Architectural Glass Thermal Shock Assessment by means of Dynamic Thermal Simulations

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Abstract

Thermally induced fracture, known as thermal shock, constitutes a high risk for many glazing applications. The risk is often assessed at pre-construction stage on a project-by-project basis and is mitigated by costly measures, but there is currently no international standard or universally accepted procedure for performing the thermal shock assessment. Consequently, there are many different methods and possible approaches for assessing the risk, ranging from overly-simplified national standards such as ASTM E2431 and NF DTU 39 P3, to very laborious coupled thermal-structural finite element analyses based on point-in-time static or transient boundary conditions. This paper briefly reviews the existing approaches, by assessing their applicability and limitations, and based on these, it presents a novel method for the quantitative assessment of thermal shock risk in glazing systems, by means of a context-specific long-term evaluation. The proposed method is intended for a broad range of architectural glazing systems, including multi-layer glazing element (e.g. insulated glazing units, glazing with fixed and operable shading systems, etc.). It is simple yet sufficiently accurate for day-to-day engineering practice and could be run as a web-based tool. The proposed methodology is applied to various glazing configurations including double and triple glazing units with different optical and solar properties. The results are compared with those obtained from ASTM E2431 and NF DTU 39 P3 standards. It is found that, in contrast to current methodologies, the proposed dynamic model provides a more precise thermal shock risk evaluation by incorporating realistic hourly climatic data and a more accurate thermal model, reducing the errors by 5-10% for Double and 20% for Triple Glazing Units compared to the French standard, with the further advantage of being applicable to environmental contexts beyond those provided in the national standards, thereby enhancing the global use of the analysis.

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Keywords

Thermal shock, glass thermal modelling, dynamic thermal simulation, standardisation

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