# ASSESSMENT OF SURFACE CRACKS AND TEMPERATURE ON POST – FIRE MORTAR

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## 1. INTRODUCTION

The performance of cementitious material, e.g. mortar and concrete, vary with its own mix design such as cement content, aggregate type, additives, water consistency and especially for service conditions. During its service life, concrete structure may be exposed to many extreme service conditions. Elevated temperature or fire incident is one of the most extreme conditions which can introduce a severe deterioration to concrete material because of underlying chemical compound after hydration (Rongviriyapanich et al., 2013; Heikal, 2000; Xu et al. 2001). Normally after exposed to high temperature treatment, heated face tends to crack whether aesthetic or serviceability deteriorations. Those surface cracks' can be used to evaluate the maximum temperature at which specimens was subjected together with recommended damage layer to be removed before repairing or strengthening (Toumi et al., 2010: Daungwilailuk, 2013). It has been discovered that there are three main mechanisms of damage at elevated temperature, i.e. thermal mismatch, effect of pore pressure and chemical compound decomposition (Fu et al., 2004). Therefore, the oven – dried mortar specimens were used to perform the surface cracks' density and depth of color change to prevent additional cracks introduced by thermal mismatch between mortar phase and coarse aggregate and developing pressure during the test.

## 2. EXPERIMENTAL DETAILS

### 2.1 Mix proportion

In this study, mortar is non air – entraining type and designed based on absolute volume of the materials constituent in saturated surface dry condition with water – cement ratio of 0.55, cement – sand ratio of 0.50. The cement content in proportion is equal to 587 kg/m$^3$. After well mixing, fresh mortar was poured and well compacted in the 100×100×400 mm$^3$ prismatic mold shape. After demolding at 24 hours, specimens were cured in lime saturated water for 28 days. Then, they were dried in the oven at 105 °C for 24 hours and kept constant moisture content until fire test date.

### 2.2 Method of investigations

Oven – dried specimens were placed at the lid of gas stove in order to simulate one directional heating by standard fire curve ISO 834 as shown in Eq. (1) where $T$ and $t$ represent temperature (°C) and elapse time (min), respectively. Fire tests were simulated for three given times, i.e. 30, 60 and 90 minutes. After reached target durations, stove would be automatically stopped and suddenly cooled down in the air condition. Then, all observations were conducted after cooled down to ambient temperature. The surface cracks' pictures were taken by lighting microscope; then, grid lines were drawn to count the interception on grid lines (IZUMO, 2006: ASTM C457/C457M, 2012). Then, the original specimens were cut for observing the depth of color changed after exposed to high temperature treatment. A 100×100 mm$^2$ internal cross section pictures were taken by high resolutions digital camera and the depth of damaged layer would be measured.

$$T = 20 + 345\log(8t + 1) \quad (1)$$

## 3. EXPERIMENTAL RESULTS

### 3.1 Maximum temperature and surface cracks' density

Although the heated face was directly exposed to fire in the stove, the measured temperature at heated face might not equal to the inside stove's temperature. Therefore, the actual maximum temperature comes from the measured one at heated face in this study. Table 1 shows a comparison between the actual maximum and oven's temperature.

Table 1 A comparison between actual maximum and oven's temperature

| Time exposure (min) | Actual maximum temp. (°C) | Oven's temperature (°C) | % difference |
|---|---|---|---|
| 30 | 749 | 843 | 12.55 |
| 60 | 895 | 945 | 5.59 |
| 90 | 975 | 1005 | 3.08 |

It can be seen that the percentage of difference between actual maximum and oven's temperature tends to decrease due to the stability of fire. The crack patterns and relationship of surface cracks' density against time are shown in Fig. 1.

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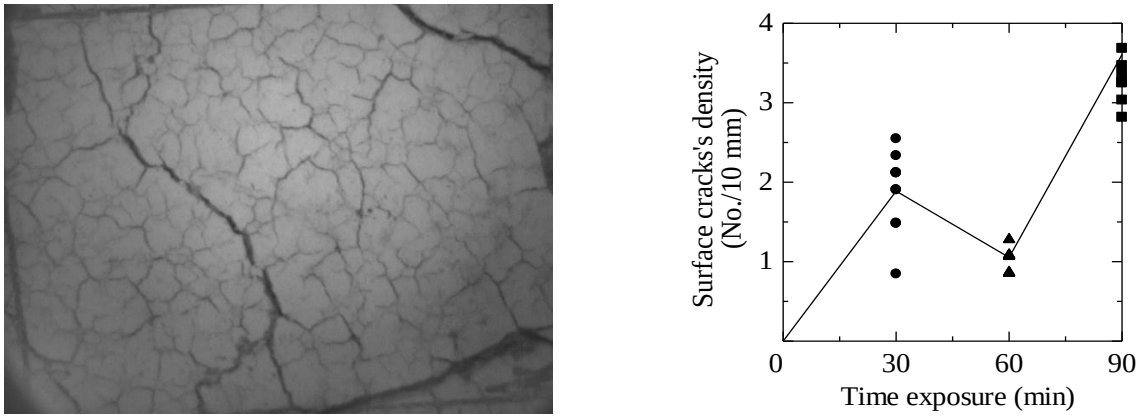


Fig. 1 Example of crack patterns and surface cracks' density at heated face

According to those two results above, a tendency of surface cracks' density change is as same as the increment of time exposure. Therefore, it can be said that density varies as the increment of elapse time exposure.

### 3.2 Color changed depth

After exposed to fire exposure, the specimens' color was obviously changed from normal color due to an oxidation reaction of Ferris ion embedded in aggregate together with the decomposition of hydrates (Daungwilailuk, 2013). Also, the depth of color changed can be used as one of parameters to indicate how deteriorations occur in cementitious material after subjected to one directional fire exposure. The results are shown in Table 2.

Table 2 Color changed depth after subjected to fire exposure

| Time exposure | Face 1 | | Face 2 | | Average |
|---|---|---|---|---|---|
| | Left | Right | Left | Right | |
| (min) | (mm) | (mm) | (mm) | (mm) | (mm) |
| 30 | 11.81 | 12.15 | 12.17 | 12.65 | 12.20 |
| 60 | 21.63 | 21.54 | 23.63 | 23.50 | 22.58 |
| 90 | 38.96 | 39.20 | 35.94 | 36.02 | 37.53 |

The depth of color changed in post – fire specimens tends to increase with respect to an increment of exposed time. As mentioned above, the chemical property within the color changed layer was affected whether the decomposition of changes in microstructure. Therefore, these depths are roughly said to be the depth of one directional fire deterioration.

## 4. CONCLUSIONS

According to the discovered results shown in Chapter 3, it can be concluded that both the surface cracks' density and color changed depth are associated with the elapse time subjected to fire. The longer duration can provide a higher maximum temperature at heated face and introduce more severe deteriorations.

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