



## KEYNOTE LECTURE

### Smart Transport Packaging Design: How to Optimize Safety and Costs?

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**Abstract:** The growing complexity of global supply chains, rising environmental demands, and the need for efficient resource utilization have transformed transport packaging into a critical component of product safety and sustainability. Corrugated board packaging, once considered merely a passive transport container, is now being redefined through digital tools, predictive simulations, and safety optimization strategies. This presentation explores how intelligent design of corrugated board transport packaging can simultaneously enhance safety and reduce operational costs. Key factors include mechanical reliability under variable environmental conditions (e.g., high humidity, temperature changes), the adoption of advanced finite element methods (FEM), and the integration of digital twin technology to simulate transport dynamics. The methodology draws upon recent works, including Garbowski (2023a) and Garbowski (2023b), which provide a scientific basis for implementing tailored safety factors in packaging design. These safety coefficients allow engineers to account for material degradation, stacking scenarios, and unpredictable environmental loads. Further insights are derived from the work of Cornaggia et al. (2024), who demonstrate how full-scale numerical models—validated by experimental data—can assess packaging deformation and failure under simulated transport vibrations, drop impacts, and compression. By combining structural optimization with predictive modeling, their research paves the way for lighter, stronger, and more cost-effective solutions. The concept of "smart packaging" in this context goes beyond sensors or RFID integration—it encompasses data-driven mechanical design. Integrating AI-assisted optimization, digital prototyping, and lifecycle assessment (LCA), designers can now reduce material usage without compromising protection, leading to reduced carbon footprint and lower logistic costs. This talk will also highlight practical guidelines for implementing simulation-based packaging validation in industrial workflows and discuss the cost-benefit trade-offs of different safety margins. Ultimately, smart transport packaging design is not just about boxes—it is about protecting value across the supply chain while embracing sustainability and innovation.

**Keywords:** corrugated board, packaging safety, FEM, safety factors, transport simulation, digital twin, optimization, sustainability, environmental conditions

#### References

- Garbowski, T. Evaluating safety factors in corrugated packaging for extreme environmental conditions. (Ocena czynników bezpieczeństwa opakowań z tektury falistej w ekstremalnych warunkach środowiskowych). *Packaging Review* **2023** 4, 6-15. DOI: 10.15199/42.2023.4.1
- Garbowski, T. . Safety Factors in the Design of Corrugated Board Packaging. (Współczynniki bezpieczeństwa w projektowaniu opakowań z tektury falistej). *Packaging Review* **2023** 3, 16-22. DOI: 10.15199/42.2023.3.2
- Cornaggia, A.; Mrówczyński, D.; Gajewski, T.; Knitter-Piątkowska, A.; Garbowski, T. Advanced Numerical Analysis of Transport Packaging. *Applied Sciences* **2024** 14(24) 11932. DOI: 10.3390/app142411932