International Journal of
Applied Mathematics,
Electronics and Computers
ISSN: 2147-8228 http://ijamec.atscience.org

Advanced Technology and Science

Original Research Paper

Determining Fire Door Resistance through Infrared Thermography

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Accepted 16h May 2016

Abstract: The resistance tests of two fire doors with standard opening single were made using the methods of thermocouples and infrared thermography according to the features stated in the regulations. With the traditional fire mechanism stated in the regulation of TS EN 1634-1, a fire resistance test of 50 and 56 minutes was made. In the 32nd and 34th minutes of the experiment, opening was observed at the upper right-hand corners of standard opening single fire doors that were tested. Temperature values obtained from the measurement points stated in the regulation were controlled and with 200 thermal images that were obtained image process were applied. The utility of Infrared Thermography (IRT) method that is a contactless and distant measurement technique of temperature is shown to be used for fire tests with the traditional methods.

Keywords: *Thermal camera, image proses, fire doors, fire safety, Infrared thermography.*

1. Introduction

In buildings, fire doors are utilized commonly. These doors entail specific fire resistance and they act as delimiters or fire enclosures. Nevertheless, the thermal and mechanical properties of materials generally change with high temperatures so sufficient knowledge needs to be known about fire behaviors of construction materials of doors to utilize these doors ideally [1]. Structural steel members can be used for the vertical and lateral support in multi-story buildings. These members may be included inside fire-resistant enclosures enabling house elevators, stairs and other services [2].

According to European Norms of TS EN 13501-2 and TS EN 1634-1, fire doors should have the features of integrity, insulation, radiation and smoke tightness. The fire resistance class of the wall on which the door will be placed determines the fire resistance of the door. According to fire conditions and resistances, they are classified with the time value. Resistance durations include the classifications of 90, 60, 45, 30 minutes and 2 hours maximum needed for any double-acting door. A door having a resistance of three-hour fire is generally seen on the wall separating the buildings [3].

Damages in most of the materials used in the constructions are related to the material behavior of temperature. Temperature measurements of the materials are important in order to understand the reasons of possible deficiencies that might be exist. For this aim, in order to test materials used in constructions, using non-destructive examining methods enabling us to evaluate behaviors of materials without interruption and destroying them could be useful [4]. IRT technique, one of these methods, is used to determine surface temperatures of substances [5].

This method enables forming of two-dimension image giving temperature distribution of the area according to thermal radiation intensity spreading from the area that will be examined [6, 7]. IRT technique can be commonly used to evaluate the performances of buildings. Especially about energy conservation, it has been commonly used to determine structural deficiencies of buildings such as thermal bridges, air-tightness and humid regions that can exist in buildings [8, 9]. At the same time, studies were made related to its utility in the pressure experiments of masonry tiles [10].

In this study, two fire doors were exposed to the fire resistance test. In the experimental work carried out, 6 thermocouples were placed on the surface of the doors and their data were transferred to data logger and recorded. Placing 1 thermocouple whose sensitivity is 12000c into fire room, their data were transferred to data logger and recorded. During the experiment, thermal images were recorded through infrared thermography method. At the end of the experiment, comparisons were made examining both thermocouple data and thermal images belonging to two doors. Comparing alternatives were developed by improving the previous pre-studies [11].

2. Material and Method

In this study, a test mechanism was prepared for two fire and smoke control doors used as fire doors according to the rules of TS EN 1634-1 [12] and an experimental study was carried out. At the same time, by taking thermal images of the fire door with infrared thermography during the experiment, thermocouples used in the experiment mechanism were compared to the obtained data. The results were examined and because the images taken through infrared thermography technique enable us to examine whole door surface and its deficiencies are continuously examined in the desired area, it comes out as a technique that can be safely used.

In the study, digital thermometers (thermocouples), thermal camera, fire door, gas concrete wall and inflammable wooden materials are used as materials.

Digital thermometer used in the experiment has the sensitivity of 1200°C and its calibrations were adjusted according to TS EN ISO/EC 17025 with the indicators of ELIMKO brand and ENDA brand by Turkish Accreditation Institution, and its Calibration certificate was taken with H12S392. 6 digital thermometers used in the measurements of surface temperature also took Calibration certificates with E12S410 given by the same institution and were

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Note: This paper has been presented at the International Conference on Advanced Technology&Sciences (ICAT'14) held in Antalya (Turkey), August 12-15, 2014.

used in this experiment.

In the experiment, infrared thermography of Flir brand and T200 model was used. Features belonging to infrared thermography are given on Table 1.

