Fire performance of concrete

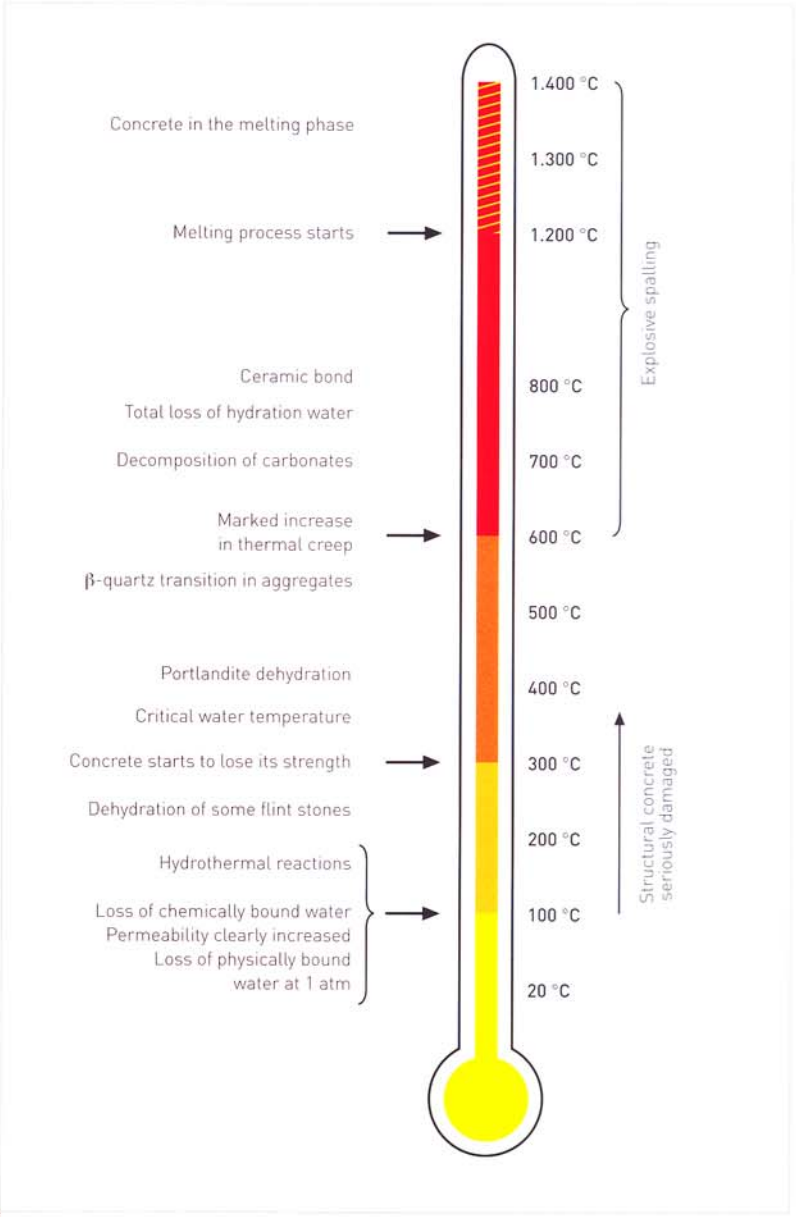
Concrete is generally considered to be a fire-resistant construction material, since it offers adequate heat insulation properties and since it is non-combustible. However, requirements of time-temperature curves for underground transport systems, and the thermo-hydraulic, thermo-mechanical and chemical conversion processes affecting the concrete do not confirm this assumption.

Explosive spalling of concrete is a thermo-hydraulic process which is based on the following mechanisms: In a fire, the water that is physically and chemically bound inside the concrete is released due to the quickly rising temperatures. As the water changes to the gaseous state, its volume increases by a factor of 1,100.

As a result of pressure compensation in near-surface concrete layers, the concrete dries in this region, whereas condensation produces zones that are almost completely water-saturated in deeper regions of the concrete. As the ambient temperatures continue to rise, the concrete has to sustain very high steam pressures on the inside. Once the tensile strength of the concrete is exceeded, the material reacts with explosive spalling, a behaviour which becomes more marked with increasing strength of the structural concrete: the pore volume in high-strength concrete is reduced, lowering its permeability. Another unfavourable factor are the complex tunnel geometries.

Other destruction mechanisms:
At the high temperatures that are typical of tunnel fires, the structural fabric tends to change above all in the quartzose aggregates. Since this also means a change in volume, the concrete may start to crumble.

Smoke enters the concrete through hairline cracks that develop in the material when exposed to a fire, accelerating the carbonation process and attacking the reinforcing steel.



Chemical changes inside the concrete