HIGH TEMPERATURE PROPERTIES OF PELLETIZED EXPANDED SLAG CONCRETE

by Donald W. Lewis, Chief Engineer

Fire tests of concretes made with pelletized expanded slag aggregate were made by the Construction Technology Laboratories, division of the Portland Cement Association, and reported in NSA MF 180-9. A study of the high temperature properties of expanded slag concrete was initiated at the same time, to use the same concrete that was fire tested. These test results were reported to this Association by Concrete Technology Laboratories (CTL) in April 1980 under the title “Properties of Concrete Made with Pelletized Expanded Slag Aggregate” by M.S. Abrams and M. Gillen

The February 1981 issue of Concrete International contained the ACI Committee Report No. ACI 216R-81, “Guide for Determining the Fire Endurance of Concrete Elements". The fire endurance aspects of lightweight concrete were the subject of a NSA discussion (see NSA Circular Letter 2-81 and NSA Bulletin 10-81). In Appendix 2 - Properties of Concrete at High Temperatures – the Guide furnished information on concretes (made primarily with carbonate, siliceous and expanded shale aggregates) that would help designers in evaluating the effects of fire on the structural capacity of members. This report summarized the CTL data on pelletized expanded slag concrete and provides a comparison with some of the data for other concretes contained in the Guide.

All tests were made on the same concrete mix that was subjected to the fire tests reported in NSA MF 180-9; "Fire Tests of 3x3 ft. Specimens Made with Pelletized Expanded Slag Aggregate". High temperature tests conducted are described and the results given in the following sections.

COMPRESSIVE STRENGTH

The compressive strength of the concrete was measured on 6” x12" cylinders moist cured for 28 days, followed by 100 days at 50% RH and 70°F. Specimens had the load-bearing surfaces lapped plane, and were heated to test temperature for several hours prior to test. Test results (average for 3 cylinders) at 70, 250 and 500°F were:

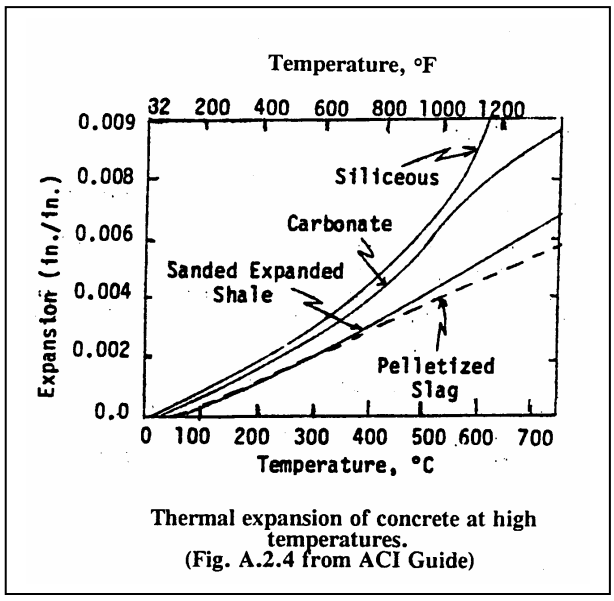
70°F	5210 psi
250°F	4100 psi
500°F	4025 psi

The loss between 70 and 250°F, about 20%, is slightly larger than that reported for other aggregates. The strength decrease between 250 and 500°F was very small. However, the overall trend is similar to that of other concretes.

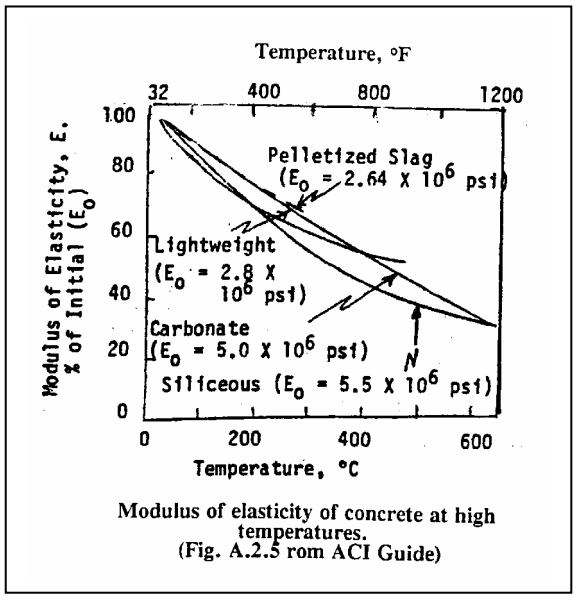
MODULUS OF ELASTICITY

The modulus of elasticity was measured on the cylinders used for compressive strength by loading them to about half of their strength prior to the compressive strength test. An initial value of 2.64 million psi was obtained at room temperature. This dropped to 2.26 million at 250°F and to 1.93 million at the 500°F temperature.

The results, as percent of initial modulus, have been plotted on Fig. A.2.5 of the ACI Fire Endurance Guide. It will be noted that the E value for the pelletized slag concrete decreased at about the same percentage rate as the carbonate aggregate concrete, the lowest rate of change for the materials tested.



Thermal expansion of concrete at high temperatures.
(Fig. A.2.4 from ACI Guide)



Modulus of elasticity of concrete at high temperatures.
(Fig. A.2.5 rom ACI Guide)

POISSON'S RATIO

Poisson's ratio determinations on the compression specimens gave values of 0.15 for both the 70 and 250°F temperatures. The average value at 500°F was 0.12.

THERMAL EXPANSION

Thermal expansion was measured from room temperature of 1600°F, using 0.5 x 3.0" cylinders cored from the 6x 12" cylinders. (Coring was done at the end of 28 days moist curing, followed. by 60 days at 50% RH prior to test.) Measurements were made in a commercially manufactured dilatometer that included an electric furnace capable of heating the specimens to the 1600°F maximum.

Variations between specimens were small, especially below 900°F. Average values for expansion formed an essentially straight line all the way to 1600°F. A linear best-fit curve was calculated and it was concluded that: "Over the entire temperature range, a coefficient of thermal expansion value of 4.34 millionths/F characterized the data quite well."

The pelletized expanded slag concrete thermal expansion curve has been plotted on the ACI Guide Fig. A.2.4. It will be seen that it is the only straight line and also the lowest coefficient of expansion.

CONCLUSION

It can be concluded that the pelletized expanded slag concrete performs in the same manner as other concretes with respect to physical properties at high temperatures. From a practical standpoint, there would appear to be no really significant differences, with the possible exception of the lower coefficient of expansion in the higher temperature range.