Zeitschrift: IABSE reports of the working commissions = Rapports des commissions de travail AIPC = IVBH Berichte der Arbeitskommissionen

Band: 14 (1973)

Artikel: Low-cycle fatigue of concrete in compression: a method of experimental investigation

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DOI: https://doi.org/10.5169/seals-14476

IV

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Low-Cycle Fatigue of Concrete in Compression. A Method of Experimental Investigation

Fatigue à basse fréquence de béton comprimé. Méthode d'une recherche expérimentale

Nieder-zyklische Ermüdung von komprimiertem Beton. Methode einer experimentellen Untersuchung

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An experimental investigation of low-cyclic fatigue of concrete in compression is in progress at the Building Research Institute of Technical University in Prague at present. The experiments are performed on prisms 15x15x40 cm with constant rate of strain-loading (speed: $\Delta\varepsilon/\Delta t \doteq 0{,}4 \cdot 10^{-3} \cdot \mathrm{min}^{-1}$). The most difficult problem associated with this type of experiment is the determination of the upper limit of cycling load P_m for each specimen. The value of P_m is in the interval from 0,85 to 0,95 of ultimate strength P_U. From number of methods attempted, the method of recording of volume-strains proved to be most useful.

On the curve of the usual stress-strain diagram $P \times \varepsilon$ only the point of ultimate strength P_U can be clearly defined. However, on the corresponding volume-strain-stress diagram $P \times \Delta V/V$ two other points can be defined (Fig.1): P_c - load under which concrete has minimum volume, P_0 - load under which volume strain is of zero value. By these two points is in fact limited the interval of low-cyclic fatigue.

It follows from results of pilot experiments that between values of P_c, P_0 and P_U, relations exist, which permit sufficiently reliable estimate of stress-state of specimen. The histograms of ratios P_c/P_U and P_0/P_U are shown in Fig.2.

The comparison of relations $P \times \varepsilon$ and $P \times \Delta V/V$ is illustrated by two examples. Fig.3 shows these diagrams for a case

of failure after five cycles of loading (spec.No65). The case of specimen (No71) which survived 20 cycles of loading is shown on Fig.4. From these examples can be seen that the curve $P \times \Delta V/V$ provides more useful information for this investigation, comparing to ordinary stress-strain diagram.

It should be emphasized that record of volume strains can be used also for evaluation of results. Results of pilot tests of about 40 specimens are shown in Fig.5. Number of cycles n_f leading to failure of concrete is plotted against the ratio v_{m1} / v_c defining the upper limit of cyclic loading (the meaning of parameters is clear from figure).

These preliminary results indicate that relation between number of cycles leading to failure and upper limit of cyclic loading defined by volume strains exists. The same result follows from ratio of number of failed (full points) and unfailed (blank points) specimens, plotted at three levels of cyclic loading (Fig.5).

