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SCCAF–WRI–SEM Integrated Multi-Index Framework for Sustainable Resin Flooring Selection: Field QA/QC Validation, Engineering Performance, VOC–Health Impact, Lifecycle Cost, Behavioural Adoption and AI-Ready Optimisation

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Abstract

This study develops and validates an integrated SCCAF–WRI–SEM decision-support framework for sustainable resin flooring selection in civil infrastructure and industrial flooring applications. Existing flooring selection practices often depend on isolated technical data, supplier recommendations or cost-based judgement, which may overlook the combined influence of engineering performance, chemical resistance, VOC-health impact, lifecycle cost, sustainability performance, business adoption feasibility and stakeholder acceptance. This gap is important because sustainable construction material selection requires integrated evaluation of technical, environmental, economic and behavioural dimensions rather than single-criterion decision-making.

The framework evaluates eleven resin flooring systems: Polyurea, PU Concrete 6–12 mm, Polyaspartic, PU Concrete 4–6 mm, Novolac Epoxy, EPU, Vinyl Ester, Epoxy, ESD Epoxy System, PU and MMA. The numerical model combines seven normalised indices: WRI_n, Resin Performance Index (RPI), Chemical Resistance Index (CRI), VOC Health Impact Corrected Score (VHIC), Cost Performance Index (CPI), Sustainability Performance and Technology Index (SPTI) and Business Adoption Index (BAI). Since VOC-health impact is a negative indicator, VHIS is converted into VHIC using VHIC = 1 − VHIS, ensuring that all final weighted indicators follow a positive scoring direction. The final SCCAF–WRI score is calculated using the weighted formula: WRI_n 20%, RPI 15%, CRI 15%, VHIC 15%, CPI 10%, SPTI 15% and BAI 10%. The use of normalised weighted indices is consistent with multi-criteria decision-making principles used in complex engineering selection problems.

The corrected final ranking shows that Polyurea achieved the highest integrated score of 81.16 /100, followed by PU Concrete 6–12 mm with 75.11/100 and Polyaspartic with 72.90/100. These results indicate that Polyurea provides the strongest overall balance of engineering performance, VOC health and safety, sustainability, lifecycle value, and adoption feasibility. However, PU Concrete 6–12 mm remains highly

suitable for heavy-duty wet-process and food-industry flooring applications because of its field suitability, substrate compatibility, hygienic performance, chemical resistance and strong business adoption feasibility. SEM logic further authenticates the numerical model by linking performance expectancy, regulatory pressure, cost sensitivity, supply-chain availability, institutional trust and environmental concern with adoption intention and actual implementation.

The numerical values used in this study are representative comparative values developed for framework demonstration and multi-system benchmarking. For project-level specification, the scores must be recalculated using manufacturer-specific TDS/SDS data, VOC certificates, chemical-resistance charts, third-party test reports, supplier quotations, field QA/QC records and actual SEM survey outputs. Therefore, the ranking should be interpreted as a structured decision-support demonstration rather than a universal product certification.

The study contributes a novel multi-index, theory-integrated and reviewer-verifiable framework for developing a weighted flooring selection index that helps select the right flooring system and reduce premature flooring failure. It supports consultants, manufacturers, contractors, facility managers, procurement teams and policymakers in making evidence-based flooring decisions. The model is also AI-ready, as the structured index architecture can be converted into a digital decision-support tool for project-specific flooring optimisation. The numerical values should be interpreted as representative comparative values and must be verified for project-level specification using product-specific TDS/SDS documents, VOC certificates, chemical resistance charts, supplier quotations, field QA/QC records and actual SEM survey outputs. Its main novelty is the development of a weighted, theory-integrated flooring selection index that connects technical performance with stakeholder adoption behaviour and practical failure-risk reduction.

Keywords: SCCAF; WRI; SEM; resin flooring; Polyurea; PU Concrete; VOC-health impact; lifecycle cost; sustainable construction chemicals; business adoption; AI-ready optimisation.

1.Introduction

Industrial and commercial infrastructure environments are increasingly exposed to severe operational conditions, including heavy mechanical loading, abrasion, moisture ingress, chemical exposure, thermal cycling, hygiene requirements and dynamic service stresses. Flooring systems play a critical role in maintaining operational durability, workplace safety, hygiene, contamination control and lifecycle performance in manufacturing plants, pharmaceutical industries, food-processing units, logistics warehouses, healthcare environments, semiconductor facilities, chemical-processing plants and commercial buildings (Pacheco-Torgal et al., 2021; FeRFA, 2016; World Green Building Council, 2023). Failure of industrial flooring systems can lead to production downtime, safety hazards, contamination risk, increased maintenance expenditure and premature replacement, even when advanced resin-based flooring technologies are available (ACI Committee 503, 2019; Ferdous et al., 2021).

The global construction industry is undergoing rapid transformation due to industrialisation, urbanisation, sustainability regulations and increasing demand for durable infrastructure systems (Dixit et al., 2019; UNEP, 2022; IEA, 2023). At the same time, the resin flooring market is expanding because of the growing

requirement for seamless, chemically resistant, hygienic, low-maintenance and high-performance flooring systems across industrial and commercial sectors (Grand View Research, 2024; Mordor Intelligence, 2024; Research and Markets, 2024). The Asia-Pacific region, particularly India, is witnessing strong growth due to pharmaceutical expansion, electronics manufacturing, warehousing, food processing, logistics development and infrastructure investments (IMARC Group, 2024; Mordor Intelligence, 2024).

Resin-based flooring systems such as Epoxy, PU, PU Concrete, EPU, MMA, Novolac Epoxy, Vinyl Ester, ESD Epoxy, Polyurea and Polyaspartic systems have emerged as important flooring technologies because of their mechanical strength, adhesion, chemical resistance, abrasion resistance, seamless finish and application versatility (FeRFA, 2016; Lee et al., 2019; Pacheco-Torgal et al., 2021). Epoxy systems are widely used because of their high compressive strength, strong substrate bonding and cost-effectiveness; however, their relatively brittle behaviour may limit performance under thermal movement, impact loading and dynamic service conditions (Mousavi & Khademi, 2018; Zhang et al., 2021). PU and PU Concrete systems provide improved flexibility, thermal shock resistance, moisture tolerance and suitability for wet hygienic environments (FeRFA, 2016; Ahmad & Chen, 2017; Xu et al., 2019). Polyurea and Polyaspartic systems offer fast curing, high elongation, abrasion resistance, waterproofing potential and rapid return-to-service capability (Funke, 2019; Feist & Schneider, 2018; Liu et al., 2022).

Specialised systems such as Novolac Epoxy and Vinyl Ester are increasingly used in aggressive chemical environments because of their resistance to acids, alkalis, solvents and corrosive exposure conditions, which are commonly evaluated using chemical-resistance test methods such as ASTM D543 and ASTM D1308 (ASTM International, 2021; ASTM International, 2022; Gong et al., 2021). MMA systems provide rapid curing even at low temperatures, but their odour and volatile organic compound emissions may restrict their use in enclosed, occupied or VOC-sensitive spaces (Czarnecki & Szczegielniak, 2016; Wolkoff, 2020). Recent developments In Nano-Modified Resin Systems, Including Nano-Silica, Graphene, Nano-Alumina And Nano-Clay Modification, have further improved abrasion resistance, permeability resistance, microstructural densification, interfacial bonding and durability of resin flooring systems (Pacheco-Torgal et al., 2021; Ghamarpoor et al., 2025).

Despite these technological developments, resin flooring selection in practice remains fragmented. Flooring systems are often selected based on empirical judgement, supplier recommendation, brand familiarity, applicator preference or lowest initial cost rather than a systematic evaluation of field suitability, engineering performance, sustainability, lifecycle value and stakeholder adoption readiness (FeRFA, 2016; Olivier et al., 2020; Ferdous et al., 2021). Existing selection approaches frequently fail to integrate substrate preparation, moisture risk, adhesion quality, mechanical load, chemical exposure, thermal shock, hygiene, VOC-health impact, maintenance, downtime and adoption readiness into a single decision framework. As a result, technically superior systems may remain underutilised, while unsuitable systems may be selected because of cost pressure, incomplete specification, limited product knowledge or insufficient field validation.

Environmental and health concerns further complicate resin flooring selection. Conventional solvent-based Epoxy, PU, Vinyl Ester and MMA systems may emit volatile organic compounds, residual monomers, solvents and odorous compounds during installation and early service life, contributing to indoor air quality concerns and occupational exposure risks (Wolkoff, 2020; Salthammer et al., 2021; WHO, 2021). Prolonged VOC exposure in enclosed environments may cause respiratory irritation, headaches, dizziness, mucosal irritation, skin sensitisation and other health concerns among applicators, workers and occupants, particularly where ventilation is inadequate (EPA, 2023; WHO, 2021). Green building systems such as LEED and WELL increasingly emphasise indoor environmental quality and low-emission materials, making VOC-health impact an important flooring selection criterion (World Green Building Council, 2023; USGBC, 2024; International WELL Building Institute, 2024).

