Prediction of light intensity inside elevator cabins using CAE simulation

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Abstract

This paper presents a comprehensive approach to predicting and optimizing light intensity within elevator cabins using CAE simulation for illuminance analysis. The primary purpose of this study is to meet the code requirement of minimum illuminance, as measured in lux, and to enhance the lighting arrangement for effective illumination inside the elevator car. Our findings demonstrate that CAE simulation results correlate very well with actual testing data, highlighting the reliability and accuracy of the simulation approach. Key benefits include early detection of potential lighting issues and the ability to automate the process, ensuring comprehensive data collection for the entire interior of the elevator cabin. The results of the study provide valuable insights into optimizing the number and type of lamps, improving both the efficiency and effectiveness of the lighting solutions. The study also emphasizes the cost-effectiveness of using simulations to reduce the number of testing loops, thereby shortening the development time, and improving time-to-market. In conclusion, this approach not only addresses meeting regulatory requirements but also explores the aspect of enhancing the overall lighting quality, contributing to better elevator user experience and satisfaction

1   INTRODUCTION

Elevator cabin lighting plays a crucial role in user safety, comfort, and adherence to regulatory standards such as EN 81-20[1], which stipulates minimum illuminance levels that must be achieved. Traditionally, cabin lighting layouts have been validated through physical mock-ups and manual lux measurements, which are prone to human error, offer limited sampling points, and result in extended development timelines. To overcome these challenges, a simulation-driven approach to predict and optimize lighting performance across multiple design variants is developed, revolutionizing the elevator light design process.

The objective of this research is to establish a reliable and validated simulation process to:
- Accurately predict illuminance at critical locations within elevator cabins.
- Support design decisions regarding lamp types, placement, and material selection.
- Reduce reliance on costly and time-intensive physical prototyping.

Through this approach, aim is to enhance the effectiveness and quality of elevator cabin lighting while ensuring compliance with regulatory standards.

2 Methodology for prediction of light intensity inside elevator cabins

Three elevator cabin configurations were selected with different parameters of size, lamp and panel, ceiling & floor materials to ensure effectiveness of the simulation methodology. (Refer Figure 1 & 2)

Simulation Setup:

Cradle scStream ™ software (Hexagon) is used to model light propagation and reflection within the cabin [2]. This step involves setting up the simulation environment to mimic real-world lighting conditions as mentioned below.

1. Cabin Modeling

Develop detailed CAD models of the elevator cabin, incorporating all relevant surfaces (panels, ceiling, floor) and lighting fixtures. Accurate CAD modeling of the lamp location and light emitting surfaces is to be done. This step ensures that the simulation accurately reflects the physical characteristics of the cabin. (Refer Figure 1 & 2)
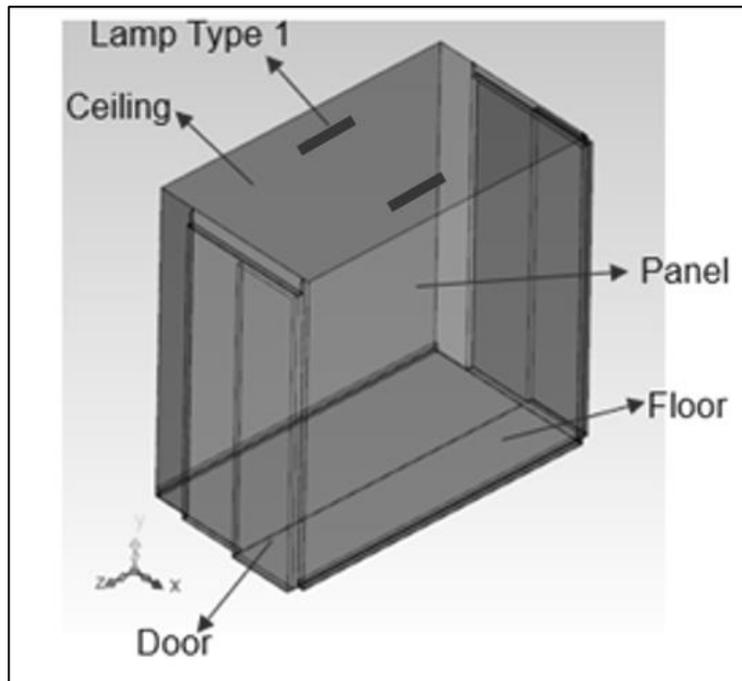

