

"Mechanical Behaviour of Adhesive joints"

31 Aug. - 2 Sept. 1987

Saint-Etienne, France

MECHANICAL BEHAVIOUR OF ADHESIVE JOINTS SUCH AS A CONCRETE EPOXY

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The sample DCB is separated in two parts then stucked by epoxy to study adhesion between concrete and epoxy resin.

The crack propagation was initiated at a notch in a double cantilever beam. The notch of the test sample was opened by an Instron tensile machin.

The crack extension was followed through direct optical observations. The displacement was measured by an extensometer.

During the fracture test, mechanical behaviour of the sample was monitored with various techniques: the experimental parameters obtained included the number of AE counts, the frequency spectra of the signals and the locations of microseismic source were also determined. Special problems relevant to different materials joining such as concrete epoxy will be discussed in this paper

Key words: ADHESION  
LOCATION  
FRACTURE

EPOXY RESIN  
ACOUSTIC EMISSION  
FAILURE

CONCRETE  
MECHANICS

SOURCE

## INTRODUCTION

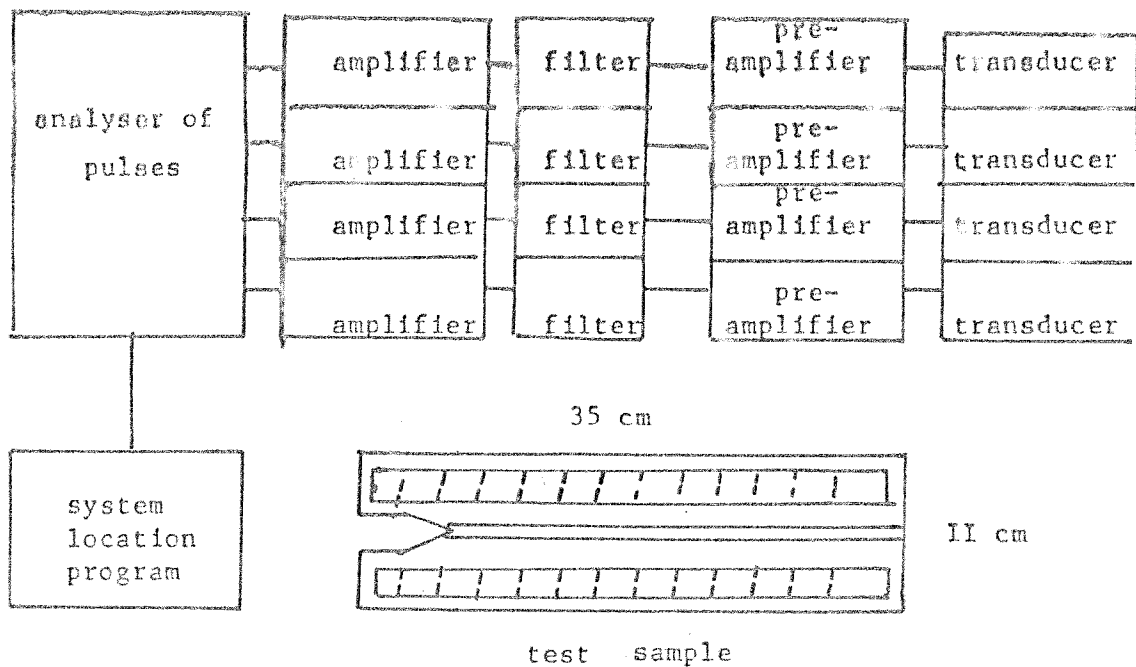
At the present time, repairing damaged buildings is as important as constructing them. Unfortunately our knowledge in the field of concrete repair is limited, (Aguiar, 1986, Paillere 1986, Denis, 1976).

We have studied adherence of concrete repair between epoxy resin and mortar. The main point of our work was the setting up of a test using the principles of fracture mechanics (Bui, 1978, Maugis, 1985) to allow determination of new parameters characterizing adherence.

After having encountered various problems which led us to reinforce the test sample, one can consider that the operating model used for the test works satisfactory.

## APPARATUS AND EXPERIMENTAL TECHNIQUES ACOUSTIC EMISSION

A block diagram of the monitoring and recording system (Briel et Kjaer) of four channels is shown in Figure I.



