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II

RAPPORT GÉNÉRAL / ARBEITSBERICHT / GENERAL REPORT

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The opening remarks at this morning's session pointed out the desirability and the hope that, as a result of interchange of experience, it might be possible to develop reasonably simple mathematical techniques for designing structures to cope with the effects of creep, shrinkage and temperature changes that would be as well agreed upon and at least as simple to apply as the well established and somewhat complicated methods for dealing with gravity loads.

Theme II for this second session is to consider how to apply the results of observations and measurements as previously discussed to the practical design of structures. This would deal not so much with the computational methods, because those are for tomorrow's program, but rather the influences these different parameters have in the design of structures.

You have heard Mr. Casado's introduction to this theme in which he summarized the current state of the art and many of the problems and gaps in our knowledge. It is my task to give you a summarization of the contributions for Theme II.

Professor Leonhardt of Stuttgart, Germany, following his own successful practice, recommends that by care in selecting materials, proportioning, and curing, the volumetric changes in the concrete can be minimized. He mentions gap-grading, small cement content, efficient curing, prohibiting loading of young concrete and other excellent suggestions. He also mentions selection of sections that behave well, guarding against excessive prestress. In difficult cases, compression reinforcement can be added. Many other practical suggestions are brought together in this excellent summary.

Mr. J. Aichhorn of Austria also has practical suggestions, such as selection of suitable sections, columns in framed bridges, amount of prestressing force, thermal insulation, cantilevered construction, and numerous similar precautions and design possibilities.

K. Ohno and M. Obata of Japan analyze multi-legged bents with buried tie beams, the former subjected to a single uniform temperature change and the latter to a different temperature change. Short term and long term effects are compared with measured values with good results.

M. F. Bauer of Austria selected the problem of a cantilevered beam with sometimes one, but usually two diagonal hangers, the beam carrying a uniform load for all or a part of its length for extended times. He concludes with suggestions that variations in tensioning can minimize the effects of shrinkage.

Two papers, one by B. Bresler, D. Helmick and L. V. Ramakrishna of California, U.S.A. and the other by K. Cederwall, L. Elfgren and A. Losberg of Sweden, concern themselves with analytical and experimental studies of eccentrically loaded relatively slender columns and compare the results quite satisfactorily.

H. Trost of Hannover, Germany develops a time-dependent relationship for the effects of creep and shrinkage in concrete and compares the results with test data. He suggests methods of application to actual structures.

C. A. Miller of Illinois, U.S.A. presents expressions for calculating deflections of beams due to creep and shrinkage and offers simplifying assumptions.

S. K. Gosh and M. Z. Cohn of Waterloo, Canada offer a non-linear analysis of structural concrete from time-dependent stress-strain relationships. A computer program appears to predict moment curve, time and deformations for long-time loads that agree with measured results.

M. A. Saeed and J. B. Kennedy of Windsor, Canada combine the various approaches including a fictitious modulus of elasticity to compute rotations and deflections for a simply supported prestressed concrete structure.

R. B. Warner of Australia also studies time-dependent stresses and deformations under sustained moment. Moment redistribution with time in double reinforced continuous beams is considerable even to the point that the ordinate of the stress block might reduce to zero or even become tension.

B. Fassel of France comments on problems of instability under sustained loading that this effect is not sudden failure but gradual yielding. Creep does sharply reduce this critical load.

J. Fauchart of France discusses the effect of creep and shrinkage on prefabricated, prestressed continuous girders.

It can be seen that we do know quite a bit about the behavior of beams and columns and something about frames, sometimes analytically, sometimes experimentally and sometimes by a combination. We could, therefore, hope to formulate procedures and agree upon design methods.

At the same time, we have available a considerable number of methods for by-passing or avoiding the more serious problems. Readers of the prepublications and these prepared discussions will doubtless agree on the following conclusions.

First, that the effects of volumetric changes can be very important. Structures have, and do, tear themselves apart. Engineers do attempt to cope with the problem, but mathematical procedures are not as well established as those for gravity loads.

Second, that there are several ways to minimize the problem.

(a) One is to cut the building into sections which can accommodate the anticipated changes.

(b) Another might well be to contain the entire structure within a prestressed ring, inducing internal compressions roughly comparable to the tensions anticipated from creep, shrinkage and temperature.

(c) Still another might be to free the structure entirely so that columns may move on their bases, beams slide upon their supports, even slabs upon their beams, so as to make the structure self-relieving.

(d) Still another way is to specify certain ranges of parameters and thereby certain unit values that would permit a reasonably close estimate of the volumetric changes which must be accommodated and then establish accepted mathematical procedures to determine the forces which must be resisted internally by the structure and transmitted from support to support.

If our Symposium brings to the attention of designers, and especially those who occasionally overlook these phenomena, the necessity for thinking about volumetric changes and trying to make some provisions to cope with them and not simply blithely forget about them, perhaps half of our task will have been accomplished. It is possible that experts never will agree upon just how to design for these volumetric changes but would prefer to keep it a highly individualized matter of judgment. It is, however, more likely that as the interchange of information goes on, we will be able to formulate our methods and procedures quite clearly, taking into account at least all of the major parameters and being able to develop calculations which another engineer in another country can understand and verify. Then it will no longer be necessary for building codes simply to say "take account of the effects of creep, shrinkage and temperature."

To draw what lessons we can from the American Concrete Institute's Symposium on the same subject held in New York last March, Bob Philleo, Chief of Concrete Research, Civil Work, U.S. Army and Chairman of ACI's Technical Activities Committee, will present a report of the principal accomplishments in New York.