The following is a discussion of the Fire-Resistance Rating for a 4-in./2-in./2.5-in. prefabricated, precast concrete sandwich panel. It should be noted that a Fire-Resistance Rating is a legal term for a fire endurance required by a building code authority. The fire endurance is the period of time elapsed before a prescribed condition of failure, or endpoint, is reached during a standard fire test. Although specific assemblies can be physically tested using the standard fire test, ANSI/UL 263, it is acceptable to mathematically calculate the fire endurance for a concrete sandwich panel.

Because concrete behavior is well known in fire testing, mathematical models can be used to predict the endpoint criteria. It includes the collapse of load bearing assemblies; creation of holes, cracks, or fissures through which flames or hot gasses may pass; and a temperature increase of the unexposed surface that exceeds an average of 250°F and a maximum of 325°F at any one point. Since stress levels are low, the collapse endpoint normally is not considered for concrete walls. The flame passage endpoint is considered in determining the requirements for sealants and insulation at joints between wall panels. The temperature increase endpoint is commonly termed the heat transmission endpoint and is normally the governing calculation for concrete walls.

The Uniform Building Code (UBC) and the 5th Edition of the PCI DESIGN HANDBOOK provide similar calculation methods. UBC Code Standard 7-7 is used for the following calculations.

The fire endurance based on the heat transmission endpoint, R, is calculated using:

\[ R = \left( R_{1.59} + R_{2.59} + R_{3.59} \right)^{1.7}, \]  

(7-1)

Where \( R_{1.59} \), \( R_{2.59} \), and \( R_{3.59} \) are the fire endurances of the individual layers in minutes. For a 4-in. thick concrete panel fabricated using carbonate aggregate, Table 7-7-C-B gives \( R_{1.59} = 14.0 \). For a 2.5-in. thick concrete panel also of carbonate aggregate, Table 7-7-C-B gives \( R_{2.59} = 8.9 \). Also, Section 7.707.2.3 indicates that a layer of foam plastic insulation one inch or greater in thickness has an endurance of 5 minutes (\( R_{0.59} = 2.5 \)). Since foam plastics melt and are consumed at about 400 to 600°F, any additional thickness has a negligible effect on the endurance of a sandwich panel. UBC Section 2602.4.3 allows for foam insulation in a concrete wall when the insulation is covered by a minimum of 1-in. thickness of concrete.

Therefore, for a 3-in./2-in./3-in. insulated wall panel, the fire endurance is given by:

\[ R = \left( R_{1.59} + R_{2.59} + R_{3.59} \right)^{1.7}, \]
\[ R = (14.0 + 2.5 + 8.9)^{1.7}, \]
\[ R = 244 \text{ minutes} = 4 \text{ hours and 4 minutes} \]

Finally, it should be noted that Vertical Fire Tests have been conducted using the industry standard, Fire Test of Building Construction and Materials, ANSI/UL 263. These physical tests, performed on an insulated precast concrete THERMOMASS sandwich wall resulted in a fire rating in excess of 240 minutes.