EMBEDMENT INSTRUMENTATION FOR PRESTRESSED CONCRETE PRESSURE VESSELS*

D. J. NAUS, J. P. CALLAHAN

Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tennessee 37830, U.S.A.

SUMMARY

Unique types of instrumentation are used in PCPVs. Their primary objective is to provide a means for monitoring these complex structures during initial proof testing and to provide continuing assurance of reliability and safety. The data generated by the instrumentation are also used to evaluate the original design calculations and to confirm concrete properties.

Numerous commercial concrete embedment instruments are presently available which are designed for measurement of strain, stress, and moisture. Based on the above criteria, these instruments must be capable of providing reliable data for extended periods of time in hostile environments. To provide insight into concrete embedment instrumentation performance an investigation is being conducted at Oak Ridge National Laboratory.

The initial phase of the program includes (1) a technology assessment of embedment instrumentation and (2) conduction of an experimental investigation to evaluate strain-indicating devices commercially available. Findings of the technology assessment will be presented briefly, but the primary emphasis will be placed on experimental results of investigations to evaluate (1) basic gage characteristics, (2) gage performance under a representative PCPV environment, and (3) gage performance under extreme environments.

Basic gage characteristics have been established through manufacturer's data and laboratory investigations. Test series have been fabricated to determine the effects of specimen size (cylinder diameter), concrete strength, and maximum aggregate size on gage performance. Results indicate that at the same stress level surface compressive strain readings are less than embedment gage values, and the differences decrease as the cylinder diameter increases. No significant differences were noted for the different strength concretes; however, an additional series of specimens using three different strength concretes has been cast and scheduled for testing to provide additional data. Specimens have been cast with different maximum aggregate sizes to determine the effect of maximum aggregate size on embedded-gage performance. Specimens 15.2 cm diam by 54 cm have been used to assess calibration data supplied by the gage manufacturers. Embedded-gage output was compared with 10 cm surface wire resistance strain gage and 20 cm gage length mechanical gage results. Results obtained from the two surface strain gage types compared favorably, but differences between them and embedded gages ranged from less than 5% to greater than 25%.

Stability of gages in a simulated PCPV environment was determined by subjecting 41 cm diam by 102 cm concrete cylinders instrumented with samples of strain meters being evaluated to representative uniaxial loadings ($0.45 f_c'$), representative temperatures (65.6 °C), or a combination of both. Strain-time plots including temperature corrections will be presented for the different gages.

Gage performance under extreme conditions has been evaluated by alkaline-water (pH ~ 10) immersion tests at room (21 °C) and elevated (65.6 °C) temperature, and excessive compressive and thermal loadings of the 41 cm by 102 cm cylinders. The immersion tests have been under way for over a year. Strain-time plots including temperature corrections will be presented for each gage type. The second phase of gage evaluation under excessive conditions will involve thermally loading the 41 cm diam cylinders in excess of the 65.6 °C design temperature and uniaxially loading the cylinders greater than $0.45 f_c'$.

* Oak Ridge National Laboratory PCRV Research and Development Program sponsored by the Energy Research and Development Administration under contract with Union Carbide.