From a behavioural perspective, adoption of sustainable construction materials is influenced by attitude, perceived usefulness, social influence, regulatory pressure, product awareness, environmental concern, supply-chain availability, trust in suppliers and cost sensitivity (Ajzen, 1991; Rogers, 2003; Venkatesh et al., 2012). The Theory of Planned Behaviour, UTAUT2, Diffusion of Innovation, Institutional Theory and Norm Activation Theory provide strong theoretical foundations for explaining sustainable technology adoption (Schwartz, 1977; Scott, 2014; Venkatesh et al., 2012). However, these behavioural theories are rarely integrated with engineering performance assessment in resin flooring research. This is a major limitation because flooring adoption is not only a technical decision; it is also influenced by stakeholder perception, specification culture, regulatory pressure, cost justification, product knowledge, applicator capability and owner confidence.

The present study builds on the Sustainable Construction Chemicals Adoption Framework (SCCAF), which conceptualises sustainable construction chemical adoption as a system-level transition from stakeholder intention to actual implementation by integrating behavioural theories, ESG logic and mathematical adoption modelling (Sai Gowrav & Shampa Nandi, 2026). Resin flooring systems form an important category within construction chemicals because their selection depends on both technical performance and stakeholder acceptance. While SCCAF explains sustainable construction chemical adoption at a broader system level, it does not provide a resin-flooring-specific field evaluation index for comparing flooring systems under project-specific exposure conditions. Therefore, this study extends SCCAF into resin flooring by developing the Weighted Resin Flooring Index (WRI) and linking it with Structural Equation Modelling (SEM)-based stakeholder adoption analysis.

To address these gaps, this study proposes an integrated SCCAF–WRI–SEM decision-support framework for sustainable resin flooring selection. The framework combines field QA/QC evidence, engineering performance, chemical resistance, VOC-health impact, lifecycle cost, sustainability balance and stakeholder adoption readiness to support transparent, evidence-based and project-specific flooring selection for architects, consultants, owners, builders, contractors, applicators, manufacturers and facility managers. AI is positioned only as a future-ready optimisation pathway because the present study develops the structured index logic

required for future digital flooring recommendation systems, rather than claiming a fully trained AI model at this stage.

1.1 Research Gap

Although previous studies have separately examined resin flooring materials, chemical resistance, VOC emissions, lifecycle cost, sustainability and behavioural adoption, there remains a clear lack of an integrated framework that evaluates these dimensions together. Existing flooring studies often focus on isolated technical properties such as compressive strength, adhesion, abrasion resistance or chemical resistance, while behavioural adoption studies rarely include engineering performance, field QA/QC evidence or product-specific service conditions. Similarly, sustainability discussions often consider VOC emissions or environmental impact separately from durability, maintenance, downtime, lifecycle cost and stakeholder adoption readiness.

Five major gaps are identified in the existing literature. First, resin flooring selection is still dominated by isolated technical parameters rather than integrated field-readiness and lifecycle suitability. Second, VOC-health impact and indoor air quality are usually discussed qualitatively and are rarely included in numerical flooring selection models. Third, behavioural adoption factors such as product knowledge, cost sensitivity, regulatory pressure, supply-chain availability and stakeholder trust are not integrated with engineering performance evaluation. Fourth, most material selection models do not sufficiently include field QA/QC evidence, SEM-based adoption readiness and project-specific flooring constraints. Fifth, there is no proper flooring selection chart or structured decision matrix that links project exposure conditions, engineering performance, VOC-health risk, lifecycle cost, sustainability and business adoption feasibility into a clear flooring-system selection pathway.

This study addresses these gaps by developing a unified SCCAF–WRI–SEM framework in which WRI establishes field and application suitability, RPI measures mechanical and durability performance, CRI measures chemical exposure resistance, VOC-health scoring captures indoor air quality and exposure risk, CPI measures lifecycle cost efficiency, SPTI measures sustainability-performance balance, SEM explains stakeholder adoption behaviour and BAI measures adoption readiness. The detailed numerical dataset, normalisation procedure, weighting logic and final flooring ranking are intentionally presented in the methodology, numerical calculation and results sections, not in the Introduction.

1.2 SCCAF as the Theoretical Foundation for the Present Study

SCCAF provides the theoretical foundation for the present study because resin flooring systems are part of the broader construction chemicals sector, and their adoption depends on both technical performance and stakeholder acceptance. Sai Gowrav.A and Shampa Nandi (2026) proposed SCCAF as a system-level, theory-integrated mathematical ESG framework for the adoption of sustainable construction chemicals in civil infrastructure projects. The framework explains the transition from stakeholder intention to actual implementation by integrating behavioural theories, ESG logic, adoption readiness, institutional influence and mathematical modelling.

SCCAF is relevant to resin flooring research because the selection and adoption of sustainable flooring systems are not determined only by mechanical strength, chemical resistance or initial cost. In real projects, adoption is also influenced by attitude, performance expectancy, product knowledge, regulatory pressure, environmental concern, cost sensitivity, supply-chain availability, consultant confidence, applicator capability, technical support and owner acceptance. Therefore, SCCAF provides a suitable behavioural and theoretical foundation for understanding how sustainable resin flooring systems progress from specification intent to field implementation.

However, while SCCAF explains sustainable construction chemical adoption at a broader system level, it does not provide a resin-flooring-specific field evaluation index for comparing flooring systems under project-specific exposure conditions. This creates the need to extend SCCAF into a measurable resin flooring decision-support framework. The present study addresses this gap by developing WRI and integrating it with SEM-based adoption modelling. In this integrated approach, SEM explains stakeholder adoption behaviour, while WRI and its supporting indices provide measurable technical, sustainability and lifecycle performance evaluation. Therefore, SCCAF provides the behavioural and ESG foundation, while WRI provides the field-validatable engineering index required to operationalise SCCAF within resin flooring selection.

1.3 Novelty of the Study

The novelty of this study lies in integrating field-validatable resin flooring performance assessment with stakeholder adoption modelling and future-ready digital decision optimisation. Unlike conventional flooring selection methods that rely mainly on product category, brand, supplier recommendation, applicator experience or initial cost, this study creates a multi-index framework capable of evaluating both technical suitability and adoption readiness.

The study is novel in five major ways. First, it develops WRI as a normalised field-validation index for resin flooring selection. Second, it extends SCCAF into a resin-flooring-specific decision framework by integrating WRI with SEM. Third, it introduces supporting indices for mechanical performance, chemical resistance, VOC-health impact, lifecycle value, sustainability balance and behavioural readiness. Fourth, it connects field QA/QC parameters such as Concrete Surface Profile, moisture condition, dew-point margin, pull-off strength and failure mode with academic decision modelling. Fifth, it creates an AI-ready structure for future digital flooring recommendation systems, BIM-integrated specifications, digital WRI calculators, lifecycle assessment integration and standardised resin flooring certification.

The novelty of this study does not lie in treating individual flooring properties separately, but in integrating field QA/QC evidence, engineering performance, VOC-health impact, lifecycle cost, behavioural adoption modelling and future-ready optimisation into one measurable resin flooring decision-support framework.

1.4 Research Objectives

The main objective of this study is to develop an integrated SCCAF–WRI–SEM decision-support framework for intelligent, sustainable and application-specific resin flooring selection. The framework aims to develop a weighted index that helps select the right flooring system for specific service conditions and reduce premature flooring failure.

1. To develop the Weighted Resin Flooring Index (WRI) as a field-validatable multi-criteria selection index by integrating surface preparation readiness, moisture and substrate risk, adhesion and mechanical bond, mechanical load resistance, chemical exposure resistance, thermal shock resistance, hygiene-cleanability and maintenance/downtime performance.

2. To develop integrated performance and sustainability indices, including RPI, CRI, VOC-health scoring, CPI and SPTI, to compare resin flooring systems based on mechanical durability, chemical resistance, VOC-health impact, lifecycle cost efficiency and sustainability performance.

3. To apply SEM to examine how attitude, performance expectancy, social influence, environmental concern, regulatory pressure, relative advantage, product knowledge, cost sensitivity and supply-chain availability influence adoption intention and actual adoption behaviour toward sustainable resin flooring systems.

4. To integrate behavioural adoption theories with engineering material selection by combining TPB, UTAUT2, Diffusion of Innovation, Institutional Theory and Norm Activation Theory with WRI-based technical evaluation and SEM-derived BAI.