Table 1. Features of thermal camera

IR resolution	200 × 150 pixels
Spectral range	7.5 - 13 µm
Object temperature range	-20°C to +120°C (–4°F to +248°F) - 0°C to +350°C (+32°F to +662°F)
Accuracy	±2°C (±3.6°F) or ±2% of reading
Thermal sensitivity/NETD	< 0.1°C @ +30°C (+86°F) / 100 mK
Display	Built-in touch screen, 3.5 in. LCD, 320 × 240 pixels
Image adjustment	Auto (min span 4°C / 7.2°F) or manual (min span 2°C /3.6°F)
Field of view (FOV) / Minimum focus distance	25˚x19˚/0.4m (1.31ft)
Radiometric IR-video streaming	Full dynamic to PC using USB
Operating temperature range	–15°C to +50°C (+5°F to +122°F)

Gas concrete wall and gas concrete roof materials produced and manufactured by Ytong firm as wall materials were used. Technical features belonging to the material are given on Table 2.

Table 2. Features of gas concrete

Dimensional Tolerance	± 1,5 mm
Profile Structure	Plane
Brickwork joint	Adhesive Knit Ytong (1–3 mm thickness)
Flame / Fire Resistance	Refractory (F180-A)
Sound Resistance	45–65 dB
Average Compressive Strength	50 kgf/cm²
Dry Unit Weight	600 kg/m³
Weight of the Wall Static Account	700 kg/m³
Thermal Conductivity Coefficient (λh)	0.19 (W/mK)

As fire door, two fire doors produced by ME-HA Steel Door Systems in Konya as in the proportions of 1000/2200 mm. Panic Exit Devices used for fire door took certificate of compliance to EN 1125:1997+A1:2001 tests by Warrington Certification Ltd. Special dye prepared for fire resistance and that was produced Boyasan Dye Industry and given certificate approval by Qualicoat (Zurich) on 9th 12, 2011 was used in fire door. All other products used on the door were produced by ME-HA Steel Door Systems according to related standards and their certificates were given.

In the experiment, in the experiment, in order to describe conventional fire and maintain it for 50 minutes, calculation of inflammable substances was made. In each experiment, using about waste wooden materials of 500 kg, the experiment was completed.

3. Experimental Studies and Results

The experimental study was carried out at the laboratory of Construction Department of Selcuk University Higher School of Vocational and Technical Sciences. The experiment mechanism is given in Fig. 1 and images during the experiment are given in Fig. 2.

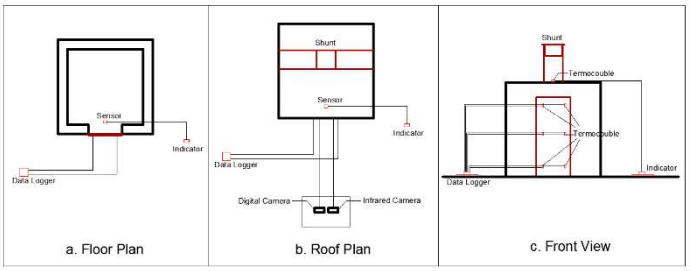


Figure 1. The experiment mechanism

Figure 2. The experiment images of the fire door

After the experiment mechanism was prepared, all the indicators and devices were tested in terms of working and first fire was lit. Since the beginning of the fire, all data records were began to be recorded. The place and time when the fire doors first have the opening from one of the corners and start to give smoke are considered as the basic value. Since the beginning of the fire, it was determined that the upper right-hand corner of the door had the opening and the door started to give smoke after 32 minutes in the first experiment and 34 minutes in the second experiment.

The first experiment was continued for 50 minutes and the second one was continued for 56 minutes. During the experiments, all the data were recorded. In both experiments, data were recorded for each minute from 6 thermocouples to the data logger and at the end of the experiment; these data were transferred to the computer. In the same way, for each minute data were taken from thermocouples that were produced as TC20-1S5Z07-60 model by Elimko firm, had sensitivity of 1200°C as S type and were placed into the room from the door back surface and the data were transferred to the computer. The graphic of temperature and time belonging to the first experiment was given in Fig. 3. According to the places of 6 thermocouples on the door, the values read from the thermocouples placed in the fire room were given in the graphic.

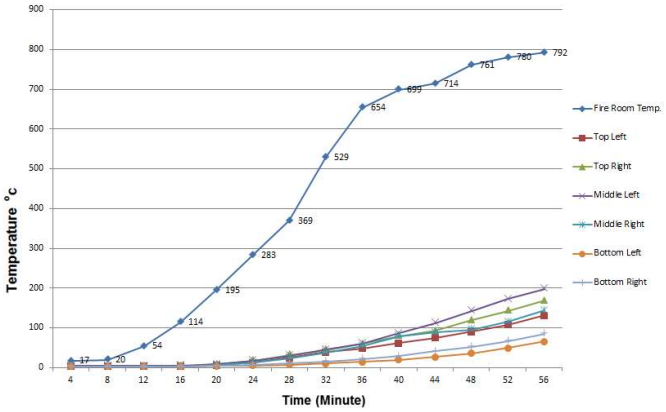
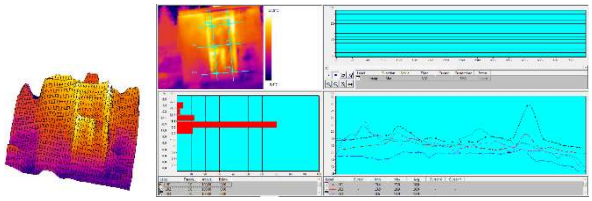


