FIRE DAMAGE OF STONE STRUCTURES

INVESTIGATED STONE TYPES

SANDSTONES
Balatonturcsan (V) – reddish, fine grain, ferruginous-clayey, Permian
Eszterházy (E) – white, fine grain, kaolinitic, Oligocene
Rico (R) – greyish, medium grain, jasolitic, Pannonian
Cottar (C) – greyish, fine grain, kaolinitic-illicit, Cretaceous
Dunorfen (D) – ochre, fine grain, ferruginous clayey, Jurassic
Maulbronn (M) – reddish-grey, fine grain, clayey, Triassic
Pfnitterl (P) – greyish red, medium grain, chlorite, Triassic
Pfizehausen (P) – yellowish white, medium grain, dolomitic, Triassic
Postaér (Po) – off-white, medium grain, siliceous, Cretaceous
Rohrschacher (R) – grey, fine grain, calcareous, Miocene Molasse

LIMESTONES
Tardos compact (T) – red, pelagic, bioclastic wackestone, Jurassic
Suitó travertine (F) – creamy, bioclastic wackestone to peloidal oncoid packstone
Sósút colitic (C) – coarse grain, Miocene

RHYOLITE TUFF
Egerthamerl (R) – grey white, Miocene

Nowadays mostly the historic buildings are built of stone, they have to be care for. Since the modern buildings contains only stone parts (embellishment, floor-plate). Natural stones were frequently used as building material in our historical monuments due to their advantageous properties.

The colour changes in natural stones almost corresponds to the temperature of 200–300°C in most rocks and it may not be apparent until a somewhat higher temperature. Big by stoneblocks is a sharp boundary between the heated, red-coloured stone surface and the unaltered stone behind. This zone has a width about 2–3 cm or less. Some stones contain a small amount of organic substance, which occur that the grey colour covering the red one.

The process of scaling and spalling is continued during the fire, the strength of the stone is surpassed and a bursting of the hot outer part is forced as in the case of a rock potato. The hot outer part is forced and the rock peels like an onion. Rounding off the edges can occur if there is an edge the heat can work from two sides. This form of decay is regularly seen on steps, pillars and window-heads. Breaking is typical where single parts are jutting out of a plane. It heat up more quickly and burst off easier, since the stresses find the way out more quickly.

The measure of damage caused by fire depends on many factors. The changes at the natural stones could be influenced by the burning circumstances, e.g. is the heating one-sided or more-sided, homogenous or heterogeneous, the size of the burned stone, velocity of heating, the maximum burning temperature, stone type and its characteristics.

MINERALOGICAL CHANGES

As result of the mineralogical analyses the changes of the texture and inner structure and hereby the increasing in porosity, the disappearance of minerals or formation of new mineral phases and the colour change are observable. On effect of heating the quartz and feldspars do not show significant alterations up to 450°C. As major effects the transformation of quartz to tridymite and wollastonite, the formation of micro-cracks at quartz and feldspar grain boundaries above the 600°C heating temperature were detectable.

PETROPHYSICAL CHANGES

The limestone samples were sensitive at the heating. On the compact limestones specimens small hairline cracks arised already after at heating on 450°C and over the 600°C heating temperature the samples exploded. These specimens suffered the elevated temperature (750°C). The travertine samples grown dark till 450°C and smell foul due to organic matter content, but after this there also paled. These specimens survived the heating, but some hours after the test the CaO had reaction with the air moisture and due to nascent portlandite and the volume increment the samples crumbled. The coarse limestone samples also stand out the effect of heat at 750°C and 900°C, but they have failed into dust soon. The heating did not result similar problems at the sandstones and the rhyolite tuff samples.

The selected stone types showed a wide range of their feature (colour, grain size, cement type, age, rock constituent minerals, porosity, strength). This compositional variation enables us to achieve a better understanding of how such properties influence the behaviour of natural stones under heat.

INVESTIGATION METHODS

- Test conditions, heating in oven 6 hours 6 temperature (22, 150, 300, 450, 600, 750, 900°C)
- Macroscopic investigation
- Petrological analyses
  - Thin sections analyses with Polariscope microscope
  - X-Ray Powder Diffraction (XRD)
  - Differential Thermal Analyses (DTA)
  - Scanning Electron Microscope (SEM)
- Petrophysical test
  - Mass properties (specific and bulk density, porosity, water adsorption)
  - Ultrasonic sound velocity, Duroskop
  - Uniaxial compressive strength test
  - Indirect tensile strength test
  - Colour measuring (CIELAB)

These curves were used in SAFIR to find the temperature evolutions on each of the exposed profiles, without fire protection.

The stone buildings were damaged by fire from ancient times until nowadays. They are often so badly spoiled that they have to be replaced by new ones.

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