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CREEP IN LIGHTWEIGHT CONCRETE
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BIBLIOGRAPHY (63-17)
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CREEP IN LIGHTWEIGHT CONCRETE

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1. Best, C.H, M. Polivka, "Creep of lightweight concrete." Mag Concrete Research 11: n 33, Nov 1959, p 129-34

Creep data covering periods up to 18 mo for concrete made with expanded-shale aggregates and having compressive strengths of 3000 and 5000 psi at 28 days;;compariscn with data for sand gravel concretes of comparable strength: creep in lightwwight concrete was equal to or less than that in normal weight concrete of comparable strength; hydraulic loading equipment used in creep tests.

2. Blakey, F.A., B.E. Hons, "Deformations of an experimental lightweight flat plate structure." Civil Eng. Trans. of the Inst. Of Eng. Australia CE 3: n 1, March 1961, p 3-7.

The deflections under dead and live load of an experimental flat plate structure of lightweight concrete are reported. Measurements were made of both the instantaneous deformation in each case and of the long term increase in deflection. Reference is also made to deformations due to temperature changes and shrinkage.

It is considered that rapid drying and lack of curing lead to very high creep under dead load. Instantaneous deformations were well within acceptable limits in spite of the slenderness of the slab. The centre deflection of individual loaded panels was found to be only slightly affected by the boundary conditions of each panel.

3. Evans, R.H., T.R. Hardwick, "Lightweight concrete with sintered clay aggregate." Reinforced Concrete Rev 5: n 6, June 1960, p 369-84 (discussion) 384-400.

Advantages of lightweight aggregates; test results on sintered expanded clay known commercially as Aglite; tests on reinforced beams for ultimate loads, deflections and cracking characteristics, post-tensioned columns for creep and shrinkage losses, columns for modulus of elasticity and pull-out performance, and prestressed concrete beams; measurement of transmission or bond lengths of columns.

4. "Experimental flat plate structure of expanded shale concrete." Constr Rev 33: n 2, Feb 1960, p 22-9.

Australian experiments have shown that only important differences between expanded shale concrete and ordinary concrete are in density and modulus of elasticity; any compressive or tensile strengths can be modified with light concrete as readily as with dense; at same cement factor and appropriate workability; there are some differences in creep; test results given for floor slab supported on steel columns.

5. "Experimental lightweight flat plate structure Part 11-Deformations due to self weight, Part 111-Long-term deformations. Construction Review 34: No. 3, p 25, March 1961 -- (pt 11) v 34, No. 4, p 21, April 1961.

Pt 1 - The design and construction of the experimental flat plate structure have been described previously, and this paper will discuss some of the deformations of the structure after removal of the form-work.

Measurements of strain were made on the columns and on the surface of the slab with a "Demec" portable mechanical extensometer, and on the steel shear headsof the columns by electrical resistance strain gauges. Deflectionsof the slab were measured by means of a Dumpy level reading on small steel rules which were magnetically attached to small metal plates glued to the under surface of the concrete. The first few sets of deflection readings could not be taken in this way as the rules took some time to install after the formwork had been removed, and they were measured on the upper deck of the slab with a level and staff. This meant that no measure of the rigid body displacement of the slab was possible, but this did not matter as it would not influence the stress consition of the slab.

Part 111- The details of this structure and the materials and methods used in its construction have been given in previous reports in this series. This paper will be confined to a report on the increase in deformation in the structure, firstly under its own weight, and then under an applied load.

Concrete for the slab was placed on October 12, 1959, and the formwork was removed ten days later. No attempt was made to cure the concrete and during the ten days the weather was generally fine and warm, with moderate winds. As soon as possible after the concrete had hardened numerous small steel discs were glued to the upper surface to provide points between which strain could be measured with a mechanical extensometer over an 8 in. gauge length. This work was completed four days after casting. After the formwork had been stripped, discs were glued to the under-surface to provide a corresponding set of locations for measuring strain.

Some small steel blocks were also glued to the under-surface. Steel rules were attached magnetically to these blocks and deflections of the slab were obtained by sighting on the rules with a Dumpy level. The Dumpy level was carried on an insulated metal column which in turn was attached to a concrete shaft sunk to a depth of about 15 ft. through the clay foundation.