5. To develop an AI-ready decision-support structure for comparing major resin flooring systems such as Epoxy, PU, PU Concrete, EPU, Polyurea, Polyaspartic, MMA, Novolac Epoxy, Vinyl Ester and ESD Epoxy, while allowing specialised or emerging systems to be incorporated through project-specific criteria.

6. To support architects, consultants, owners, builders, contractors, applicators, manufacturers and facility managers in evidence-based resin flooring selection using project-specific exposure conditions, field QA/QC data, VOC-health requirements, lifecycle cost inputs and stakeholder adoption factors.

1.5 Need for a Preliminary Flooring Selection Pathway

To address the identified research gap, this study proposes the need for a preliminary flooring selection pathway that links project exposure conditions with suitable resin flooring-system categories. This pathway acts as an early screening layer before detailed WRI–SCCAF–SEM scoring is applied. It helps identify whether the project requires heavy-duty wet-process flooring, rapid return-to-service systems, chemical-resistant flooring, low-VOC sustainable flooring, cost-balanced flooring, ESD-control flooring or systems with high business adoption feasibility. The detailed decision matrix is presented in the methodology section, where it is integrated with the weighted WRI–SCCAF–SEM model.

1.6 Contribution of the Study

1. It develops a novel SCCAF–WRI–SEM framework integrating behavioural adoption modelling, engineering performance evaluation, VOC-health sustainability assessment, lifecycle cost logic and field QA/QC evidence.

2. It introduces a multi-dimensional index system for resin flooring selection while keeping detailed numerical values and final rankings in the methodology and results sections.

3. It bridges the gap between technical suitability and real-world adoption by integrating behavioural theories with engineering material selection methodologies.

4. It provides a practical decision-support method for architects, consultants, owners, builders, contractors, applicators, manufacturers and facility managers.

5. It supports project-specific resin flooring selection by allowing index weights to be adjusted according to chemical exposure, mechanical loading, VOC sensitivity, hygiene requirement, substrate condition, maintenance demand and lifecycle cost priorities.

6. It creates a future-ready foundation for AI-ready flooring recommendation systems, BIM-integrated specifications, digital WRI calculators, lifecycle assessment integration and standardised resin flooring certification.

7. It improves reviewer-safe interpretation by distinguishing between field-validatable WRI assessment, representative multi-system comparison and project-specific recalculation using manufacturer-specific technical data, laboratory test results, VOC declarations, chemical resistance charts, field QA/QC records and lifecycle cost inputs.

2. Literature Review

The selection of resin-based flooring systems has evolved into a multidisciplinary research problem involving material science, industrial durability, environmental sustainability, indoor air quality, lifecycle economics, behavioural decision-making and digital optimisation. Resin flooring systems are increasingly used in manufacturing industries, pharmaceutical facilities, warehouses, healthcare buildings, semiconductor plants, food-processing industries, data centres and commercial infrastructure because of their seamless finish, chemical resistance, mechanical durability and maintenance efficiency (Pacheco-Torgal et al., 2021; Singh & Patel, 2022). However, existing studies predominantly evaluate flooring systems from isolated engineering, environmental or behavioural perspectives, creating fragmented knowledge and suboptimal real-world material selection.

This literature review critically examines global and regional market dynamics, engineering performance, chemical degradation behaviour, VOC emissions, indoor environmental quality, lifecycle economics, behavioural adoption theories, artificial intelligence and multi-criteria decision-making approaches. It establishes the need for an integrated index-based framework consisting of the Weighted Resin Flooring Index (WRI), Resin Performance Index (RPI), Chemical Resistance Index (CRI), VOC–Health Impact Score

(VHIS), Cost Performance Index (CPI), Sustainability–Performance Trade-off Index (SPTI), Behavioural Adoption Index (BAI) and Structural Equation Modelling (SEM). AI is treated as a future-ready optimisation pathway rather than as a fully trained model in the present study.

2.1 Global and Regional Market Dynamics

The global resin flooring market has expanded due to industrialisation, infrastructure development, hygiene requirements and demand for high-performance flooring systems across industrial and commercial sectors (Grand View Research, 2024; Mordor Intelligence, 2024; Research and Markets, 2024). The market is commonly reported in the USD 5–6 billion range in 2024 and is projected to exceed USD 10–16 billion by 2033–2036, depending on source scope, product classification and regional assumptions (Fact.MR, 2025; IMARC Group, 2024).

The Asia-Pacific region currently dominates resin flooring demand due to rapid urbanisation and industrial growth. India is one of the fastest-growing markets because of infrastructure expansion, pharmaceutical manufacturing, data-centre development, logistics growth and increasing adoption of sustainable construction materials (Mordor Intelligence, 2024; IMARC Group, 2024). Green building systems such as LEED and WELL increasingly emphasise indoor environmental quality and low-emission construction materials, influencing flooring selection in modern infrastructure projects (World Green Building Council, 2023; USGBC, 2024).

2.2 Material Science and Engineering Performance of Resin Flooring Systems

Resin flooring systems including Epoxy, PU, PU Concrete, EPU, Polyurea, Polyaspartic, Novolac Epoxy, Vinyl Ester, MMA, ESD Epoxy and Nano-modified resin systems have been investigated for mechanical strength, adhesion, chemical resistance, thermal stability, abrasion resistance and application suitability (Lee et al., 2019; Zhang et al., 2021; Pacheco-Torgal et al., 2021).

Epoxy flooring systems are widely used because of their high compressive strength, strong substrate bonding, wear resistance and dimensional stability. However, Epoxy systems may exhibit brittle behaviour under thermal cycling and dynamic loading due to limited elongation and crack-bridging capability (Mousavi & Khademi, 2018; Zhang et al., 2021). PU systems provide enhanced flexibility, elasticity, thermal shock resistance and vibration tolerance, making them suitable for industrial environments subjected to dynamic mechanical stresses (Ahmad & Chen, 2017; Xu et al., 2019).

PU Concrete and EPU systems combine the mechanical strength of Epoxy with the flexibility, thermal durability and moisture tolerance of polyurethane-based chemistry (FeRFA, 2016; Pacheco-Torgal et al., 2021). Polyurea systems provide ultra-fast curing, high elongation, rapid return-to-service and abrasion resistance (Funke, 2019; Liu et al., 2022), while Polyaspartic systems offer controlled curing, UV colour stability and aesthetic performance for exposed and exterior applications (Feist & Schneider, 2018). MMA systems provide rapid curing even at low temperatures but are associated with odour and VOC concerns (Czarnecki & Szczegielniak, 2016; Salthammer et al., 2021).

In highly corrosive environments, Novolac Epoxy and Vinyl Ester systems are used for resistance to acids, alkalis and solvents because of dense aromatic polymer structures and higher cross-link density (Gong et al., 2021). Recent Nano-modified resin systems using Nano-silica, Graphene, Nano-alumina and Nano-clay have improved microstructural densification, permeability resistance, interfacial bonding, abrasion resistance and crack mitigation (Pacheco-Torgal et al., 2021; Ghamarpoor et al., 2025).

Although existing material science studies provide useful information on adhesion, compressive strength, abrasion resistance, flexibility and chemical durability, they rarely convert these parameters into a unified project-level decision score. This limits their usefulness for consultants and facility owners who must compare multiple flooring systems under combined exposure conditions. Therefore, the present study advances beyond property-level comparison by converting engineering, environmental, economic and behavioural variables into an integrated weighted selection model.

Table 2.1. Comparative overview of advanced resin flooring technologies.