The monitoring system consists in a transducer (primary resonance at 200 KHz), connected through a preamplifier and amplifier (with 60 dB total gain), a band pass filter selected in the range 100 KHz to an analyser of pulses. After then the data are analysed by the source location program.

A second system (analysis spectra) for recording and analysing of AE data was used to establish a relationship between number of counts and cycles number and frequency spectra.

## MATERIALS

The material which was studied was mortar. The first series of tests was constituted by Double cantilever beam (DCB) samples moulded with dimensions of 35 cm length 1 cm width and 0,3 cm depth. The specimen has a notch 7 cm length located at the lower side of the beam.

The longitudinal prestressing was applied with two steel plates located on each side of the eventual failure to reinforce the test sample. This allows the measurement of mortar toughness under the condition of stable crack growth.

Ten test samples were produced using the design.

A second series of tests specimens is constituted by the sample DCB separated into two parts then stucked by epoxy resin to study adhesion between mortar and epoxy resin.

The crack propagation was initiated at a moulded notch in a double cantilever beam. The notch of the test piece was opened by a tensile machine. Displacement was measured by an extensometer and tests of cyclic loading were carried on with an Instron tensile machine.

The crack extension was followed through direct optical observations.

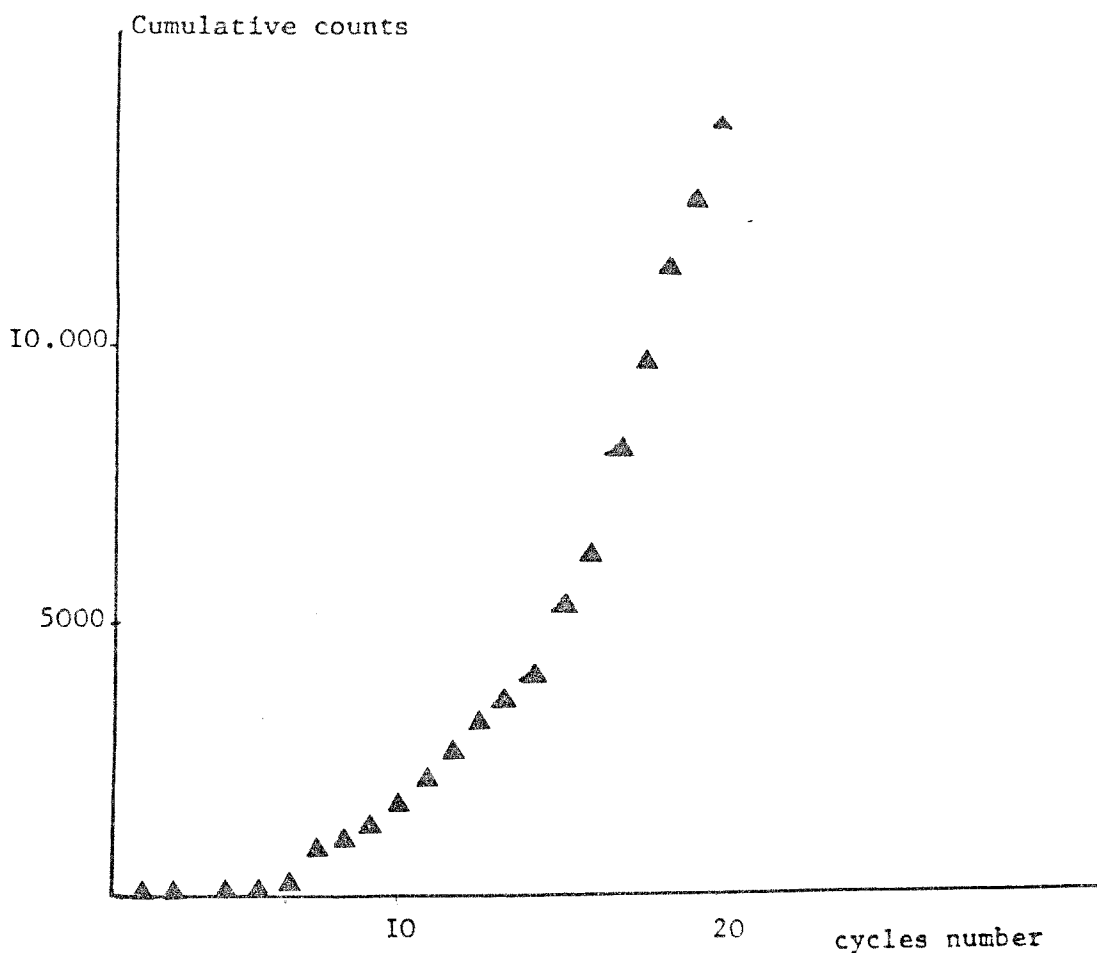
During the fracture test, mechanical behaviour of the sample was monitored with various techniques. The experimental parameters obtained included the number of AE counts, frequency spectra of the signals and the locations of microseismic sources were also determined.

