Study on the Diagnosis System for Materials by Using of AE method-I : The characteristics of Mortars

Bull. Univ. Osaka Pref., Ser. B, Vol. 46,
大阪府立大学紀要，農学・生命科学，1994

Study on the Diagnosis System for Materials by Using of AE method-I
The charactaristics of Mortars

Takao KUWABARA and Masashi MOTEGI

Laboratory of Environmental Dvelopment Engineering, College of Agriculture

(Received, 1993)

Abstract

On the problems of mentainance and management for structures, there are two faces. One is as to the management of the function of structures and the other is as to the maintainance of materials. In the functional side, inicial conditions at the designing stages affect to the management of structures, and may be forced at times to be changed foundamentally. On the other hand, in the material side, it is an important subject how to grasp the change of material quality according with time progress and situation for common use.

In this study, the latter face is focused. And so, it is the purpose of this study to construct a comparatively simple diagnosis system for materials by using non-distractive methods, such as the acoustic impact technique and the acoustic emission test. And at first, by using non-distractive method, the foundamental properties of mortar materials which are generally used for structures are discussed and some standards of the evaluation as to AE parameters are proposed.

I Introduction

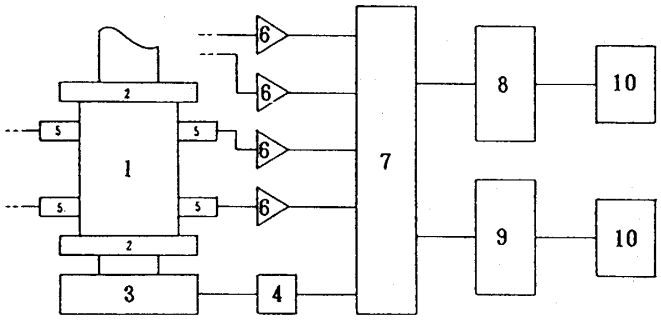
This report is described of the characteristics of mortar materials which are tested by the uni-axial compressive loading and measured by using of AE method. Genarally, AE is generated when the strain energy stored in materials is released by cracking of materials and so on. AE waves are propegated in materials as samely as elastic waves and are affected by characteristics of materials. Some parameters are measured, which are velocity, event rate, total count and spectrum density. From the changes of these parameter's characteristics, it can be estimated how are materials situated.

In this paper, mortar materials are the subject of discussion and from the results of the commpressive tests, fundamental characteristic properties of AE waves are investigated in order to find out the criteria of the diagnosis, whether materials are damaged or not.

II Method of Test

Mortar materials are tested by the uni-axial loading and AE parameters are measured by AE-measuring system as shown in Fig. 1. And these parameters are limited in this report as follows; Count Rate, Amplitude, and Spectrum.

Table 1 Shows the details of mortar specimens used in this research and Fig. 2 shows the location of AE transdusers set at surfaces of mortar in order to obtain AE signals.



1) speciment 2) boad for loading 3) load detector
4) degital indication box 5) AE transducer
6) pre-amplifier 7) data chenber 8) FFT analyzer
9) personal computer 10) printer

Fig. 1 System block diagram for acoustic emission measurement

Table 1 Details of specimen

size (L * W * H)	water:sand:cement	wet curing	age
100 * 100 * 100 (mm)	1:2:0.55	35 days	2 months

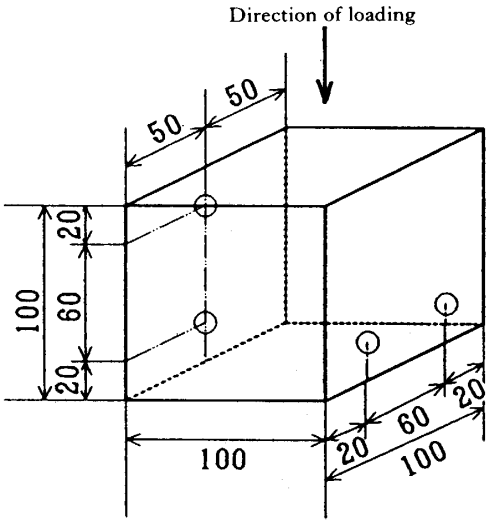


Fig. 2 Location of AE transducers

Mortar specimen is loaded uni-axialy at a constant loading speed, 2.5 kgf/cm²/sec, up to 5 tf and unloaded up to 0 tf. After then, the next loading is loaded up to 10 tf and also unloaded up to 0 tf. These patterns of loading are continued until the specimen is destroyed.