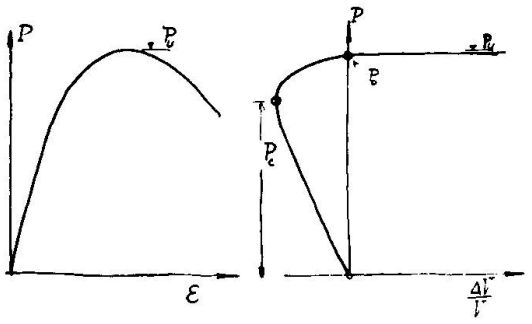

Fig.1 Stress-strain diagram and volume-strain-stress diagram

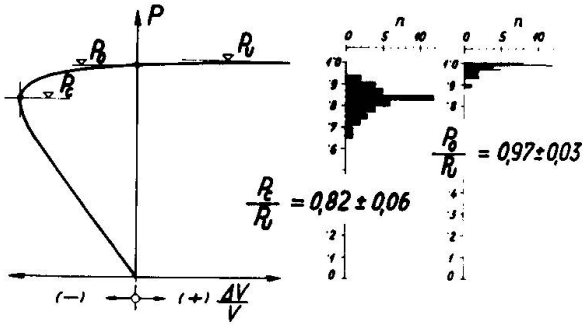

Fig.2 Characteristics of volume-strain-stress diagram

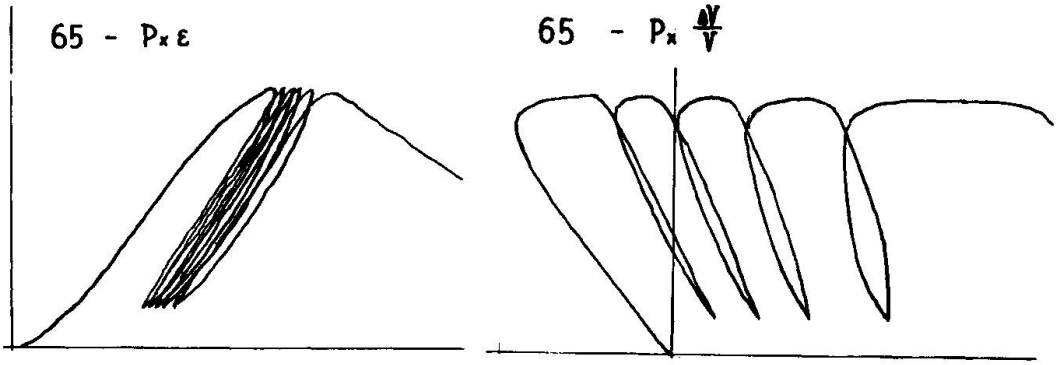

Fig.3

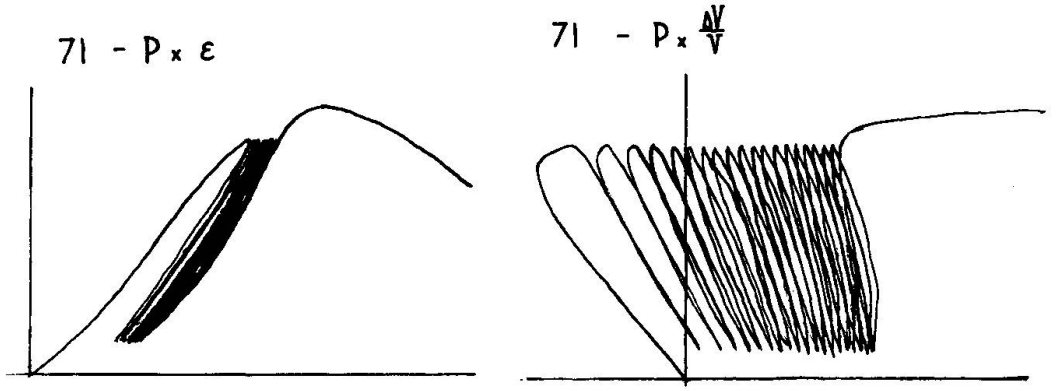

Fig.4

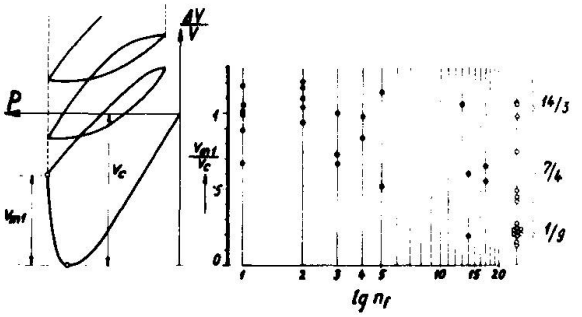

Fig.5 Experimental results of pilot tests

● – failed

○ – unfailed

SUMMARY

The volume strain of concrete is a suitable parameter describing the behaviour of concrete specimens under cyclic loading. The use of volume-strain/stress-curves enables to perform low-cycle fatigue tests with acceptable reliability of reaching failure at a required number of cycles.

RESUME

Le changement de volume du béton constitue un paramètre utile pour décrire le comportement d'éprouvettes en béton sous charges cycliques. L'utilisation de courbes changement de volume/charge permet d'exécuter des essais sur cycles à basse fréquence avec une fiabilité admissible en atteignant la ruine au nombre de cycles requis.

ZUSAMMENFASSUNG

Die Volumenbeanspruchung von Beton ist ein geeigneter Parameter zur Beschreibung des Verhaltens von Betonprobekörpern unter zyklischer Belastung. Die Verwendung von Volumenbeanspruchung/Spannungs-Kurven erlaubt die Durchführung von Versuchen für nieder-zyklische Ermüdung mit annehmbarer Zuverlässigkeit beim Erreichen des Versagens bei einer verlangten Anzahl von Zyklen.