The European Group of Organisations for Fire Testing, Inspection and Certification

EGOLF RECOMMENDATION 011-2017

Subject of Recommendation	EN 1363-1 rate of deflection – timestep in calculations
Related test standard	EN 1363-1:2012 Fire resistance tests: General requirements
Date of issue	
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Previous publication number (if applicable)	
Keywords (max. 20)	Deflection, loadbearing capacity

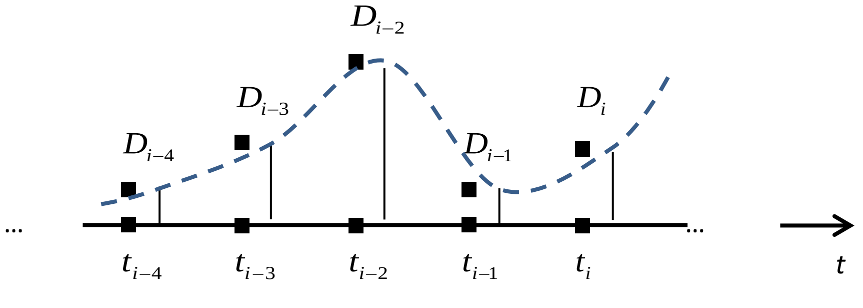
Problem

The EN 1363-1 standard does not specify what time step to be used in calculations of rate of deflection (dD/dt) in relation with the performance criteria of the loadbearing capacity of a construction.

Recommendation

In EN 1363-1 arises the question to determine the rate of deflection. Only is available a discrete-time form of this deflection, resulting from test measurements whose data acquisition provides a sampled signal.

Various numerical differentiation methods exist to compute an approximated derivative of a signal from its discrete values. Amongst them, one of the most commonly applied is the finite difference method.



- $D = D(t)$ *[in mm]*: continuous time-dependant deflection, only known through its measured values at times t_i
- $t_i = i\Delta t$ *[in min]*: sampled time (*i* is an integer)
- $\Delta t = t_i - t_{i-1}$ *[in min]*: sample step, or time step (sampling period)
- $D_i = D(t_i)$ *[in mm]*: sampled deflection, i.e. deflection measured at time t_i
- $\frac{dD_i}{dt} = \left.\frac{dD}{dt}\right|_{t_i}$ *[in mm/min]*: 1st time-derivative of *D*, i.e. rate of deflection at time t_i

- $\Delta T = k\Delta t$ *[in min]*: differentiation step (*k* is an integer greater or equal to 1)

According to the standard EN 1363-1 §10.4.4.2 the deflection measurements shall be made at 1 min intervals during the heating period.

The recommendation is to compute the rate of deflection at each sampled time t_i using a first-order backward difference $\frac{dD_i}{dt} = \frac{D_i - D_{i-k}}{\Delta T}$ with $\Delta T = 1\min$, which means:

$$\frac{dD_i}{dt} = D_i - D_{i-1\min} \quad \textit{[in mm/min]}$$

<u>Remark:</u>

The backward differences produce a relative time shift between the calculated derivative and the exact derivative, leading to a delayed estimation of the derivative. It can be shown that the resulting delay for the first order backward scheme amounts to $\frac{\Delta T}{2}$, namely 30 seconds in the present proposition. In other words, the so-computed derivative is shifted to the right by 30 seconds in the time domain. This leads to a less conservative assessment (by 30 seconds) of the "limiting rate of deflection" criterion, and thus a less severe loadbearing capacity performance with regard to fire safety.