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Fire Testing Methods of Structural Elements

ABSTRACT

This report investigates the heating conditions required by various international standards in order to conduct a standard fire test on building elements. This investigation also aims to obtain an understanding of the various methods used in order to conduct standard fire tests, and the various criteria that building elements are required to adhere to during a fire. The outcome of the investigations conducted here is an apparatus and a testing method that can be used in future investigations to conduct full scale fire tests on building elements while complying with international standards. Various tests are conducted with the use of different methods and the viability and repeatability of each method is assessed.

Various methods exist in international standards that propose standard heating conditions and criteria upon which the performance of a building element in a fire is assessed. The most common temperature – time relationship used in fire tests is that of the standard temperature – time curve seen in the British Standard: BS 476 and the South African National Standard: SANS 10177. Another widely used temperature – time relationship is that seen in the American Society for Testing and Materials standard: ASTM E119. Eurocode 1 proposes a natural / parametric compartment fire model that allows one to establish a temperature – time curve specific to a particular enclosure.

By conducting a fire test with temperatures regulated according to a specified temperature – time curve, one may determine the fire resistance rating of a building element. The fire resistance rating is the time period for which an element is able to adhere to certain criteria during a fire.

Through a series of preliminary natural fire tests, shortfalls to the standard temperature – time curve were observed when the natural fire did not behave in a manner similar to the unnatural heating requirements described by the standardized time - temperature curve; as these temperatures will rarely be encountered in a building fire.
By conducting preliminary tests with the use of flammable liquids, however, such as petroleum and diesel, the furnace temperature requirements of SANS 10177 were able to be replicated for a period of 20 to 30 minutes. A test was also conducted with the use of liquefied Petroleum Gas as

the fuel type, however, this fuel did not produce a large enough flame for the purpose of achieving the desired furnace temperature.
Through a series of preliminary experiments with the use of flammable liquids, a method of conducting a fire test according to SANS 10177 was developed with the use of a prototype flammable liquid burner capable of controlling furnace temperature with respect to time.
A testing sheet was also proposed that can serve as a generic sheet containing the necessary instructions to conduct a fire test. The test sheet can be used to record all necessary data and observations from the test.

The next series of tests conducted after the preliminary tests aimed to replicate the requirements of international standards, and to test the repeatability of the method used. These tests were conducted with the use of a diesel burner that was fabricated in such a way as to overcome shortfalls noted in the preliminary tests. The burner made use of a diesel – air mixture, to initiate a flame inside the furnace that could be controlled as necessary. An average correlation with respect to the SANS10177 time - temperature curve of 0.944 was achieved for all 8 diesel burner tests conducted.

It was also clear that testing procedures improved significantly with experience as results began to correlate closer with SANS requirements for each subsequent test. Test 8 temperatures fell within the allowable temperature tolerances for 91 percent of the testing time and were also within the allowable range with respect to the ASTM E119 heating requirements.
The diesel burner used in the final tests is a suitable burner to be used when conducting fire tests according to SANS 10177, BS476, and ASTM E119 requirements. A high level of repeatability was achieved in all 8 tests as all results fell within the specified temperature range.

The size of the furnace used in all tests conducted in this study however does not meet the minimum dimensional requirements of any of the international standards. In order to conduct fire tests according to SANS 10177 a full sized furnace will need to be constructed using the principles and apparatus outlined in this report.