III Results and Consideration

(1) The charateristics of ultrasonic propagation Verocity

Table 2 shows the unit weight of mortar specimens and the mean value of ultrasonic propagation velocity to each specimen. The value of velocity is nearly equal 4000 m/sec.

Table 2 unit weight and average of ultrasonic propagation velocity

no.	unit weight	ave. vel.
1	2.128	—
2	2.128	—
3	2.126	—
4	2.132	—
5	2.138	—
6	2.141	—
7	2.194	—
8	2.198	—
9	2.198	—
10	2.191	—
11	2.189	4013.9
12	2.195	4022.6
13	2.173	3993.2
14	2.162	4004.4
15	2.166	3996.4
16	2.167	3999.4
17	2.159	3983.4
18	2.166	3969.3

It is considered that AE waves are propagated through a mortal material as samely as ultrasonic waves. But in the cases which specimens have some cracks inside, the propagation velocity is changed and decreased. And so, from the degree of decreasing of velocities, the inside state of materials can be estimated roughly.

Therfore, it is an important means for the diagnosis system to measure the value of propagation velocities of materials.

And also, the propagation velocity is affected by another pysical parameter as the density of a material. Fig. 3 is showing the raltionship between the densities and the value of velocities obtained in this study. Though there are some scattering of datum, the density and the velocity seem to have a linear relation.

(2) The Kaiser's Effect and AE Event Rate

AE waves are generally generated when the strain energy stored in materials is released by some unbalanced inside states of materials, however, even if materials are not damaged, AE waves are generated when materials are reloaded by the loading level over the previous loading level. These phenomena are called as the Kaiser's Effect. And so, from these phenomena, it can be estimated how much are materials previously experienced of loading levels, or whether materials are damaged inside or not.

Fig. 4 is showing one representative result of AE evevt rate for a mortar material.

From this result, it can be described that the material seems to be stable before cyclic