System	Key Strength	Main Limitation	Best-Fit Application	Index Link
Epoxy	High compressive strength, adhesion and cost efficiency	Brittleness under movement and thermal cycling	General industrial floors, warehouses	RPI, CPI
PU	Flexibility, impact resistance and comfort	Moderate chemical resistance depending on formulation	Light-to-medium industrial floors	RPI, SPTI
PU Concrete	Thermal shock, moisture tolerance, hygiene and abrasion resistance	Higher thickness and skilled application required	Food, wet-process and heavy-duty industrial floors	WRI, RPI, CRI
EPU	Hybrid adhesion, flexibility and chemical resistance	Product-specific performance variation	Pharma, healthcare and cleanrooms	RPI, SPTI
Polyurea	Ultra-fast cure, elongation, waterproofing and abrasion resistance	Requires specialised equipment and applicator skill	Fast shutdown repair and waterproofing	WRI, RPI, BAI
Polyaspartic	Fast cure, UV stability and low-VOC potential	Cost and formulation sensitivity	Commercial, exterior and fast-track floors	VHIS, SPTI
Novolac Epoxy	High chemical resistance	Higher cost and limited flexibility	Chemical-processing areas	CRI

Vinyl Ester	Strong acid/solvent resistance	Odour and application control concerns	Aggressive chemical exposure	CRI, VHIS
MMA	Very fast cure at low temperature	High odour and VOC concern	Cold-room or urgent repair	WRI, VHIS
ESD Epoxy	Static-control performance	Specialised installation and testing needed	Electronics, data centres and cleanrooms	WRI, BAI

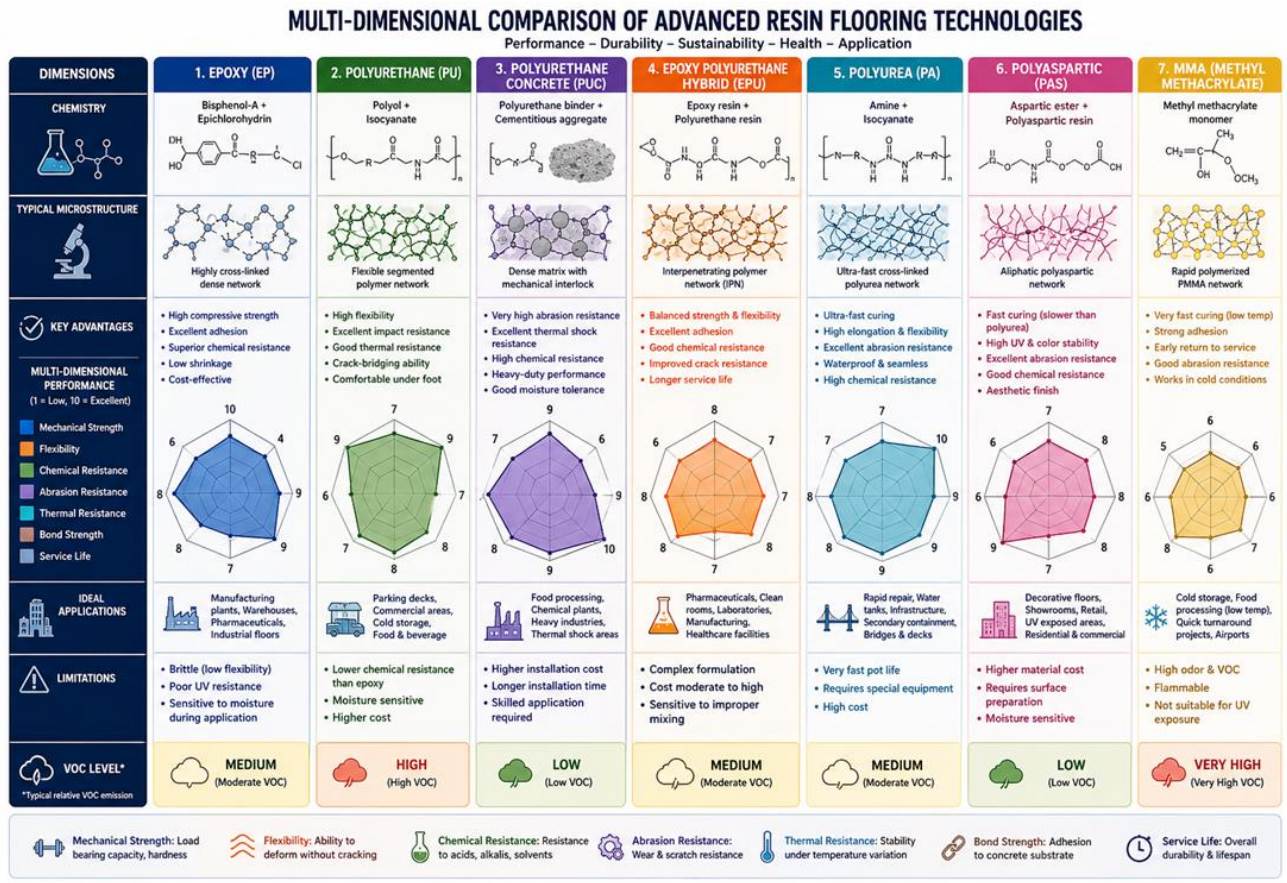


Figure 2.1. Multi-dimensional comparison of advanced resin flooring technologies based on chemistry, microstructure, key advantages, performance dimensions, ideal applications, limitations and relative VOC level.

The multi-dimensional comparison shows that each resin flooring technology has a distinct performance profile based on its chemistry, polymer network structure and application behaviour. Epoxy flooring provides high compressive strength, excellent adhesion and cost-effective performance, but it is relatively brittle and has lower UV resistance. PU flooring offers higher flexibility, impact resistance and comfort underfoot. PU Concrete provides superior abrasion resistance, thermal shock resistance, moisture tolerance and heavy-duty performance, making it highly suitable for food-processing, chemical plants, wet-process industries and industrial floors.

EPU systems combine the adhesion and chemical resistance of Epoxy with the flexibility of PU, making them useful in pharmaceutical, healthcare and cleanroom environments. Polyurea provides ultra-fast curing, waterproofing, high elongation and excellent abrasion resistance. Polyaspartic flooring offers fast curing, UV colour stability, low VOC potential, and a good aesthetic finish. MMA flooring provides very fast curing even at low temperatures, but its high odour and VOC level limit its suitability in enclosed or sensitive environments.

This comparison demonstrates that no single flooring system is universally superior. Selection must depend on project-specific requirements such as mechanical loading, chemical exposure, thermal shock, moisture conditions, hygiene requirements, installation time, VOC sensitivity, lifecycle cost, and stakeholder adoption readiness.

The figure supports the central argument of this study by showing that resin flooring selection cannot be based on a single performance parameter. Epoxy may perform well in compressive strength and cost-efficiency, while PU Concrete performs well in wet-process and thermal-shock environments. Polyurea and Polyaspartic systems offer rapid curing and faster return-to-service, whereas Novolac Epoxy and Vinyl Ester are more suitable for aggressive chemical exposure. MMA provides rapid curing but carries higher odour and VOC-related concerns. Therefore, the figure justifies the need for a weighted multi-index model such as SCCAF–WRI–SEM, in which each flooring system is evaluated according to technical, environmental, economic, and adoption-related criteria rather than by general product reputation.

2.3 Chemical Degradation Mechanisms and Durability Behaviour

The long-term durability of resin flooring systems is influenced by chemical degradation mechanisms arising from exposure to acids, alkalis, solvents, moisture and aggressive industrial contaminants. Acid attack may cause hydrolysis of ester and urethane bonds, resulting in polymer chain scission, embrittlement and reduced mechanical integrity (Pascault et al., 2002; Gong et al., 2021). Alkali exposure can induce saponification reactions and hydrolytic degradation, leading to swelling, softening and loss of adhesion.

Solvent exposure results in diffusion-driven swelling, plasticisation and reductions in tensile and adhesive strength due to penetration of solvent molecules into polymer networks (Pritchard, 1999; Salthammer et al., 2021). Degradation severity is governed by cross-link density, polymer backbone stability, permeability, curing efficiency and nano-filler incorporation. Novolac Epoxy generally provides superior chemical durability due to dense aromatic structure and reduced hydrolysable bonds, whereas conventional PU and MMA systems may be more vulnerable under aggressive exposure conditions (FeRFA, 2016; Gong et al., 2021).

Chemical resistance is critical for flooring systems in chemical plants, pharmaceutical industries, wastewater treatment facilities, food-processing units and heavy manufacturing environments. However, chemical resistance is often reported qualitatively in product literature. This creates the need for CRI, which can convert exposure to acids, alkalis, solvents, oils, disinfectants and cleaning chemicals into a structured chemical-suitability score.

Figure 2.2. Conceptual chemical attack mechanisms on resin flooring systems under acid, alkali and solvent exposure.

