EFFECT OF OILING UP ON ACOUSTIC EMISSION DETERMINED FAILURE OF CONCRETE

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Results of research into the pattern of the stress failure of different grades of concrete oiled up with mineral oil are presented. Acoustic emission was the investigative method. The values of initial stress σ_I and critical stress σ_{cr} determined both for oiled up and oil-free concretes indicate clearly that oiling up affects significantly the process of their failure. Practical implications of the obtained results are discussed.

INTRODUCTION

The problem of the oiling up of reinforced concrete or concrete structural components occurs mainly in industrial buildings. Mineral oil leaking from machines or production equipment installed there usually oils up floors, foundations and all sorts of supports for the machines. The possible effect of mineral oil on the physical and mechanical properties of concrete has been investigated by many authors, e.g., (1, 2, 3, 4). The literature, however, does not contain any data on the basis of which an opinion could be formed about the effect of oiling up on the course of the destructive processes taking place in the structure of concrete during its loading, particularly how it affects initiating stress σ_I and critical stress σ_{cr} values in concrete. This papers deals with the latter problem. One should bear in mind that the above kinds of stress delimit the particular stages in the failure of concrete, i.e. a stage of the stable initiation of cracks, a stage of the stable propagation of cracks and a stage of the unstable propagation of cracks. According to (5, 6, 7), initiating stress can be defined as the lower limit of failure

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of concrete, whereas critical stress is equated with the long-lasting strength of concrete.

DESCRIPTION OF TESTS

Four series of concrete—designated by letters A, B, C and D—possessing a similar B 25 class compressive strength but differing sharply in the grading of the rounded aggregate were subjected to tests. The composition of the tested concrete batches and the values of selected material properties characterizing them have been compiled in table 1.

TABLE 1 - Compositions of the tested concrete series and values of selected material parameters

Concrete composition Parameter type	Concrete A	Concrete B	Concrete C	Concrete D
Portland cement 35 from Górażdże Cement Plant [kg/m^3]	294	321	350	469
Natural gravel [kg/m^3]	1439	1185	697	-
River sand [kg/m^3]	480	711	1045	1480
Tap water [l]	163	178	194	257
Sand point [%]	25	37.5	60	100
Overall interior surface of aggregate per 1 m^3 of F_k mix [m^2]	3755	5180	7186	9768

The tests were carried out on 100 x 100 x 100 mm cube specimens after 360 days. 90 days after the specimens had been made, 12 specimens for each concrete batch A, B, C and D were oiled up and labeled as series AO, BO, CO and DO. The remaining specimens—also 12 for each concrete batch A, B, C and D—were stored as reference samples in a lab up to the date of the testing. They were labeled as series AL, BL, CL and DL. Lux 10 mineral oil whose physical and chemical properties corresponded to standard PN-53/C-96085 was used for the oiling up which was carried out as follows. The specimens were dried to a constant weight at the temperature of 105^{0}C and then put into a container and placed in a low pressure test chamber where they remained at the temperature of 50^{0}C and the air pressure lowered to 0.006 MPa for about 24 hours while the level of oil in the container was being raised progressively. Then the oiled up specimens together with the container filled with oil were carried over to the lab where they were left until the testing time. The aim of the described procedure was to speed up considerably, by removing water and air from the pores and capillaries of the concrete, the usually long process of the complete oiling up of its structure.

Acoustic emission in the axial compression test was used as the investigative method. Total acoustic emission counts were recorded as the function of stress increment.

TEST RESULTS AND THEIR ANALYSIS

The strength tests showed about a 5 % reduction in the compressive strength for all the tested oiled up batches of concrete against the oil-free reference series. Markedly different figures of total emission counts both for the particular stress levels and the whole process of failure of the oiled up concrete batches in comparison with the reference concrete series were recorded. The differences between the total emission counts grow as the fine aggregate content in the concrete increases. The relevant test results have been presented in figure 1.

The significantly lower acoustic "activity" of the oiled up concrete series in comparison with the reference ones is presumably due to the weakening of their cohesion and the loosening of their structure as a result of the penetration of oil. Also the damping of elastic waves by the oil filling up the pores and capillaries in the concrete is a major factor here.

To obtain a clearer picture of the failure of oiled up concrete against oil-free concrete, the values of initiating stress σ_i and critical stress σ_{cr} in the considered series of concrete were determined. This was done on the basis of the total acoustic emission counts recorded during the course of failure. The growth rate of total acoustic emission counts as a function of stress increment was determined from the relation and the description given in (8). Figure 2 illustrates how total acoustic emission counts growth rate IAE changes as a function of stress increment σ/R for concrete series CO and CL. As it can be seen in figure 2, the growth rate of this counts total as a function of stress increment has a three-stage character both in the CO and CL concrete series. One can discern stages of constant, stable, and unstable growth of the counts total. This indicates a tri-stage process of the failure of the structure of concrete. The constant growth of total acoustic emission counts signals a stage of the stable initiation of cracks. Whereas the stable growth followed by the unstable growth of this counts total indicates stages of the stable propagation and the unstable propagation of cracks. It follows from the figure that in all the oiled up concrete batches, initiating stresses reach lower values than in the oil-free reference concrete series. A similar tendency has been observed for critical stresses.

It has been found for all the tested concrete series that the stage of the constant growth of total acoustic emission counts is always shorter while the stage of the unstable growth of this counts total is always longer than in the case of the reference concrete series. The stress levels at which the constant stage, and the stable stage as well as the stable stage, and the unstable stage of the growth of the total acoustic emission counts rate are demarcate cleary correspond to initiating stress σ_i and critical stress σ_{cr} (9). The variation of the values of these stresses determined for all the tested oiled up and oil-free concrete series depending on the overall interior surface of the aggregate is illustrated in figure 3. It follows from the figure that in all the oiled up concrete batches values of initiating stresses reach lower values than in the oil-free reference concrete series. A similar tendency has been observed for critical stresses.

