ACOUSTIC EMISSION AND ELECTROMAGNETIC MONITORING OF THIN TRC SANDWICH COMPOSITES IN BENDING

Nicolas Ospitia[1,2,]*, Ali Pourkazemi[2], Eleni Tsangouri[1], Mohammadsadegh Kesharvazi[1], Johan H. Stiens[2] and Dimitrios G. Aggelis[1]

[1] *Department of Mechanics of Materials and Constructions (MeMC), Vrije Universiteit Brussel, Brussels, Belgium,*
[2] *Department of Electronics and Informatics (ETRO), Vrije Universiteit Brussel, Brussels, Belgium*
** Presenting Author email: nicolas.ospitia.patino@vub.be*

Abstract
Textile Reinforced Cementitious (TRC) sandwich composites are innovative materials that combine the loadbearing capacity of TRC facings, with a lightweight core. However, this materials may fail under early interlaminar debonding, substantially reducing the loadbearing capacity of the composite. For this reason, thin TRC sandwich composites are subjected to three-point-bending test, and monitored with Acoustic Emission (AE), and milimeter wave (MMW) spectrometry.

1. Introduction

Traditional steel reinforced concrete (RC) sandwich composites have been widely used as a façade [1], that provide acoustic and thermal insulation. However, since the steel reinforcement is prone to corrosion, the minimum required cover can exceed 7 cm, depending the environmental conditions of the structural [2], , compromising the lightweight nature of the composite. This cover can be substantially reduced by using TRC as facing materials, that due to the noncorrosive nature of the textiles (usually carbon, glass, aramid, etc..) allow to reduce the cover to the order of mm. The mechanical behavior of TRC sandwich composites has been widely reported [3]–[5]. The interlaminar bond has shown to be a key parameter that may determine the failure mode, and early debonding may substantially reduce the loadbearing capacity of the composite. Therefore, along this study, a combination of AE and MMW spectrometry is proposed to monitor thin TRC sandwich beams subjected to three-point-bending. The lower interlaminar bond is artificially weakened by applying a thin layer of oil before casting (see Figure 1), and results are compared with a reference beam.

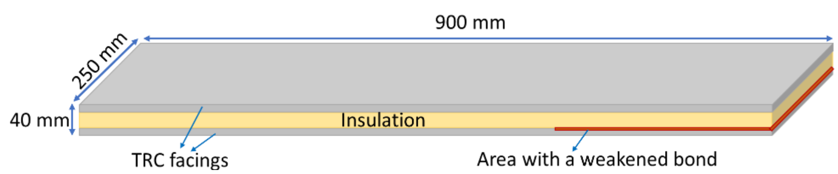

Fig 1. Ilustration TRC sandwich beam with destroyed bond.

2. Results

Figure 2a, shows the load vs. vertical displacement of both a reference beam, and one with a destroyed lower interlaminar bond, producing a mode 2 crack initiation. Results show a reduction of more than 80% of the maximum load when destroying the interlaminar bond. Figure 2b, shows the AE hits for both samples. The sample with destroyed bonding presented less AE activity, but also the characteristics of this activity are different. Specifically, the frequency content of the signals, as measured by the time domain "average frequency" (AF) of the reference sandwich beams is higher, while RA standing for the opening part of the signal (Rise Time, RT) over the amplitude (A) is lower, indicating that there is more tensile related activity in the reference beam, than the one with the destroyed lower interlaminar bond (figure 2c).

Furthermore, figure 2d shows the change in electromagnetic wave transmission (S21) vs. vertical displacement. There, the reference beam presents a constant decrease, attributed to an increase in the angle of incidence, due to the characteristics of the test, and certain small "jumps", that match with crack openings in the Area Of Interest (AOI) of the MMW antennas. While the sandwich beam with destroyed interlaminar bond, also shows a decrease in the average transmission, however, it is a less stable signal, that shows sensitivity to crack openings in the AOI, but also debonding, and an increase in the angle between the lower TRC facing, and the upper TRC facing.

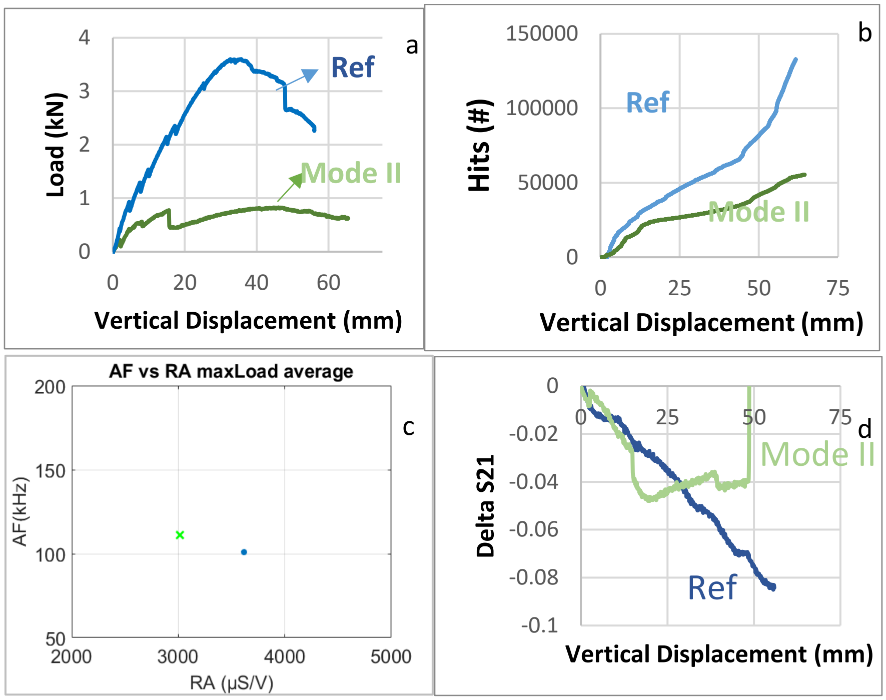

Fig.2 – Results a) Load vs vertical displacement b) Hits vs vertical displacement c) Cluster of AE activity until the maximum load for the reference (blue), and mode II (green) AF vs RA and d) change in average S21 vs vertical displacement.

3. Conclusions

Damage monitoring under three point bending tests was attempted by means of AE, and MMW Spectroscopy. AE results showed once again its capacity to characterise damage and discern between damage modes, showing differences in the quantity, and characteristics of the AE activity between the tested samples. In addition, MMW evidenced sensitivity to the damage, and direction of cracking occurring in its AOI.

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