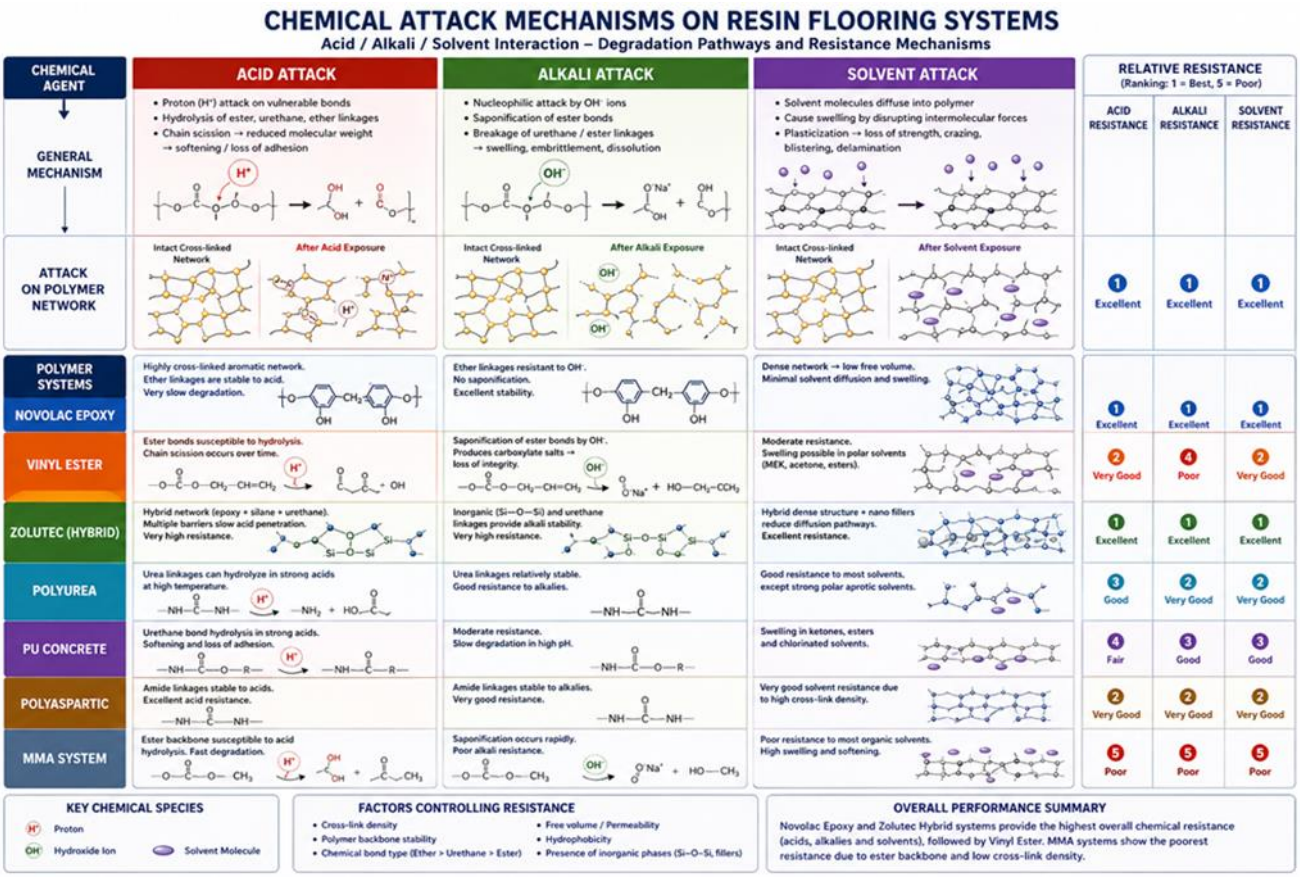


Figure 2.2 illustrates the major degradation pathways affecting resin flooring systems when exposed to acidic, alkaline and solvent-based industrial environments. Acid exposure may cause proton-driven bond cleavage, hydrolysis and polymer-chain degradation, particularly in resin systems containing hydrolysable ester or urethane linkages. Alkali exposure may trigger hydroxide-driven hydrolysis or saponification reactions, leading to softening, swelling and reduction in adhesive integrity. Solvent exposure may cause diffusion-driven swelling, plasticisation and loss of cohesive strength due to penetration of solvent molecules into the polymer network.

The figure also compares the relative resistance behaviour of different resin flooring systems, including Novolac Epoxy, Vinyl Ester, Epoxy, PU Concrete, Polyurea, Polyaspartic and MMA. Systems with higher cross-link density and chemically stable polymer backbones generally show better resistance under aggressive exposure. However, final chemical suitability must be verified using product-specific TDS/SDS documents, chemical-resistance charts, exposure concentration, temperature, contact duration, cleaning frequency, curing quality and actual project service conditions.

2.4 Environmental Sustainability, VOC Emissions and Indoor Air Quality

Environmental sustainability and indoor air quality have become critical considerations in flooring selection due to sustainable infrastructure, occupational health and green building development (UNEP, 2022; IEA, 2023; World Green Building Council, 2023). Conventional solvent-based Epoxy, PU, Vinyl Ester and MMA systems may emit volatile organic compounds, residual monomers, curing agents and solvents during

installation and early service life, contributing to indoor air pollution and health risks (Wolkoff, 2020; Salthammer et al., 2021; EPA, 2025).

VOC emissions can affect indoor environmental quality in pharmaceutical plants, hospitals, warehouses, laboratories, cleanrooms, data centres, educational institutions and office buildings with inadequate ventilation (WHO, 2021; EPA, 2025). Prolonged exposure may contribute to respiratory irritation, headaches, dizziness, mucosal irritation, allergic reactions, skin sensitisation and occupational health concerns among applicators, workers and occupants (Salthammer et al., 2021; WHO, 2021; EPA, 2025).

Green building systems such as LEED, WELL and BREEAM increasingly emphasise low-emission construction materials and healthy indoor environments (USGBC, 2024; World Green Building Council, 2023). Despite this, many flooring selection methods still prioritise engineering and cost parameters while treating VOC and health impacts as secondary considerations. This establishes the need for VHIS, which integrates VOCs, odour, indoor air quality, applicator exposure and occupant health into flooring selection.

2.5 Lifecycle Cost, Maintenance and Sustainability Performance

Resin flooring systems are frequently selected based on initial installation cost, even though long-term value depends on service life, maintenance frequency, repair cost, downtime, cleaning requirement and replacement cycle. A lower-cost flooring system may become more expensive over its lifecycle if it fails early, requires frequent repairs, causes production shutdowns or increases cleaning and maintenance burdens (Dixit et al., 2019; UNEP, 2022; IEA, 2023).

Sustainability in flooring should not be limited to low VOC or recycled content alone. A low-VOC system that fails prematurely may increase repair waste, replacement material, labour, downtime and environmental burden. Similarly, a highly durable system with high emissions may create indoor environmental quality concerns. This creates the need for CPI and SPTI. CPI links technical performance with lifecycle cost efficiency, while SPTI balances durability, VOC-health impact, service-life extension, repair reduction and environmental responsibility (World Green Building Council, 2023; USGBC, 2024).

2.6 Behavioural Adoption and Technology Acceptance Theories

Adoption of sustainable construction materials is influenced not only by engineering performance but also by behavioural, institutional, organisational and economic factors (Ajzen, 1991; Rogers, 2003; Venkatesh et al., 2012). In industrial construction environments, flooring decisions are affected by stakeholder perception, risk aversion, cost sensitivity, regulatory compliance, product awareness, organisational culture and long-term operational expectations.

The Theory of Planned Behaviour explains adoption behaviour through attitude, subjective norms and perceived behavioural control (Ajzen, 1991). UTAUT2 extends adoption understanding through performance expectancy, effort expectancy, social influence and facilitating conditions (Venkatesh et al., 2012). Diffusion of Innovation explains adoption through relative advantage, compatibility, complexity, trialability and observability (Rogers, 2003). Institutional Theory highlights regulatory, normative and coercive pressures

influencing organisational decisions (Scott, 2014), while Norm Activation Theory explains pro-environmental behaviour through awareness, moral obligation and personal responsibility (Schwartz, 1977).

Despite the relevance of these theories, their application within resin flooring research remains limited. Existing flooring studies predominantly focus on engineering and material science while neglecting behavioural adoption dynamics. This establishes the need for SEM and BAI. SEM statistically validates adoption relationships, while BAI converts stakeholder perception, adoption intention and behavioural readiness into a measurable adoption-readiness score.

A major limitation in existing sustainable construction material adoption research is that behavioural models often remain disconnected from technical material performance. Stakeholders may show positive environmental attitudes, but adoption may still fail if the product lacks proven durability, applicator availability, cost justification or field performance confidence. Therefore, integrating SEM-based behavioural adoption with WRI-based technical scoring provides a more realistic model of resin flooring selection.

2.7 Artificial Intelligence and Multi-Criteria Decision-Making Approaches

Recent advancements in artificial intelligence, machine learning and multi-criteria decision-making have influenced construction engineering, material optimisation and infrastructure management research (Lu et al., 2020; García de Soto et al., 2020; Zhou et al., 2022). Methods such as AHP, TOPSIS, entropy weighting, fuzzy logic and neural-network-assisted optimisation enable comparative ranking of alternative materials under varying project priorities and operating conditions.

AI-driven optimisation frameworks specifically developed for resin flooring systems remain limited. Existing models rarely integrate engineering performance, chemical durability, behavioural adoption, environmental sustainability, lifecycle cost and indoor air quality assessment. Therefore, the present study is positioned as AI-ready: it develops structured indices and decision logic that can later support project-specific digital recommendation systems, without over claiming a trained AI model at this stage.

