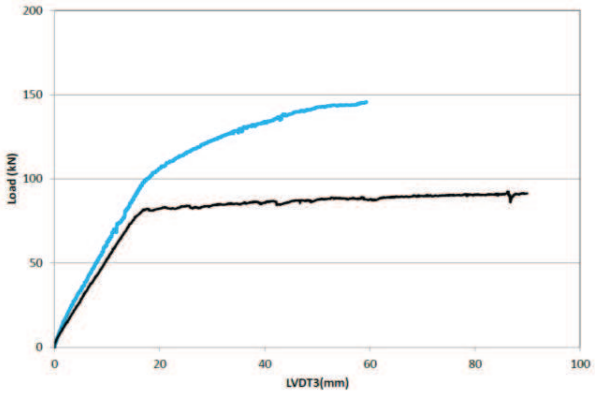

Figure 1 Load-deflection response of the T-shaped RC beam with (blue) and without (black) strengthening using CFRP laminates.

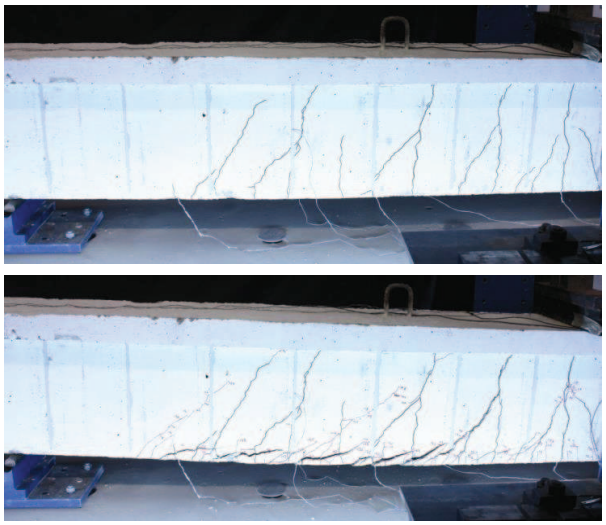

Figure 2 Crack pattern at the left span of the strengthened T-shaped RC beam: (top) at imposed deflection of L/250; (bottom) right before failure.

Evaluation

The multiple parameter evaluation criterion employed was based on the following five parameters with different relative weights: 1) accuracy of the predictions to estimate the load to cause a deflection of

L/250; 2) accuracy of predictions of ultimate load and deflection; 3) overall accuracy of predicted load-deflection response as measured by the area under the response; and 4) a subjective review of the paper assessing the accuracy of the predicted load-displacement responses and of the description of the expected failure mechanism, the innovative character of the proposed model, and the creativity and the theoretical soundness of the model principles described.

Results

Among the eight reports submitted, six teams supported their predictions using finite element method (FEM) models, of which one was a force-based fibrous formulation, two were displacement-based and adopted solid elements, and four used plane stress displacement-based finite element formulations. The remaining two teams adopted purely analytical approaches. The overall shape of the predicted and experimental responses were generally similar as shown in Figure 3.

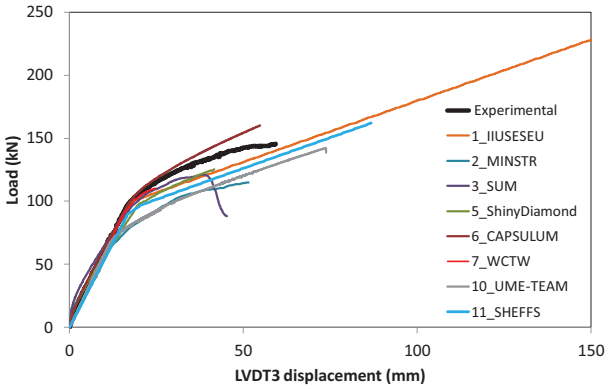

Figure 3 Predicted load-displacement responses by all competing teams and the obtained experimental response.

The four evaluation parameters were generally predicted well by all teams, although teams were more accurate at predicting the strength-related parameters than the ductility/deformability related ones. The type of model used to support the predictions seemed to have an effect on this outcome. The reports also obtained very positive feedback from the Jury members.

Three teams were awarded first, second and third place prizes: CAPSULUM from ISISE-University of Minho (Portugal), UME-TEAM from IUSS Pavia (Italy), and SHEFFS from the University of Sheffield (UK), respectively, were awarded prizes of 1000€, 500€ and 250€, respectively. Considering the excellent quality of the reports, the Jury members also decided to attribute two honorable mentions, the Excellent Report Award, to the two best reports delivered by the teams SUM from the company Simpson Strong Tie (USA) (see subsequent article) and ISISE-University of Minho, and WCTW from ISISE-University of Minho.

Figure 4 Group photo of the SC@M Challenge awarded teams at the closing session of FRPRCS-11.

This initiative was welcomed by all involved members of the scientific community, and received very positive feedback. It was common understanding that the challenge created a unique atmosphere to stimulate the emergence of alternative approaches and creative solutions for FRP strengthening and technology. The contribution of young researchers to the development of the current state-of-the-art can be encouraged in the future through other events and periodic initiatives of this kind.

Competing Teams

IIUSESEU	South East University	China
MINSTR	University of Minho	Portugal
SUM	Simpson Strong Tie and University of Minho	USA and Portugal
ShinyDiamond	University of Minho	Portugal
CAPSULUM	University of Minho	Portugal
WCTW	University of Minho	Portugal
UME-TEAM	IUSS Pavia	Italy
SHEFFS	University of Sheffield	UK

initially 19 teams expressed interest, representing, in addition to those countries listed above: Greece, Taiwan, Iran, Poland, Russia and Saudi Arabia.

This article is condensed from an entry in the SC@UM competition at FRPRCS-11. It was selected for reader interest by the editor.

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