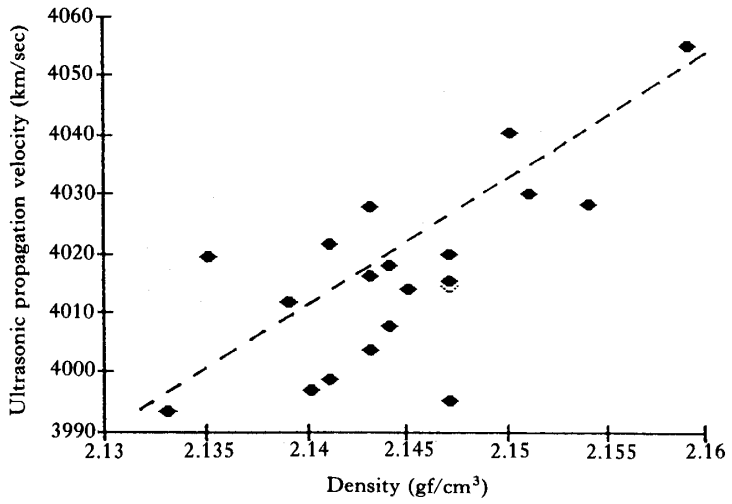


Fig. 3 Relationship between density and ultrasonic propagation velocity

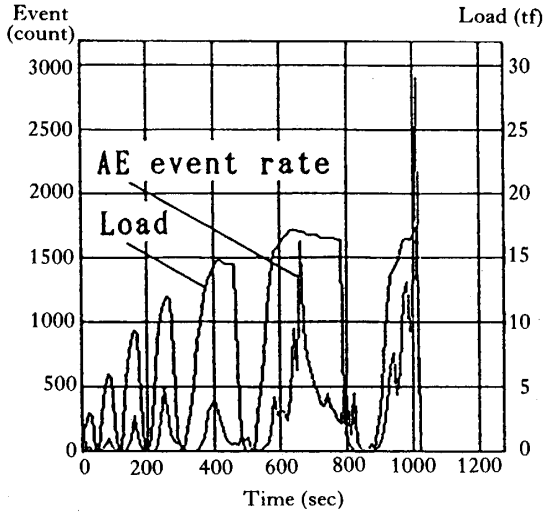


Fig. 4 Load and AE event rate in cyclic loading

loadings reach at 6 th loading, because the Kaiser's Effect is recognized at each cycle. But after 7 th cyclic loading starts, AE events are little by little generated and at last, suddenly increased when the material is destructed. In 7 th cyclic loading, the Kaiser's Effect can not be seen. Therefore, it can be said that the Kaiser's Effect gives one important index to estimate the state of a material.

Generally, AE events are generated even by small deflections of a material and also which means that the material is not still damaged, however, the value of the event rate is comparatively small. And so, it is also another important index for the diagnosis system to monitor the appearance of AE events.

(3) Distribution of Amplitude for AE Waves

AE waves have various kinds of amplitude levels in accordance with the degree of released strain energy, which means that the amplitude of AE wave becomes higher and higher as deflections and cracks in materials are bigger and bigger.

Fig. 5 shows the relationships between the amplitude of AE waves which are over some level of the output voltage and the total count of AE events which are generated at

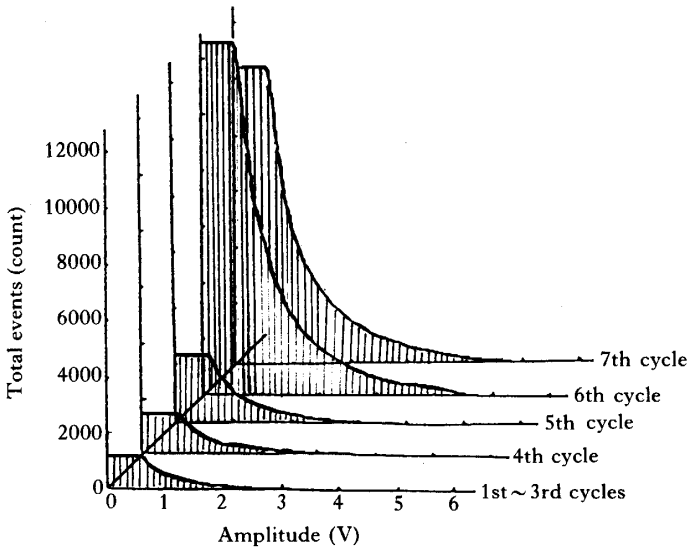


Fig. 5 Distribution of Amplitude

the times coresponded to the amplitude in each cyclic loading.

From this figure, it can be seen that by 5 rd cyclic loading, low amplitude and small count distributions are appeared, but after 6 th cyclic loading, heigher amplitude and big count distributions are appeared. And so, it can be said that the change of amplitude distributions as this like gives also another important index for the diagnosis system.

(4) Spectrum of AE waves

AE waves are remarkably affected by the pysical characteristics of materials and the mechanical characteristics added to materials as to amplitudes and frequencies.

Therefore, the frequency characteristics of AE waves give many impotant informations for materials and can be used well for the esimation of material states.

Fig.-6 shows the distributions of spectrum for mortar materials in the cases of cyclic loadings, in which (a) is corresponding with 3 rd cyclic loading and (b) is corresponding with 6 th cyclic loading.

Fig.-6 shows distributions of spectrum in the comparatively stable states of materials and that the excellent frequency range is lower and the power level for spectrum is also lower. On the other side, Fig. 6 (b) shows distributions of spectrum in the unstable states of materials and that the excellent frequency rang is heigher and wider, and the power level of spectrum is also heigher.

From these results, it can be said that AE waves have some kinds of characteristics as to frequencies which are able to be important indexes to estimate the states of mortar materials.