2.8 Integrated Indices Required by the Research Gap

The literature demonstrates that resin flooring selection cannot be adequately addressed through isolated technical properties, qualitative sustainability statements or behavioural theory alone. Each major research gap corresponds to a measurable decision need, as summarised in Table 2.2.

Table 2.2. Research gaps and required indices for integrated resin flooring selection.

Research Gap	Why Existing Approach Is Insufficient	Required Index / Model	Purpose
Overall flooring suitability is not measured through a unified score	Selection is often based on product type, brand, cost or isolated properties	WRI	Provides a normalised field-validatable score
Mechanical performance data are fragmented	Strength, abrasion, adhesion and service-life values are difficult to compare together	RPI	Combines mechanical and durability performance
Chemical resistance is often qualitative	Acid, alkali, solvent and cleaning exposure are not systematically scored	CRI	Quantifies chemical exposure suitability
VOC and health impact are weakly integrated	VOC is often discussed qualitatively rather than used in selection scoring	VHIS	Measures VOC, odour, indoor air quality and exposure risk
Lifecycle cost is reduced to the initial cost	Maintenance, downtime and service life are often ignored	CPI	Links performance with lifecycle cost efficiency
Sustainability is treated separately from performance	Low VOC, durability and service life are not balanced together	SPTI	Balances sustainability and engineering performance
Stakeholder adoption readiness is not quantified	Cost sensitivity, product knowledge and trust are ignored	BAI	Converts adoption readiness into a measurable score
Adoption drivers are not statistically validated	Latent constructs influencing adoption are not tested together	SEM	Validates model fit, path coefficients and explanatory power
Digital flooring selection is underdeveloped	AI models rarely include VOC, behaviour, field QA/QC and lifecycle logic	AI-ready optimisation	Supports future project-specific recommendation logic

2.9 Critical Synthesis and Research Gap

Existing studies have advanced the understanding of resin flooring systems in terms of mechanical durability, chemical resistance, polymer engineering, sustainability assessment and lifecycle performance (Pacheco-Torgal et al., 2021; Gong et al., 2021). Behavioural adoption theories have contributed to understanding technology acceptance and sustainable material adoption in construction and infrastructure systems (Ajzen,

1991; Venkatesh et al., 2012; Scott, 2014). In parallel, AI and multi-criteria decision-making approaches have improved engineering optimisation and construction material selection methodologies (Lu et al., 2020; Zhou et al., 2022).

Despite these advancements, existing research remains fragmented across disciplinary boundaries. Engineering studies evaluate resin flooring systems primarily based on isolated indicators such as compressive strength, adhesion, abrasion resistance or chemical durability, without integrating VOC-health impacts, lifecycle economics or behavioural adoption. Conversely, behavioural adoption studies focus on organisational and psychological determinants while neglecting engineering performance optimisation and material science considerations.

The key research gap is the absence of an integrated framework capable of simultaneously addressing engineering performance, chemical durability, VOC-health impact, indoor environmental quality, lifecycle cost efficiency, behavioural adoption and future-ready optimisation. Another limitation is the inadequate representation of hybrid systems such as PU Concrete, EPU and Nano-modified resin systems in intelligent decision-making models.

2.10 Research Positioning and Conceptual Advancement

To address the limitations identified in the literature, this study positions SCCAF–WRI–SEM as a unified resin flooring selection framework. The framework integrates behavioural modelling, engineering performance evaluation, VOC-health sustainability assessment and lifecycle cost logic into one decision-support structure.

The proposed framework combines WRI for field-validatable flooring suitability, RPI for engineering performance evaluation, CRI for chemical durability assessment, VHIS for environmental-health and indoor air quality assessment, CPI for lifecycle cost-efficiency analysis, SPTI for sustainability-performance balance, SEM for behavioural adoption evaluation and BAI for adoption-readiness scoring. AI is positioned as a future optimisation pathway once sufficient verified project datasets are available.

2.11 Need for the Study

Despite significant advancements in resin flooring technologies, flooring selection practices remain fragmented and predominantly dependent on empirical judgement, vendor recommendations or cost-driven approaches. Existing methodologies rarely integrate engineering performance, chemical durability, environmental sustainability, indoor air quality, lifecycle cost efficiency and behavioural adoption dynamics into a unified analytical framework.

The proposed study is needed because modern infrastructure requires flooring systems that are technically reliable, environmentally responsible, economically feasible and behaviourally adoptable. The increasing emphasis on sustainable infrastructure, occupational health, indoor environmental quality and ESG-oriented construction has heightened the importance of low-VOC and high-performance flooring technologies (UNEP, 2022; IEA, 2023; USGBC, 2024).

2.12 Literature Review Summary

Table 2.3. Summary of literature streams, remaining gaps and study response.

Literature Stream	Key Contribution	Remaining Gap	Study Response
Market and industry studies	Show rapid growth of resin flooring demand	Do not provide a technical selection framework	Develops SCCAF–WRI for application-specific selection
Material science studies	Explain mechanical, adhesion and durability behaviour	Often evaluate isolated parameters	Develops RPI and WRI
Chemical durability studies	Explain degradation under acids, alkalis and solvents	Chemical suitability often remains qualitative	Develops CRI
VOC and indoor air quality studies	Highlight health and environmental concerns	VOC impact is not integrated into flooring optimisation	Develops VHIS
Lifecycle and sustainability studies	Emphasise service life and environmental responsibility	Cost, durability and sustainability are not integrated	Develops CPI and SPTI
Behavioural adoption theories	Explain adoption intention and behaviour	Rarely connected with engineering flooring selection	Uses SEM and BAI
AI and MCDM studies	Support optimisation and ranking	Rarely include VOC, behaviour and field QA/QC	Develops AI-ready integrated framework

2.13 Final Literature Review Conclusion

The reviewed literature confirms that resin flooring selection is a multidimensional problem requiring integration of engineering performance, chemical resistance, VOC-health impact, lifecycle cost, sustainability, behavioural adoption and future-ready optimisation. Existing research has advanced each area separately, but lacks a unified index-based framework that can translate them into a practical, field-validatable decision model.

Therefore, the present study addresses a clear academic and industrial gap by developing the SCCAF–WRI–SEM framework. The integration of WRI, RPI, CRI, VHIS, CPI, SPTI, BAI and SEM makes the study original, practical and future-ready. It enables resin flooring selection to move from subjective, cost-led and

product-led decision-making toward transparent, evidence-based, sustainability-oriented and stakeholder-aligned decision support.

Based on the identified gaps, the next section develops the SCCAF–WRI–SEM methodology by defining the index structure, normalisation logic, weighting system, VOC-health correction procedure, SEM-based behavioural adoption pathway and final integrated flooring score. This ensures that the literature review directly leads into a measurable and reviewer-verifiable decision-support model.

3. Methodology

3.1 Research Design

This study adopts a quantitative, interdisciplinary, and multi-stage research design to develop and validate a decision-support framework for the intelligent selection of resin flooring systems. The methodology integrates behavioural adoption modelling, engineering performance assessment, sustainability evaluation, lifecycle cost analysis, and AI-ready multi-objective optimisation within the proposed Sustainable Construction Chemicals Adoption Framework (SCCAF).

The research design is structured to address the central limitation in existing flooring selection practices: the absence of an integrated model that simultaneously evaluates technical performance, chemical durability, VOC-health impact, cost efficiency, stakeholder adoption behaviour, and intelligent optimisation. Therefore, the study combines both human decision-making variables and material performance variables into a unified analytical framework.

The methodology follows six sequential stages:

1. Literature review and research gap identification

2. Development of the behavioural adoption framework

3. Survey design, sampling, and data collection

4. SEM-based behavioural model validation

5. Engineering and sustainability index development

6. AI-ready multi-objective optimisation and flooring system ranking

This integrated approach enables the study to evaluate not only which resin flooring system performs best technically, but also which system is most likely to be adopted in real industrial and commercial construction environments.

3.2 Methodological Framework

The proposed methodology integrates three analytical layers: behavioural adoption, engineering and sustainability assessment, and AI-ready optimisation.

3.2.1 Behavioural Adoption Layer

The behavioural layer evaluates stakeholder perceptions and adoption intentions using constructs derived from established behavioural and institutional theories, including the Theory of Planned Behaviour, UTAUT2, Diffusion of Innovations Theory, Institutional Theory and Norm Activation Theory (Ajzen, 1991; Rogers, 2003; Venkatesh et al., 2012; Scott, 2014; Schwartz, 1977).

This layer explains how stakeholder attitude, product knowledge, regulatory pressure, environmental concern, performance expectancy, social influence, and cost sensitivity influence the adoption of sustainable resin flooring systems.

