STATIC STRAIN AND DEFORMATION CONTROLLED TESTING OF COMPOSITE BEAMS

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ABSTRACT

Test control is commonly performed by a feedback signal from a gauge in an actuator. However, if a certain strain level is sought, it is more accurate to operate the test by measurements acquired directly on the specimen [1]. This is valid when testing a structure of complex geometry and/or under complex loading. The work presented in this paper, documents the use of fibre Bragg grating (FBG) [2] and digital image correlation (DIC) [3] for strain and displacement control, respectively. The test control was performed by software capable of: acquiring data from the FBG and DIC systems and operate the actuator accordingly. The technique was verified in a quasi-static three point bending test with a GFRP beam.

The GFRP specimen constitutes 22 plies of E-glass fibre mats oriented in the longitudinally direction and Epoxy resin. The optical fibres are located between the 1st-2nd, and the 21st-22nd plies each containing three sensors. The DIC system includes three measurement points. The test rig with gauges is seen in Figure 1.
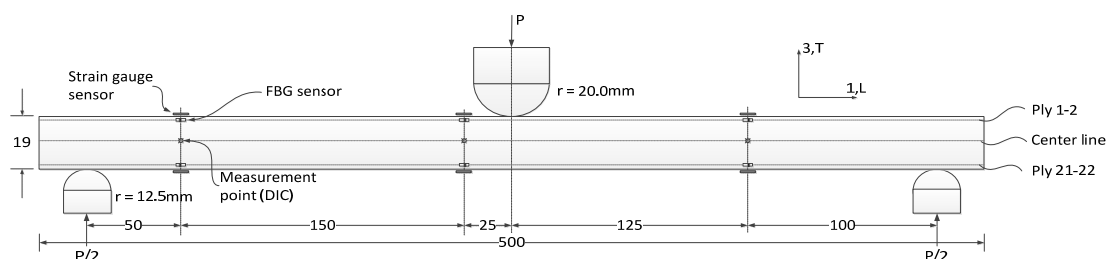
Figure 1: Schematic illustration of the 3-point bending test, the depth is 45mm

The force P is applied by a deformation controlled hydraulic actuator operated by a feedback signal acquired by DIC and FBG measurements. This configuration is handled by LabVIEW 8.6 and is executed in the state-machine framework presented by Figure 2.
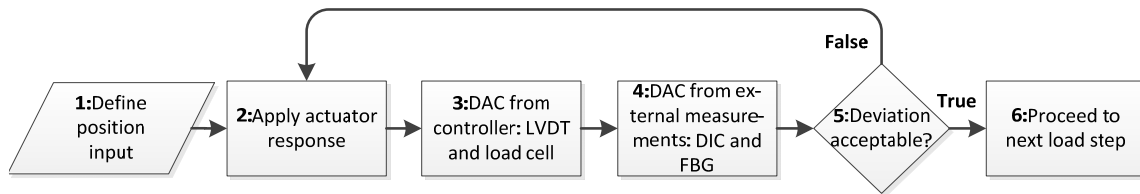
Figure 2: Operating and acquiring data from: controller, FBG interrogator and DIC system

As shown in Figure 2 the position input is defined in (1) after which a deformation is applied by (2). The deformation of the specimen is derived from the external measurement in (4) by an Euler-Bernoulli assumption and compared with the position input. If the deviation exceeds a certain tolerance the actuator is moved in the direction necessary to reduce the inaccuracy with a magnitude equal to the deviation. This process is repeated in a loop from (2) – (5) until a deviation below the acceptance tolerance is obtained.

Five GFRP beams were loaded to 3kN in two separate tests A) deformation control by DIC with an acceptance tolerance of 0.01mm and B) strain control by FBG with an acceptance tolerance of 5με. The deviation between position input and external input is presented in Figure 3.
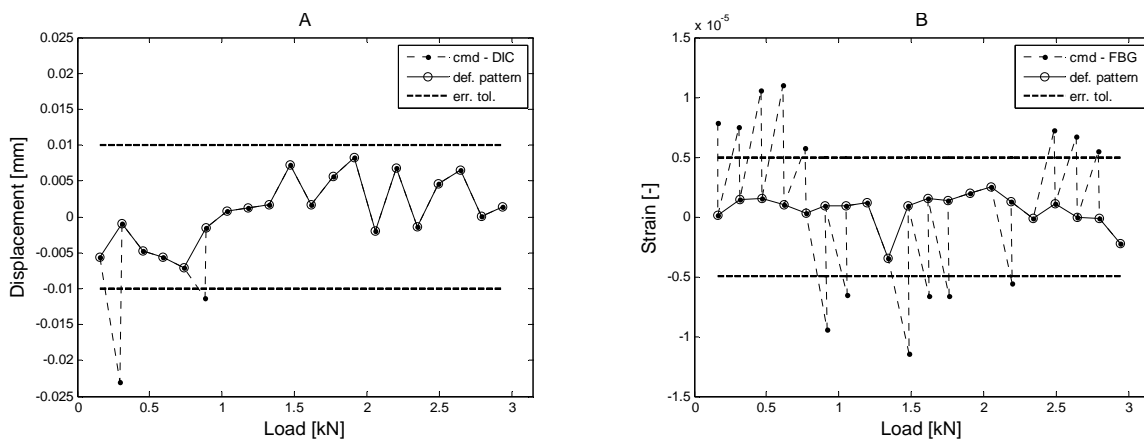

Figure 3: Deviation between position input (cmd) and external measurements: A) DIC and B) FBG

Figure 3 verifies the control loop with a reasonable amount of correlation loops. When the deviation is larger than the acceptance tolerance the program corrects the displacement/strain and proceeds to the next load step as described in Figure 2. The acceptance tolerance is set with respect to the precision and accuracy offered by the DIC and FBG system.

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