

Sustainable behaviour of buildings with steel-intensive façade systems

PhD Thesis – Summary

A Thesis Submitted to obtaining
the Scientific Title of PhD. in Engineering
from

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The PhD thesis includes 7 chapters, 216 pages, 29 tables, 147 figures and charts, and 190 bibliographic titles. Its purpose is to evaluate the behavior of steel-intensive façade systems from a sustainable perspective by 1) assessing the environmental impact of steel-intensive façade systems through a life cycle analysis and 2) achieving a deeper understanding of the behavior of liner trays under the dynamic effect of wind loads.

Chapter 1: Introduction

The research subject was introduced, highlighting the scope and objectives of the thesis. In addition, an overview of the thesis structure was provided.

Chapter 2: State of knowledge

The second chapter presents the state-of-the-art on legislative proposals, frameworks, and principles for climate action that has an impact on the construction sector, as well as the environmental impact of the construction sector. Global concerns about environmental sustainability have escalated in the last three decades, pressing industries to critically examine their practices and their contribution to the overall ecological footprint. The construction sector has become a significant contributor to environmental deterioration due to its extensive energy consumption, raw material extraction, and waste generation. The construction sector has the potential to reduce its environmental impact through two methods: reducing the embodied carbon footprint of buildings and reducing energy consumption during the construction use phase. The embodied carbon footprint of the building is related to the extraction of raw materials, the manufacture of building materials, the transportation of building materials, the energy used during the construction process, the energy consumption related to the demolition / deconstruction process, the transport of construction waste, the construction waste process, and disposal. The embodied carbon footprint can be decreased by the three R approaches – reduce, reuse, recycle and by using renewable construction materials. Emissions related to energy consumed during the operational phase of buildings represent the preponderant share of emissions associated with buildings reported throughout the life cycle of a construction. This highlights the urgent need to improve building performance, which is directly related to the performance of the construction envelope.

The state of knowledge also provides insight into the structural behaviour of the liner trays subjected to wind loads. Among façade system solutions, steel liner tray claddings have emerged as a promising technology that has the potential to transform the industrial construction landscape. The research endeavour seeks to investigate the benefits, challenges,

and broader implications of using steel liner trays as claddings in industrial halls. In this chapter, the advantages of experimental tests on wind loads conducted through a vacuum chamber are outlined while the experimental investigations of the liner trays carried out in a vacuum chamber represented pioneering experimental test accomplished in Romania on structural liner trays subjected to wind loads.

Chapter 3: Experimental investigation of liner trays subjected to wind loads

The third chapter presents a calculation of the design values of liner trays in wall claddings subjected to horizontal loads following the procedure recommended by European Standards (EN). Furthermore, the experimental investigation on liner trays subjected to wind loads was presented. Different test configurations of liner trays (simple liner trays with and without outer cladding, restrained liner trays with and without outer cladding) were tested, in a vacuum chamber, to establish their ultimate moment resistance under real conditions of service. The test results were split into two groups based on the type of wind loading, namely, pressure and suction. Within each group, the test results were described, observing the location and nature of the failure zones. The results of the experimental tests were compared to the design values obtained following the procedure recommended by EN.

Chapter 4: Numerical investigations on liner trays

Chapter four presents the results of two sets of numerical simulations performed: (1) two models calibrated in order to replicate the experimental behaviour of liner trays in the post-test finite element analysis: one model that simulates the behaviour of simple-opened liner trays subjected to wind pressure and another model that reflects the behaviour of simple-opened liner trays subjected to wind suction; (2) study of the influence of parameters such as thickness, web height, and static scheme / liner tray length in liner trays subjected to pressure and suction.

Chapter 5: Environmental impact of buildings with steel-intensive façade systems

In this chapter was presented the evaluation of the environmental impact of steel-intensive façade systems from a life-cycle perspective through a comparative life-cycle assessment (LCA) of various single-storey steel structures made of completely new materials, as well as structures made of reused elements. Starting from an optimal design case of a single-storey industrial hall considering a new steel structure with new materials, a comparative life cycle assessment of further design possibilities for the same steel building using reclaimed elements is presented. The structural feasibility and the environmental benefits of a construction strategy based on the circular economy approach were shown. The analysis is also completed by a comparative LCA of industrial buildings that have envelopes consisting of liner tray cladding systems and sandwich panel cladding systems.

Chapter 6: Conclusions of PhD study. Contributions of the author. Future research

The final chapter provides an overview of the conclusions drawn from the PhD study, highlights the main contributions made by the author, discusses the dissemination of results, and outlines future research activities.

Annex

Within the annex, additional information is provided regarding the specifics of liner tray specimens following experimental tests.

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