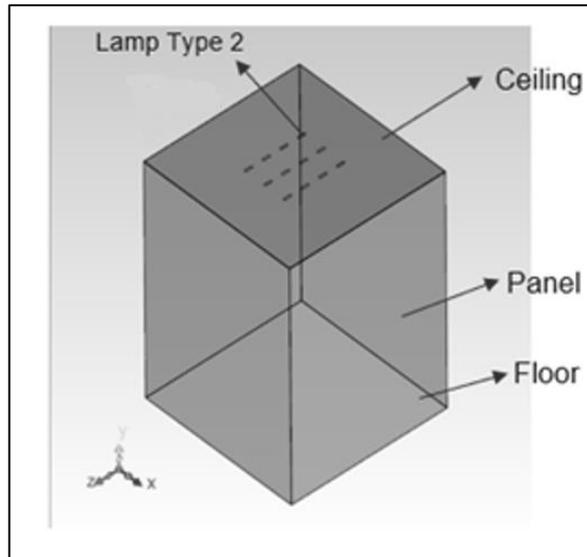Figure No. 1 – Elevator cabin schematic Case 1 & Case 2

Figure No. 2 – Elevator cabin schematic Case 3

2.   Lamp Data:
Data from technical sheet of the lamp for luminous flux and light diffusion characteristics to accurately model the light sources used in the cabin.

3.   Material Properties:
Material properties for panels, ceiling, and floor based on their finish and colour to model quantum of light reflected from different surfaces.

Simulation Results:
Lux levels are predicted at specified probe heights (commonly 1m from the floor) at multiple cabin points as defined in the EN81-20 code. Refer Figure 3.
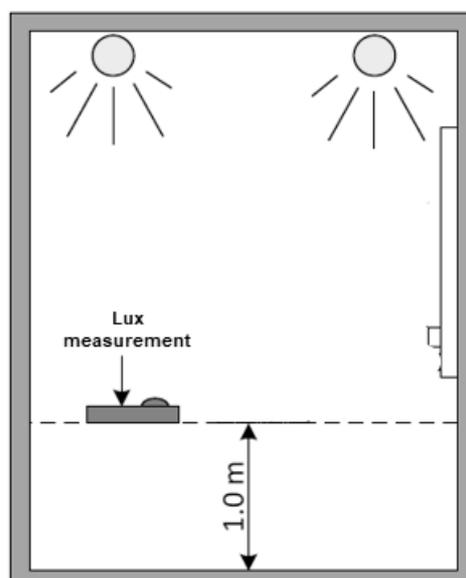

Figure 3: Measurement points for EN81-20

Lux values from simulation results are visualized as contours and Figure 4-6 show the lux contours at 1m plane from the cabin floor. Lux values on this plane can be probed for at any specific location. Simulation outputs are compared with experimental lux measurements and the results match well (+-15% accuracy). This validates the reliability of the simulation results against physical test data.
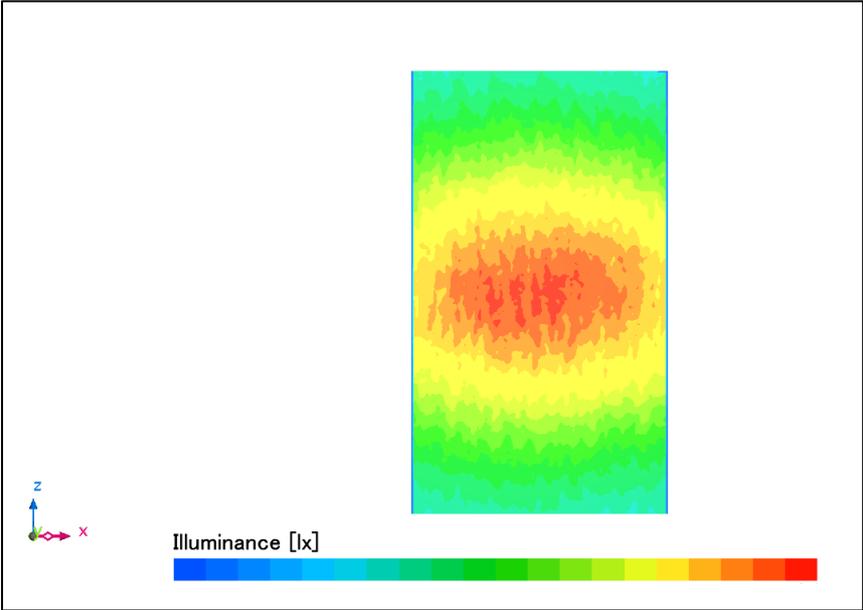