RECAPITULATION

By applying the acoustic emission method it has been demonstrated that oiling up affects the course of the failure of concrete—as evidenced by the determined values of initiating stress σ_i and critical stress σ_{cr}. These stresses delimit the particular stages of the failure of concrete. It has been found that no matter what the fine aggregate content is, the values of initiating, and critical stresses in oiled up concrete are generally lower than the corresponding values in the reference oil-free concrete.

Since initiating stress σ_i is identified with the safe fatigue life of concrete, this means that oiling up may lower the safety of the structure. For example, the purpose of an object whose structural components became oiled up or its function may change as a result of which these components will be subjected to changing loads producing stresses whose values exceed those of the initiating stresses characteristic for the given concrete, which may have disastrous consequences.

By contrast, the lowered values of critical stress in oiled up concrete structures do not increase the danger of their precipitate failure.

SYMBOLS USED

F_k = overall interior surface of aggregate per 1 m^3 of mix (m^2)

IAE = growth rate of total acoustic emission counts (imp)

ΣAE = total acoustic emission counts (imp)

σ_i = initiating stress

σ_{cr} = critical stress.

REFERENCES

(1) Bastian, S., Cement-Lime-Gypsum, No.7-8, 1960, pp. 204-211.

(2) Grabiec, K., Archives of Civil Engineering, Vol. 19, No. 3, 1973, pp. 567-572.

(3) Resistance of Concrete to Chemical Attack, Report of the RILEM 32-RCA Commission. Materiaux et Constructions, Vol.14, No. 80, 1981, pp. 130-137.

(4) Błaszczyński, T., Proc. of the Third Kerensky Conf., Singapore, 1994, pp. 67-70.

(5) Shah, S.P. and Chandra S., ACI Journal, Vol. 65, No. 9, pp. 770-781.

(6) Newman, K. and Newman, I.B., „Failure theories and Design Criteria for Plain Concrete Structure", Solid Mechanics and Engineering Design, Proc. Southampton, 1969, Civ. Eng. Mat. Conf., 1971, London, England, pp. 963-995.

(7) Flaga, K. and Furtak, K., Archives of Civil Engineering, Vol. 27, No. 4, 1981, pp. 653-666.

(8) Broniewski, T. and Hoła, J. and Śliwiński, J., Materials and Structures, Vol. 27, 1994, pp. 331-337.

(9) Hoła, J., Archives of Civil Engineering, Vol. 38, No.1-2, 1992, pp. 85-101.

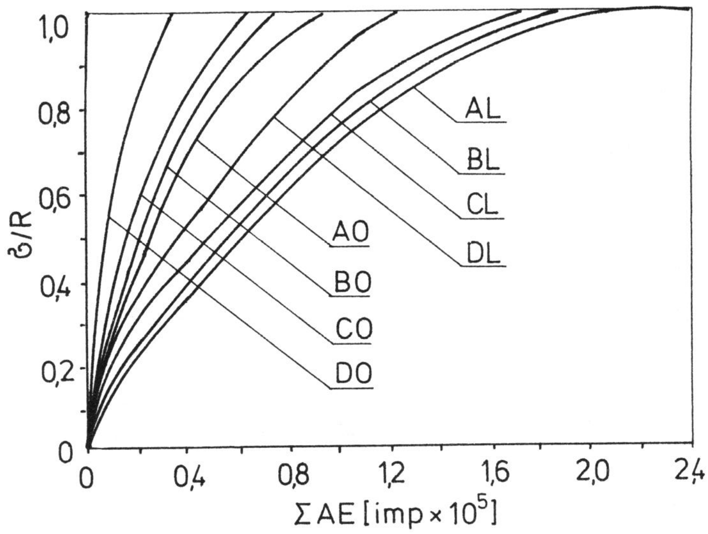

Figure 1 The variation of total emission counts in axially compressed oiled up, and oil-free concrete series as a function of stress increment

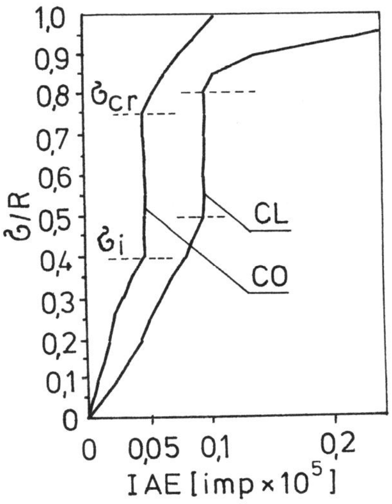

Figure 2 The growth rate of total acoustic emission counts in CO, CL concrete

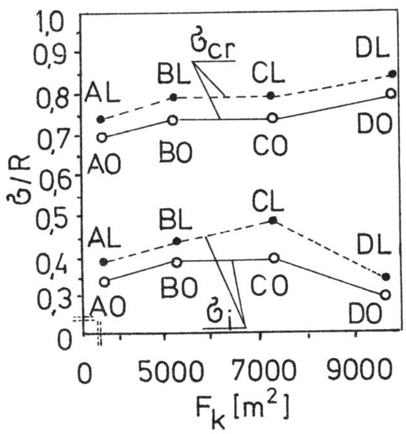

Figure 3 Initiating stress and critical stress values in the tested concrete series