



Chapter 5

Lifecycle Assessment of Aluminium Composite Panel Façades in Tropical and Temperate Climates: A Durability–Informed Approach to Sustainable Design

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ABSTRACT

This chapter develops a durability-informed lifecycle assessment perspective for aluminium composite panel (ACP) façades in tropical and temperate climates. It argues that ACP sustainability cannot be judged by initial embodied carbon alone, because climatic exposure influences coating degradation, corrosion risk, sealant ageing, moisture ingress, maintenance frequency, service life, and end-of-life recovery. Tropical climates tend to intensify humidity-, rainfall-, UV-, and corrosion-related deterioration, while temperate climates present challenges associated with thermal movement, freeze-thaw exposure, sealant fatigue, and seasonal moisture manage-

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ment. The chapter integrates lifecycle assessment, façade durability science, and green building certification implications to show that ACP façade sustainability is a dynamic whole-life performance outcome. It concludes that more reliable assessment requires climate-sensitive durability assumptions, preventive maintenance planning, realistic recycling pathways, and transparent environmental documentation.

1. INTRODUCTION

1.1 Role of Façade Systems in Sustainable Building Performance

Façade systems are central to the sustainability performance of contemporary buildings because they mediate heat flow, daylight access, weather resistance, indoor comfort, energy demand, and architectural identity. As the boundary between internal space and external climatic exposure, the façade is both a technical assembly and a long-term environmental asset. Recent concern over climate change, resource depletion, and the environmental burden of construction has therefore shifted façade evaluation beyond appearance and short-term functionality toward whole-life performance (Cabeza et al., 2014; Pomponi & Moncaster, 2017).

This shift is particularly important because reductions in operational energy demand through efficient mechanical systems, renewable energy integration, and improved controls increase the relative importance of embodied environmental impacts. Embodied carbon associated with extraction, manufacturing, transport, installation, maintenance, replacement, and disposal can represent a substantial share of total building-related emissions, especially in high-performance buildings (Pomponi & Moncaster, 2017). Façade materials such as glass, aluminium, cladding panels, insulation, sealants, and supporting framing systems therefore require careful assessment because they influence both embodied and operational performance.

Lifecycle thinking has consequently become a necessary part of façade engineering and material selection. Rather than evaluating façade systems only by initial cost, appearance, or short-term performance, designers are increasingly expected to consider environmental consequences across the service life of the envelope. Lifecycle assessment (LCA) provides a structured method for examining impacts associated with raw material extraction, production, transport, construction, maintenance, repair, replacement, and end-of-life treatment. Standards such as ISO 14040, ISO 14044, and EN 15978 provide the methodological basis for applying this logic in the building sector (International Organization for Standardization, 2006a, 2006b; European Committee for Standardization, 2011). When applied to façade systems, these frameworks allow engineers and architects to compare alternatives not only

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