THE BEHAVIOUR OF CONCRETE IN PRESTRESSED CONCRETE PRESSURE VESSELS

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In the design of prestressed concrete pressure vessels, long term concrete property data is required by the designer such that realistic estimates can be made of the vessels' 30-year stresses and deformations under the various operating conditions to which it will be subject. To achieve this aim, the shrinkage, short and long term deformation under load and thermal expansion behaviour of the vessel concrete has to be determined under conditions simulating those likely in the structure. In this paper, therefore, concrete properties are examined in relation to vessel design. Results obtained from the test programmes carried out for the Wylfa and Hartlepool nuclear power stations are presented in relation to our understanding of each property obtained from a detailed literature analysis.

The effect of temperature on three concrete properties of major importance in vessel design, e.g. compressive strength, thermal expansion and long term deformation under load (creep), is discussed at operational temperature up to 70°C. Consideration is also given, in the light of experimental data, on the effect of higher temperatures on these properties.

DISCUSSION

Q A. PEDERSEN, Denmark

1. Does the figure concerning growth of concrete with irradiation refer to loaded or unloaded specimens. Do you actually have experiments on the behaviour of loaded specimens with irradiation ?
2. Have you considered possible differences in neutron flux spectrum between the research reactor and the Wylfa power reactor ?
3. What effect would changes in heat conductivity of the concrete irradiation have on the temperature peaks in the inner layer of the vessel ?

A R. D. BROWNE, U. K.

1. Aggregate growth under irradiation with load

Test work so far undertaken was using unloaded samples only. Loading would probably reduce growth, like it reduces thermal dislocation, but only if triaxial support existed. But this support certainly does not exist in concrete by itself, since the growth and strength loss can be of a similar magnitude.

2. Irradiation test neutron energy spectrum compared with vessel irradiation levels

The total dose levels for the tests undertaken in the Herald reactor were corrected to give equivalent vessel doses for damage assessment. Figs. 9 and 21, in my paper, give the correction the other way round; the maximum Hartlepool dose quoted is the equivalent Herald dose value.

3. Effect of thermal conductivity change under irradiation on temperature peaking in the vessel wall

At our vessel dose levels, little change in thermal conductivity is anticipated even after 30 years. However, if high dose levels existed, then the associated loss in thermal conductivity with time would increase both the maximum temperature and the temperature gradients in the nuclear heating zone of the vessel. This would not only be due to aggregate change but also to increase in the moisture migration away from the peak temperature zone. Decrease in the moisture content in concrete decreases its thermal conductivity.

C I. DAVIDSON, U. K.

Amplifying Dr. Browne's reply to the last questions, I would mention that the effects of neutron and gamma irradiation were reported in reference (5) of Dr. Browne's paper.

Q R. LENSCHOW, Norway

I think Dr. Browne's remarks on in situ strength and standard cube tests are most relevant. Dr. Browne mentioned a few factors which influenced or affected the difference in strengths. Could Dr. Browne comment on this, and is there a systematic investigation to

clarify this problem ?

A

R. D. BROWNE, U. K.

The relationship between the 28 day cube strength and the in situ strength of concrete.

In my paper, I showed the relationship between our predicted in situ strength and the 28 day cube strength. We have based this understanding on the analysis of data from a wide range of published data, for example, by Peterson in Sweden, and from our own core strength measurements on non-nuclear structures.

Of course, I would like to confirm our predictions by taking cores from existing nuclear vessels but this would not be a popular activity. In any case, I believe the knowledge available is adequate for present design. As regards strength development in general, our laboratory tests on strength with time for samples subject to a heat of hydration cycle and scaled from casting, to simulate mass concrete, give results comparable with core data from mass concrete casts.

For example, the cube is subject to really a triaxial loading due to the platen restraint, giving higher compressive strength than the long cylinder. This strength increase may in part compensate for the gain in strength due to maturity in the structure.

C

Z. P. BAŽANT, U. S. A.

1. The data on creep curves extending over long periods of time and widely different ages at the instant of load application show much greater deviations from the assumption of time-temperature shift and a refinement of this method will probably be needed.
2. The data on moisture distributions throughout concrete specimens after various periods of drying indicate that the diffusion coefficient varies considerably (by order of magnitude) with the water content. Such an effect is not easily detected from measurements of weight.