3.2.2 Engineering and Sustainability Layer

The engineering layer evaluates resin flooring systems using quantitative performance and sustainability indices, including the Resin Performance Index, Chemical Resistance Index, VOC–Health Impact Score, Cost Performance Index, and Sustainability–Performance Trade-off Index.

3.2.3 AI-Ready Optimisation Layer

The optimisation layer develops an AI-ready multi-objective decision-support structure that can later be converted into a digital or machine-learning-based flooring recommendation tool when sufficient verified project datasets become available. In the present study, optimisation is performed through transparent weighted scoring rather than a trained artificial intelligence model. The model ranks flooring alternatives by maximising performance, chemical resistance, lifecycle value, sustainability and adoption readiness while minimising VOC-health risk through the corrected VHIC score.

3.3 Research Workflow

The research workflow was developed as a sequential decision-making process.

Stage 1: Literature Review and Research Gap Identification

A structured literature review was conducted to examine previous studies on resin flooring systems, polymer flooring performance, chemical resistance, VOC emissions, lifecycle cost, green building materials, behavioural adoption theories, and AI-ready material selection models.

Stage 2: Behavioural Framework Development

Behavioural constructs were selected and mapped to relevant theoretical foundations to evaluate stakeholders' adoption intentions for sustainable resin flooring systems.

Stage 3: Survey Design and Data Collection

A structured questionnaire was developed using validated constructs from behavioural adoption theories. Responses were collected from stakeholders involved in industrial and commercial flooring projects.

Stage 4: SEM-Based Behavioural Analysis

Structural Equation Modelling was applied to validate the measurement model, test hypotheses, and evaluate the influence of behavioural constructs on adoption intention.

Stage 5: Engineering Index Development

Engineering and sustainability indices were developed to quantify the comparative performance of resin flooring systems.

Stage 6: AI-Ready Optimisation

The final stage involved multi-objective optimisation to rank resin flooring systems based on performance, VOC-health impact, and lifecycle cost efficiency.

3.4 Sampling and Data Collection

A structured quantitative survey was conducted among 350 stakeholders involved in the selection, specification, execution, and maintenance of industrial and commercial flooring.

- Contractors
- Consultants
- Architects
- Civil engineers
- Project managers
- Facility managers
- Flooring applicators
- Construction professionals
- Industrial end-users

A purposive sampling technique was adopted because the study required respondents with practical knowledge of resin flooring systems, construction chemicals, industrial flooring requirements, and sustainable material selection.

The questionnaire used a five-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

3.4.1 Sample-Size Justification

A sample size of 350 respondents was considered adequate for SEM because it exceeds commonly recommended minimum thresholds for models involving multiple latent constructs and observed indicators (Kline, 2016; Hair et al., 2019). The sample also provides sufficient stakeholder diversity by including contractors, consultants, architects, engineers, project managers, facility managers, applicators, construction professionals and industrial end-users. Therefore, the sample size supports reliable measurement-model validation and structural path analysis.

3.5 Questionnaire Design

The questionnaire was developed in alignment with the theoretical constructs used in the SCCAF framework. Each construct was measured using multiple items to improve reliability and validity.

Construct	Theoretical Basis	Measurement Focus
Attitude	Theory of Planned Behaviour	Positive or negative perception toward sustainable flooring
Perceived Behavioural Control	Theory of Planned Behaviour	Ease or difficulty of adopting advanced flooring systems
Performance Expectancy	UTAUT2	Expected improvement in durability, safety, and lifecycle performance
Social Influence	UTAUT2	Influence of consultants, clients, peers, and industry norms
Relative Advantage	Diffusion of Innovation	Perceived superiority over conventional flooring systems
Compatibility	Diffusion of Innovation	Fit with existing project requirements and construction practices
Product Knowledge	DOI / UTAUT2	Awareness of technical and sustainability benefits
Regulatory Pressure	Institutional Theory	Influence of codes, green building norms, and compliance requirements
Environmental Concern	Norm Activation Theory	Awareness of VOC impact, indoor air quality, and sustainability
Cost Sensitivity	Economic Behaviour	Perceived barrier due to initial cost and budget limitations
Adoption Intention	Behavioural Outcome	Willingness to specify, recommend, or adopt sustainable flooring

3.5.1 Sample Questionnaire Items

Construct	Sample Questionnaire Item
Attitude	I believe sustainable resin flooring improves long-term project value.
Performance Expectancy	Sustainable resin flooring improves durability, safety and service life.
Regulatory Pressure	Green building norms influence my flooring selection decisions.
Environmental Concern	VOC emissions from flooring systems affect indoor air quality and worker health.
Cost Sensitivity	Higher initial cost reduces my willingness to adopt sustainable flooring systems.
Adoption Intention	I am willing to recommend or specify sustainable resin flooring in future projects.

3.6 Behavioural Framework Development

The behavioural framework was developed to explain how stakeholders form adoption intention toward sustainable resin flooring systems. The model assumes that adoption is not determined solely by technical performance, but by the interaction among performance perception, environmental awareness, regulatory pressure, product knowledge, and economic feasibility.

• The Theory of Planned Behaviour evaluates attitude, subjective influence, and perceived behavioural control.

• UTAUT2 evaluates performance expectancy, effort expectancy, facilitating conditions, and social influence.

• Diffusion of Innovation evaluates relative advantage, compatibility, complexity, trialability, and observability.

• Institutional Theory assesses regulatory pressure, green building certification, consultant specifications, client requirements, and environmental compliance.

• Norm Activation Theory evaluates environmental concern, moral responsibility, and awareness of VOC-related health impacts.

3.7 Structural Equation Modelling Procedure

Structural Equation Modelling was used to validate the behavioural component of the SCCAF framework. SEM was selected because it allows simultaneous analysis of multiple latent constructs, observed variables, mediating effects, moderating effects and structural relationships while accounting for measurement error (Kline, 2016; Hair et al., 2019).

1. Measurement model specification

2. Confirmatory Factor Analysis

3. Reliability and validity testing

4. Structural path analysis and hypothesis testing

The SEM model included independent, mediating, and moderating variables, as well as a dependent variable.

Variable Category	Variables
Independent Variables	Attitude; Performance expectancy; Social influence; Environmental concern; Regulatory pressure; Product knowledge; Relative advantage
Mediating Variables	Cost sensitivity; Supply chain availability; Perceived implementation feasibility
Moderating Variables	Product knowledge; Trust in supplier or manufacturer; Technical support availability; Application complexity
Dependent Variable	Actual adoption behaviour, including selection, specification, continued use, recommendation, and long-term implementation

3.8 Measurement Model Validation

The measurement model was validated using reliability and validity tests, including Cronbach's alpha, Composite Reliability, factor loadings, Average Variance Extracted and HTMT ratio, following commonly accepted SEM validation thresholds (Fornell & Larcker, 1981; Henseler et al., 2015; Hair et al., 2019).

Fit Index	Recommended Value	Interpretation
CFI	≥ 0.90	Good fit
TLI	≥ 0.90	Good fit
RMSEA	≤ 0.08	Good fit
χ^2/df	≤ 3.00	Acceptable fit

The reported SEM fit values are presented as demonstration values for showing the required reporting structure. In final empirical submission, these values should be replaced with actual SEM output generated from the cleaned survey dataset.

3.9 Hypothesis Testing

Hypothesis testing was conducted through structural path analysis. The SEM results indicated that attitude, regulatory pressure, relative advantage, performance expectancy, product knowledge, and environmental concern were positive predictors of sustainable flooring adoption. Cost sensitivity showed a negative influence on adoption intention, indicating that higher perceived cost remains a major barrier to adoption.

3.10 Engineering Performance Evaluation

To evaluate resin flooring systems quantitatively, engineering performance indices were developed. The selected parameters represent the most important performance requirements in industrial and commercial flooring applications.

Parameter	Unit	Performance Meaning
Compressive strength	MPa	Load-bearing and structural durability
Tensile strength	MPa	Resistance to tensile stress
Flexural strength	MPa	Resistance to bending stress
Adhesion strength	MPa	Bond strength with concrete substrate
Abrasion resistance	mg loss	Resistance to surface wear
Shore hardness	Scale value	Surface hardness and indentation resistance
Elongation	%	Flexibility and crack-bridging ability
Thermal resistance	°C	Resistance to heat and thermal shock
Chemical resistance	Rating score	Resistance to acids, alkalis, solvents, and oils
VOC emission	g/L or mg/m³	Indoor air quality and health impact
Lifecycle cost	₹/m²	Economic efficiency over service life

3.11 Data Classification and Validation Basis

The SCCAF–WRI–SEM integrated multi-index framework uses different data categories for engineering comparison, field validation, behavioural modelling, and decision-support calculations. Since resin flooring performance depends on formulation, substrate condition, application thickness, curing environment, surface preparation and workmanship, the source and validation strength of each data category must be clearly identified before numerical index calculation.