## ANALYSIS DATA

### Relation between cumulative counts and cycles number

The form of the curve has been explained in terms of the mechanisms of fracture with the aid of AE.

Evaluation of such data obtained from the various tests on specimens indicated three definite stages associated with the notch length, namely: Figure 2.



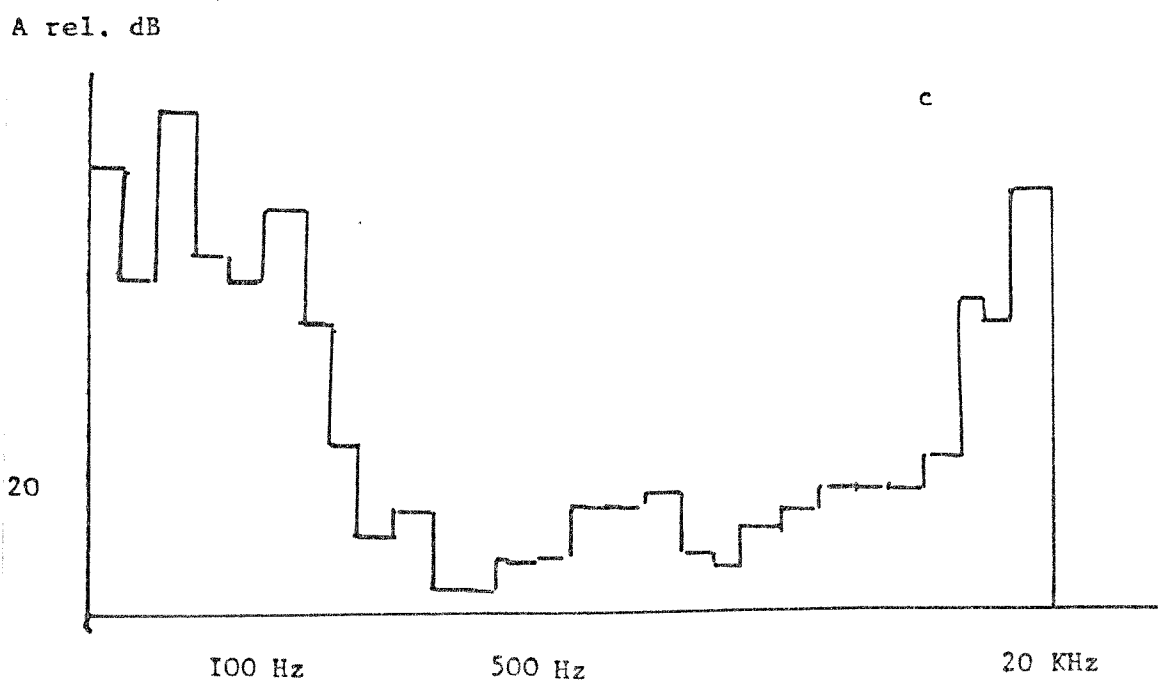
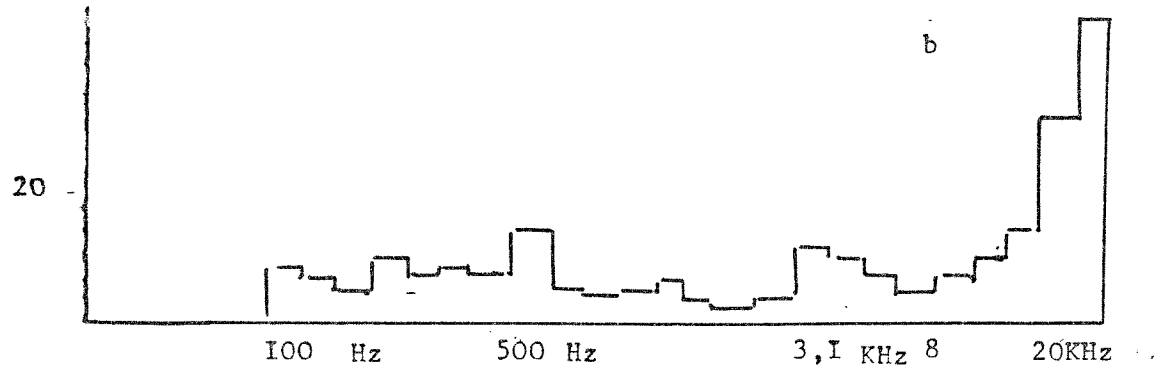