Because of the time required to attach the metal blocks and discs to the under-surface, all of the earlier measurements were made on the top surface only. The deflection readings were taken with a leveland staff and referred to an arbitrary datum; this was possible because only relative deformations within the structure cause stresses, not rigid-body displacements. When the necessary arrangements had been made, readings were taken both on the top and on the under-surface of the slab to obtain corresponding values, and then all subsequent measurements of deflection were made below the slab.

Strain readings were continued on the upper surface of the structure until the water tanks by which the live load was applied were installed, after which that surface was no longer accessible.

6. Grant, W. "Lightweight Aggregates." Concrete 65: n 7, 8 July 1957 p 30-2, Aug p 28, 30, 32, 34.

Properties and qualities of natural, by-product and manufactured aggregates.

7. Hansen, T.C., "Creep of concrete: a discussion of some fundamental problems." Svenska Forsknings institutet for Cement och Betong vid Kungl.Tekniska Hogskolan i Stockholm, Meddelanden. No. 33 Stockholm, 1958 (Swedish Cement and Concrete Research Institute)(In English with French summary)

The subject is treated under the following headings: Creep and methods of measuring creep: Relations between creep amd shrinkage of concrete; basic creep, elastic, plastic, and viscous properties of concrete; relations between creep and composition of concrete; a rheological model for concrete. There are forty references to the literature. (Road Abstracts, London, March 1959, no. 3, Abstract # 258 to 335.

8. Jones, R.H. and H.E. Vivian,"Cement-aggregate reaction: mortar containing reacting aggregate. (Council Sci. Ind. Research Organization, Melbourne). Australia, Commonwealth Sci. Ind. Research Organization, Bull. No. 256, 7-12 (1950); cf. C.A. 43, 8311; 45, 9239c, Chemical Abstracts, Vol. 46, No. 9, May 10, 1952.

Mortars made with high-and low-alkali cements and an opaline-chartaggregate were examined microscopically in thin sections. Swelling of reacted aggregate particles caused abnormal expansion and cracking. There was no evidence of the formation of membranes across cracks as postulated in the osmotic-pressure cell theory for the expansion of mortar. (Kalousek,J. Am Concrete Inst. 15, 228 (1944).

When the proportion of reactive component in the aggregate is small, mortar expansion depends largely on the amount of reactive material. But as the amount of reactive component is increased the amounts of alkali and water available to each reactive particle decreases and total expansion is reduced. Maximum expansion was observed with 5 percent reactive component, while no expansion occured with less than 1 percent or more than 40 percent reactive material.

Mortar expansion depends largely on the amount of water available for absorption by reacting aggregate particles. In mortars containing large amounts of removable water the reaction product becomes a sol, but in mortars withlittle removable water it remained as a gel.

Added NaOH attacked reactive aggregate at all concentrations used (o.5-9.5 percent of cement). Increased alkali concentrations increasedthe rate of reaction and the amount of removable water in the mortar.Large amounts of alkali produced a fluid rather than a solid reaction product. Mortar expansion depended on the relative amounts of the 3 interdependent variables; reactive aggregate, alkali, and available water. Generallly mortars expanded only when the amounts of both alkali and reactive aggregates were small.

Additions of NaOH lowered the tensile strength of mortars, evidently because of deleterious effects on the hydrated cement. In mortars containing reactive aggregate the tensile strength was further reduced by cracking which occurred whether the mortar expanded or not.