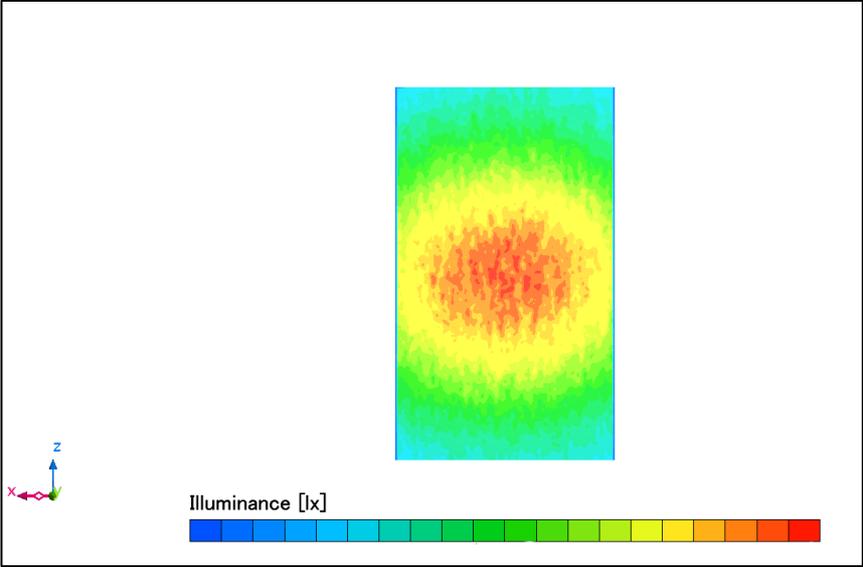Figure 4: Lux contours for Case 1
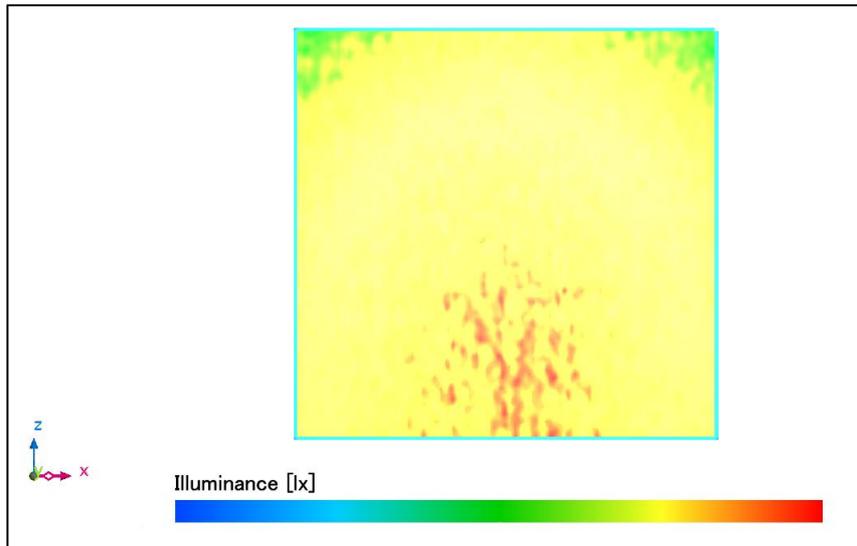

Figure 5: Lux contours for Case 2

Figure 6: Lux contours for Case 3

CONCLUSION

The study successfully illustrates that CAE simulation is a powerful tool for predicting and optimizing light intensity within elevator cabins and addresses the limitations of traditional physical mock-ups and manual lux measurements, which are often time-consuming and prone to errors. The CAE approach ensures compliance with regulatory standards such as EN 81-20, which mandates minimum illuminance levels, thereby enhancing user safety and comfort.

Key Advantages of CAE Simulation include:

1. Accuracy: Ensures good accuracy with ±15% variation from physical test data for precise illuminance predictions.
2. Design Optimization: Facilitates exploration of various configurations for improved lighting quality.
3. Cost and Time Efficiency: Reduces prototyping needs, cutting development costs and time-to-market.
4. Enhanced User Experience: Improves lighting quality, boosting user satisfaction in elevator cabins.

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[1]   EN 81-20, (2020), Safety rules for the construction and installation of lifts - Lifts for the transport of persons and goods - Part 20: Passenger and goods passenger lifts

[2]   Hexagon. (2024). scSTREAM User's Guide. (v2023.2).
https://nexus.hexagon.com/documentationcenter/en-US/bundle/scStream_2023.2_operation_eng/page/St_cover_eng.htm

BIOGRAPHICAL DETAILS

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Mechanical Engineer with a MTech in Automotive Technology from the University of Pune, India. Currently serving as Principal Engineer at Schindler India Pvt Ltd, he specializes in CAE simulations catering to durability, noise, and vibration etc. with extensive experience in both the automotive and elevator industries.