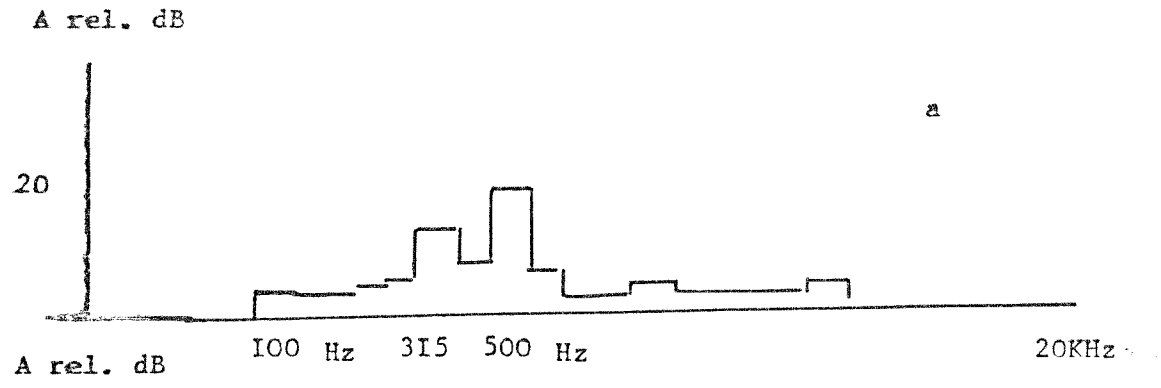
- before crack initiation, the length of the microcracking zone is stable.
- during the extension of the crack to a length, the zone of microcracking increases and the cracks begins to propagate slowly. During this period the length of the crack can be followed by eye.
- Afterwards during the last cycles, the final crackgrowth corresponding to an inflexion of this AE curve,