9. Kesler, Clyde E., "Correlation of creep of concrete with its dynamic properties." Department of Theoretical and Applied Mechanics Report No 603, University of Illinois, 187p+

Creep of concrete, i.e., its property of exhibiting time-dependent deformation under and due to stress and damping in concrete, i.e., its property of dissipating energy when subjected to cyclic stresses, are conceivably two aspects of the same basic phenomenon of the in-elastic behaviour of concrete and, hence, should be interrelated. Based on this concept, creep and dynamic tests were carried out on a number of 6 by 12 in. cylindrical specimens from several batches of medium rich concrete mixes with gravel and crushed stone as coarse aggregates. Two different sustained stresses were used for compressive creeptests, the specimens being loaded at ages of 7 and 28 days in controlled environments of 50 percent relative humidity and 73 F. The compressive creep tests were carried out using specially designed apparatus for maintaining the load. Dynamic properties were obtained using a decaying amplitude method.A special method was developed to photograph oscilloscope traces of decaying amplitudes of 6 by 12 in. cylindrical specimens in the first mode flexual free-free vibrations. In addition, flexual creep tests were carried out on 6 by 64 in. prismatic beams loaded at their third points. Midspan strains of longitudinal fibers along the depth and midspan deflections were measured.

An integrated hypothesis of creep was developed from a critical analysis of available hypotheses. A rheological model of the Kelvin-Maxwell type with the Kelvin-viscosity proportional to the square root of time and the Maxwell-viscosity increasing exponentially with time was developed. Creep expression derived on this basis was found to describe all the compressive creep curves very well for the duration of creep-time studied.

10. Girgrah, Mageed and Clyde E. Kesler, " A study of the rheological and damping properties of concrete. University of Illinois. <u>Department of Theological and Applied Mechanics Report</u> No. 173, 35 p + diagrams and charts.

This paper presents a study of the rheological and camping properties of plain concrete. Since concrete is considered to be a visco-elastic material, the creep behaviour of concrete is investigated with the aid of rheological models. A brief theoretical treatment of rheological models is also given as a background to the investigation. The treatment includes consideration of generalized linear rheological models and their conversion to the canonic forms.

Creep and damping are two closely allied properties of concrete, The damping of plain concrete and neat cement is studied with the aid of several decaying amplitude curves, and the damping charcateristics are interpreted in terms

of a rheological model, whose creep behaviour is then examined. The paper also includes a study of the variation of the damping and elastic properties of both concrete and neat cement with age.

Both the resonant method and the decaying amplitude method for measuring the damping are used. The two methods are compared, and an explanation of the double hump phenomenon encountered in sonic testing is given and verified by evidence from the decaying amplitude method.

11. McCammon, J.W., " Lightweight aggregates in British Columbia." Can Min & Met Bul 50: n 538, Feb 1957, p 88-9.

Results of laboratory tests of foamed slag, cinders, pumice, diatomite, vermiculite, perlite, and bloated clay and shale.

12. Patten, B. J. F.,"Drying shrinkage and creep of expanded shale lightweight aggregate concrete." Constr Rev 33: n 11, Nov 1960, p 29-32.

Comparative investigation of drying shrinkage and creep of lightwwight concrete made from expanded shale aggregate from New South Wales and of concrete made from river sand and gravel; lightweight concrete exhibits slightly greater creep strains and its drying shrinkage is considerably less; instantaneous strain is cancelled out by end of 3 mo of sustained loading: test prodecure and apparatus diagrams.

13. Rogers, Grover L.,"On the creep and shrinkage characteristics of solite concrete." World Conference on Prestressed Concrete Proc San Francisco, 1957 p 2-1.

Data is presented in this paper which shows the variation of creep strain with time for three mixes of the lightweight Solite concrete and a conventional sand and gravel mix. The information presented is of special interest in that it relates to a sustained load applied to cylinders of concrete when only 24 hrs old. Curves are presented which show the variations of creep with time and also drying shrinkage with time over a period of 400 days. The stress level used was 600 psi.

14. Ross, A.D., "Creep of portland blast-furnaces cement concrete." Instn Civ Engineers--J 4,Feb 1938, p 43-52.

Analysis of series of original laboratory tests; stresses induced by creep.

15. Shideler, J.J., "Lightweight-aggregate concrete for structural use." Am Concrete Inst--J 29: n 4, Oct 1957, p 299-328.

Investigation of properties of lightweight aggregates concrete; program includes tests of plain, conventionally reinforced, and prestressed concrete specimens; data reportedon concrete mixproportions, compressive and flexual strength, modulus of elasticity, bond, creep and drying shrinkage.