Figure 3. The graphic of temperature - time belonging to fire door

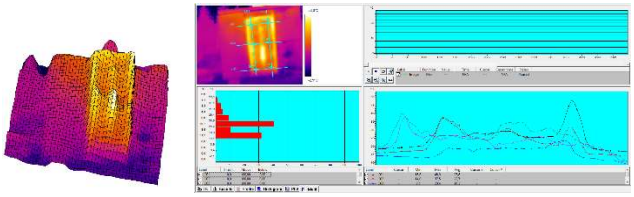
The images obtained through infrared camera and their values related to temperatures were examined and it is seen that each minute of temperature changes with regards to the fire door can be examined in the images and it is followed that the material

used shows which sensitivity at which time to the heat and they are interpreted. As the heat increased, steel frame and back band parts began to move heat quickly. When faced to rock wool used in the door, heat continued to move just on steel frame and back band.

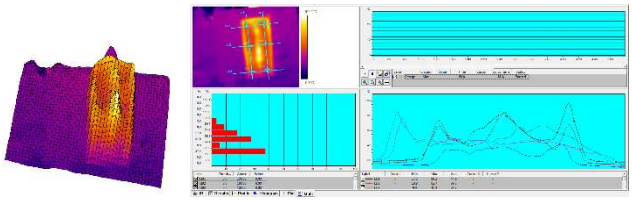
Usage of developed opportunities in thermal camera technology puts forward that both economical and more accurate results can be obtained. In Fig. 4, there is the analyzing phase of images related to fire door and taken by thermal camera, and also graphics of temperature changes belonging to minimum, maximum and average values on the lines.



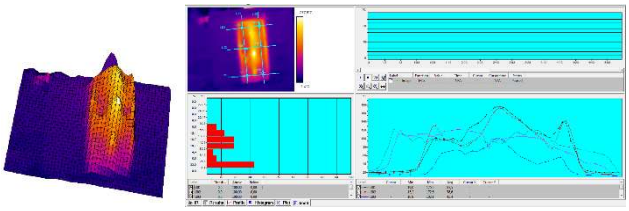
3D thermal image at the beginning moment of the experiment and the graphics of surface temperature changes



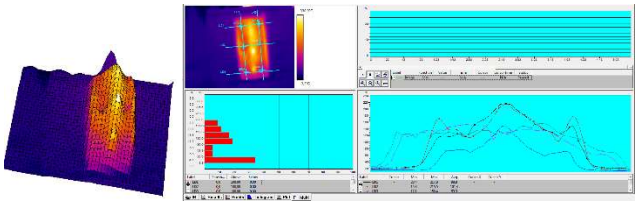
3D thermal image at the 10th minute of the experiment and the graphics of surface temperature



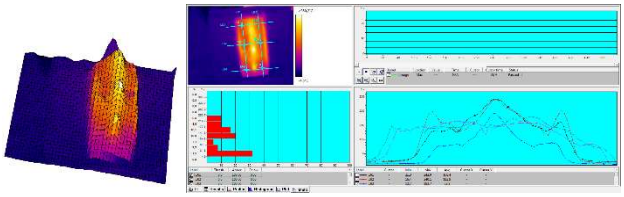
3D thermal image at the 20th minute of the experiment and the graphics of surface temperature changes



3D thermal image at the 30th minute of the experiment and the graphics of surface temperature changes



3D thermal image at the 40th minute of the experiment and the graphics of surface temperature changes



3D thermal image at the 50th minute of the experiment and the graphics of surface temperature changes

Figure 4. 3D thermal image belonging to the experiment and the graphics of surface temperature changes

4. Conclusion and Suggestions

In this study, the fire door experiments were carried out through the mechanism that was prepared. Fire is important in terms of having the knowledge and taking necessary precautions in order to control the energy coming out and prevent every kind of loss of life and properties. In this experimental study, it is tested whether the possible doors we are using and will use have resistance to fire or not and it is determined that they are resistant to fire in accordance with the related regulations. In the experimental study, 7 thermocouples were used and according to the obtained data, evaluations were made. At the same time, with the infrared camera, data were taken at each minute and recorded. For the fire test, these two methods were compared and it is indicated that the Infrared thermography method and thermal cameras as a contactless and distant technique temperature measurement may be used in this kind of studies. During the experimental study, over 200 thermal images were recorded and they were evaluated through image processes.

Our experimental studies were performed at the laboratory of Construction and Construction Insulation Technology Department in Selcuk University Higher School of Vocational and Technical Sciences and at a place where students could watch and contribute to the experiment.

Acknowledgements

For the contributions, I am grateful to Selcuk University Financial Coordination Office for Research Projects, ME-HA Steel Door Systems and Ytong firm.

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