IV Conclusion

The diagnosis system must be constructed by many factors which are clearly evaluable and useful for every materials. In this report, AE characteristics for the mortar which are events rate, amplitud and spectrum, are discussed whether estimation of materials states can be established or not.

It can be said as conclusions that these parameters are recognized to be useful for the

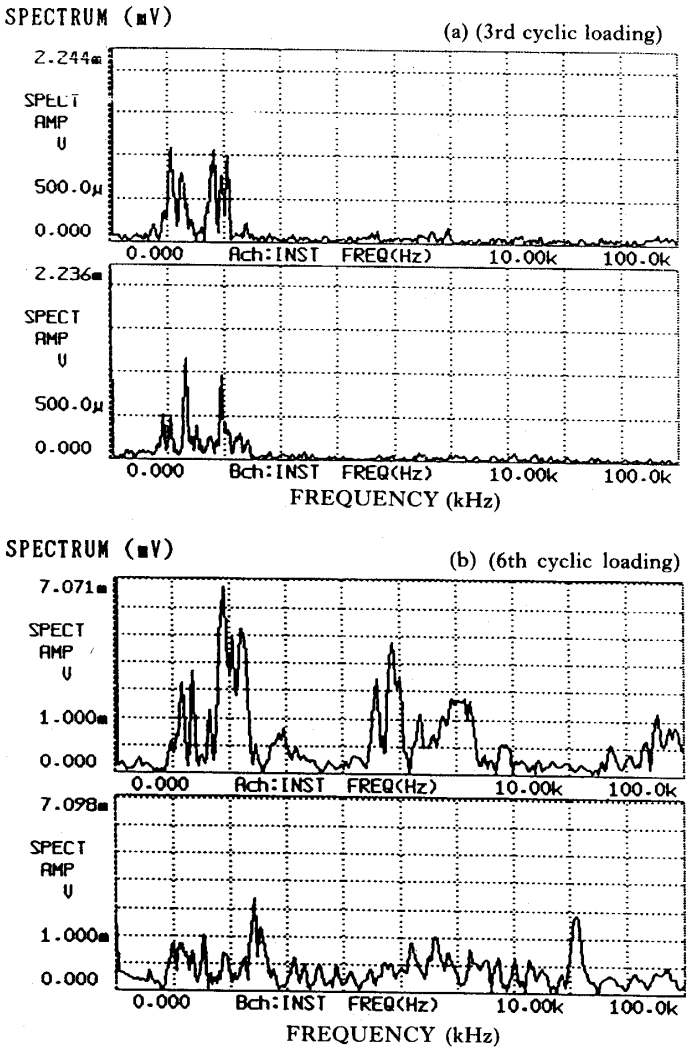


Fig. 6 Spectrum of AE waves

Table 3 Parameters and standards for deteriorational diagnosis of mortar

Parameters for judgement	Standards for judgement	
	safety condition	unsafety condition
AE event count rate	Kaiser Effect appears. The value of AE event count rate is constant and low.	Kaiser Effect does't appear. The value of AE event count rate is inconstant and high.
Amplitude distribution	There are few events which have big amplitude.	There are much events which have big amplitude.
Spectrum of AE wave	Peak of spectrum is low. Low frequency is remarkable.	Peak of spectrum is high. High frequency is remarkable.

diagnosis system. And so, from results of tests for mortar materials, the evaluational standards are proposed as shown in Table 3.

When the states of materials are separated as two stages which mean stable state and unstable state, each parameter of AE wave is just well corresponding with each stage.

However, in the unstable state, more detailed investigation must be needed in order to establish the useful diagnosis system for every materials. And so, the tests for other materials as like as concretes and wood materials will have been done.

Though this report may be situated as the first step for the diagnosis system, it can be said that many useful results and a good suggestion for the diagnosis system were obtained.

References

1) M. Outu (1988). Characteristics of Acoustic Emission and Theory. Morikita Press, p 5-33
2) Kuwabara, T., Motegi. M. (1992). On the Study of Materials by Using AE Method. Trans. JSIDRE p 88-89