A comparison between the AE counts emitted by the DCB specimen mortar indicated that AE in the sample mortar is lower ( $10^4$ ) than the DCB specimen sticked with epoxy resin. This showed that a resistance of this type of composite material to crack propagation is increases. Consequently this new method is valid.

#### Analysis spectra

Concerning DCB testing, frequency spectra were observed in the frequency range 20 Hz-20KHz.

The three damaging stages of the specimen (DCB sample sticked with a mortar resin epoxy piece) are presented in Figure 3,



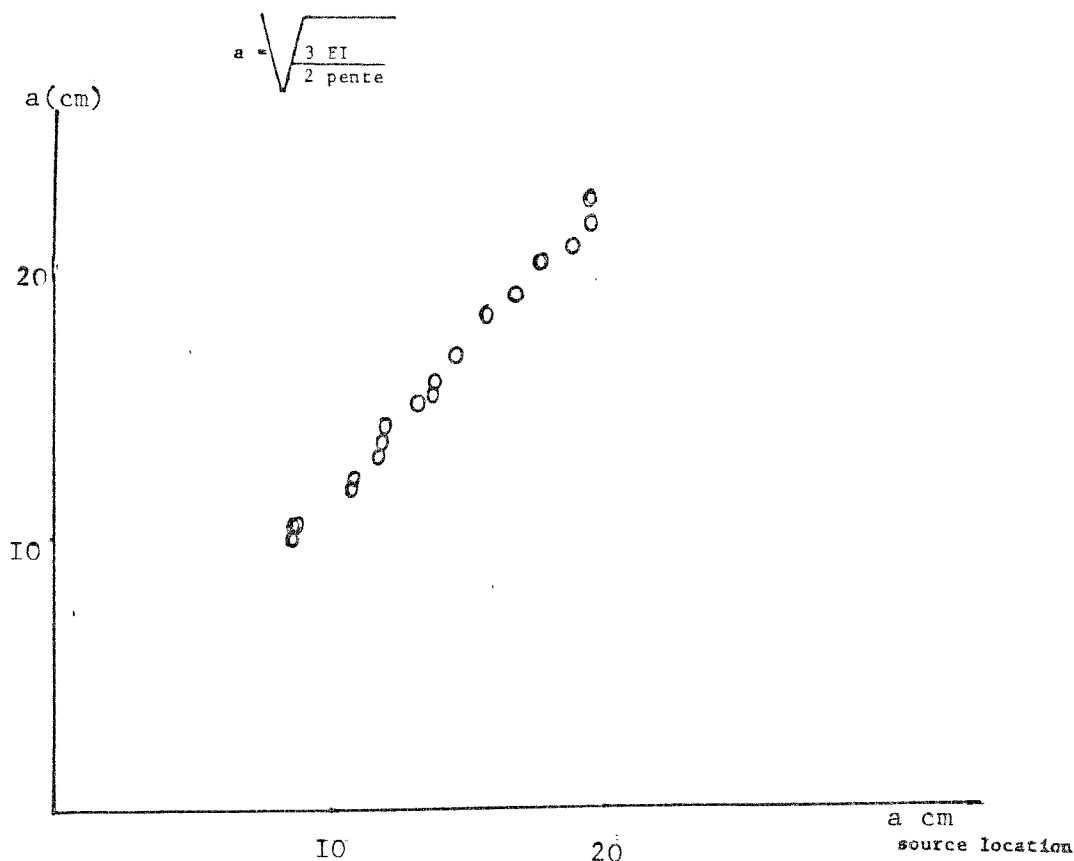
a) before crack initiation, the most common frequency observed was in the range of 100 Hz - 3,1 KHz. The lower frequency signals were generally of long duration.

b) During the crack growth, the most common frequency observed was in the range of 10KHz - 16 KHz. A large percentage of high frequency signals of short duration were observed.

c) At the point characterising by a total damaging , spectra are dominated by the low frequency components

Relation between a mechanical and a(source location)

In figure 4 this relationship is exhibited very well



The fracture energy measurements are not described in this paper, these analysis data being not exploited entirely. The difference in arrival time of wave from the reference transducer of coordinates yields a set of arrival time difference. This system has been only considered.

The Kaiser effect is not found in this material. When the sample was reloaded after initial loading and visible crack propagation, the acoustic emission recorded before the previous load level at which the crack arrested was reached again.

## DISCUSSION

The detection and location of the acoustic emissions have shown clearly that there are a number of stages involved in the fracturing of a notched specimens:

- a) In the elastic region of the stress strain curve, there is a zone of microcracks created near the tip of the crack.
- b) At the point of non linearity, the zone of microcracking attains a size and the crack begins to propagate slowly. During this period which can be followed by channel location system, the zone of microcracking ahead of the crack increases.
- c) After that there is a critical size of the crack growth until complete failure of the specimen.

## CONCLUSIONS

After having used various methods for determining the exact length (involved damaged zone) at a given time, we can say that the acoustic localization and the data obtained by analysing the force displacement curve have a relative fiability.

Fracture mechanics is a very good method to study the comportment of adhesive joints. The possibility to concentrate stresses at the joint is essential to lead to our objective. One consider that the test sample and the operating model used is the appropriate method. However, it is necessary to study the influence of surface treatment of mortar and adhesive composition.

## ACKNOWLEDGEMENTS

The authors wish to express their appreciation to Mr Jacky Dumas, Bruel et Kjaer, for their technical help (monitoring system of location).

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