Table 3.11 classifies the data sources used in the framework and explains their role in reviewer-safe interpretation.

Data Category	Source Type	Used For	Validation Strength	Reviewer-Safe Interpretation
Manufacturer TDS Data	Product technical data sheets	Compressive strength, tensile strength, flexural strength, adhesion, Shore hardness, VOC	High	Should be used for final product-specific selection
Standard Test Data	ASTM, ISO, EN test methods	Pull-off adhesion, abrasion, impact, VOC emission, chemical resistance	Very High	Best basis for laboratory validation
Field QA/QC Data	Site testing and inspection	CSP, moisture, dew-point margin, pull-off strength, failure mode	Very High	Best basis for project-specific WRI validation
Harmonised Representative Dataset	Literature, TDS ranges and industry benchmarks	Demonstration of RPI, CRI, VHIS, CPI and AI model	Medium	Suitable for model demonstration, not universal ranking
Expert Judgement	Consultants, applicators, facility managers	Practical suitability, maintenance, downtime, adoption barriers	Medium	Useful when combined with SEM and field validation
SEM Survey Data	Stakeholder questionnaire	BAI and adoption intention	High if statistically validated	Requires reliability, validity and model-fit reporting

3.12 Distinction Between Field Data and Representative Dataset

This study uses two categories of data. First, actual field QA/QC data were used to demonstrate the WRI procedure for a polyurethane concrete flooring system in a food-industry application. These field data include Concrete Surface Profile, substrate condition, dew-point margin, pull-off adhesion strength, failure mode and application-related observations. Second, a harmonised representative dataset was developed to demonstrate comparative multi-system evaluation across Epoxy, Polyurethane, PU Concrete, EPU, Polyurea, Polyaspartic, MMA, Novolac Epoxy and Vinyl Ester flooring systems.

The representative dataset was prepared using literature-supported engineering judgement, manufacturer technical datasheet ranges, typical industry performance values and normalised comparative assumptions. Therefore, the multi-system ranking should not be interpreted as a universal product ranking or as direct field-tested performance for all systems. Instead, it demonstrates how the SCCAF–WRI–SEM framework can be applied for project-specific decision support. For actual project specification, all index values must be recalculated using manufacturer-specific technical data sheets, laboratory test results, VOC declarations, chemical resistance charts, field QA/QC records, lifecycle cost data and stakeholder adoption inputs.

3.13 Dataset Interpretation Statement

The numerical dataset used in this study is a harmonised representative dataset developed for model demonstration and comparative decision-support purposes. It should not be interpreted as a universal product ranking. For project-level specification, the values must be replaced with manufacturer-specific TDS data, laboratory test results, field QA/QC records and approved project specifications. This is necessary because engineering values may vary depending on resin formulation, substrate condition, application thickness, curing environment, surface preparation quality, workmanship, exposure severity and maintenance practices.

3.14 Data Normalisation

The use of min–max normalisation and weighted aggregation is consistent with multi-criteria decision-making approaches used for engineering material selection and sustainability assessment (Saaty, 1980; Hwang & Yoon, 1981; Triantaphyllou, 2000). For positive performance indicators, where higher values indicate better performance, the normalised score is calculated as:

$$P_i = (X_i - Xmin) / (Xmax - Xmin)$$

For negative indicators, where lower values indicate better performance, the normalised score is calculated as:

$$P_i = (Xmax - X_i) / (Xmax - Xmin)$$

Where:

Symbol	Meaning
P_i	Normalised score between 0 and 1
X_i	Actual value of the flooring system
Xmin	Minimum benchmark value
Xmax	Maximum benchmark value

Positive indicators include compressive strength, tensile strength, flexural strength, adhesion strength, Shore hardness and service life. Negative indicators include abrasion loss, VOC impact, toxicity, odour intensity, exposure risk and normalised lifecycle cost.

3.15 Resin Performance Index

The Resin Performance Index was developed to combine multiple engineering performance parameters into a single comparative score.

$$\mathbf{RPI = \Sigma(wi \times Pi),}$$

subject to $\Sigma wi = 1$.

Where RPI is the Resin Performance Index, wi is the weight assigned to the ith performance parameter, Pi is the normalised score of the ith parameter, and n is the total number of engineering parameters. A higher RPI indicates superior overall engineering performance.

3.16 Chemical Resistance Index

The Chemical Resistance Index was developed to evaluate durability under aggressive industrial chemical exposure.

$$\mathbf{CRI = waA + wbB + wcC + woO,}$$

subject to wa + wb + wc + wo = 1.

Where A is acid resistance, B is alkali resistance, C is solvent resistance, O is oil and hydrocarbon resistance, and wa, wb, wc, and wo are weighting coefficients. A higher CRI indicates stronger resistance to chemical degradation.

3.17 VOC–Health Impact Score and Corrected VOC Score

The VOC–Health Impact Score was developed to quantify the environmental and occupational health impact of resin flooring systems.

$$\mathbf{VHIS = \Sigma(\alpha j \times Vj), \text{ subject to } \Sigma \alpha j = 1.}$$

The VHIS considers VOC content, odour intensity, exposure duration, toxicity weighting, ventilation sensitivity, applicator exposure risk, occupant exposure risk, and indoor air quality impact.

Exposure impact was calculated as E = C × t, where C is VOC concentration and t is exposure duration. Toxicity-adjusted VOC impact was calculated as Vj = E × T, where T is the toxicity weighting factor. A lower VHIS indicates lower environmental and health impact.

Because VOC-health impact is a negative indicator, the normalised VOC–Health Impact Score was converted into a positive corrected score before final weighted aggregation:

$$\mathbf{VHIC = 1 - VHIS_n}$$

Where $VHIS_n$ is the normalised VOC–Health Impact Score and VHIC is the VOC–Health Impact Corrected Score. A higher VHIC indicates lower VOC-health risk and better suitability for indoor, occupied or sensitive environments. VOC-health impact scoring is aligned with indoor air quality and occupational exposure concerns reported in environmental health and green building literature (WHO, 2021; EPA, 2023; USGBC, 2024; International WELL Building Institute, 2024).

3.18 Cost Performance Index

The Cost Performance Index was developed to evaluate lifecycle cost efficiency.

$$\mathbf{CPI = RPI / C^*,}$$

where C* = Ci / Cmax.

Where Ci is the lifecycle cost of flooring system i and Cmax is the maximum lifecycle cost among compared systems. A higher CPI indicates better performance per unit lifecycle cost.

3.19 Sustainability–Performance Trade-off Index

To evaluate the balance between technical performance and environmental-health impact, the Sustainability–Performance Trade-off Index was developed.

$$\mathbf{SPTI = \lambda_1 RPI + \lambda_2 VHIC + \lambda_3 SLI,}$$

subject to $\lambda_1 + \lambda_2 + \lambda_3 = 1$.

Where RPI is the Resin Performance Index, VHIC is the VOC–Health Impact Corrected Score and SLI is the Service-Life Index. A higher SPTI indicates a better balance between high technical performance, lower VOC-health risk and longer service life. This weighted formulation avoids mathematical distortion caused by dividing RPI by VHIS.

3.20 Weight Allocation Strategy

Weighting coefficients were assigned based on engineering significance, industrial relevance, sustainability importance, and literature-supported performance priorities.

• Importance of the parameter in industrial flooring performance

• Frequency of failure associated with the parameter

• Impact on lifecycle durability

• Influence on occupational safety

• Relevance to sustainability and indoor air quality

• Applicability across industrial and commercial flooring environments

The weighting system can be adjusted depending on project type. For example, chemical resistance may carry greater weight in chemical plants, while VOC impact may carry greater weight in hospitals and food processing units.

3.23 AI-Ready Multi-Objective Optimisation Procedure

An AI-ready multi-objective optimisation model was developed to identify the most suitable resin flooring system under varying project requirements.

$$\mathbf{F(x) = \beta 1 RPI - \beta 2 VHIS - \beta 3 C^*,}$$

subject to $\beta 1 + \beta 2 + \beta 3 = 1$.

Where F(x) is the final optimisation score for flooring system x, RPI is the Resin Performance Index, VHIS is the VOC–Health Impact Score, C* is normalised lifecycle cost, β1 is the weight assigned to engineering performance, β2 is the penalty weight assigned to VOC-health impact, and β3 is the penalty weight assigned to lifecycle cost.

The optimal flooring system is selected as: Optimal System = arg max F(x).

3.21 Scenario-Based Optimisation

Scenario	Priority	Suggested Weighting Logic
Heavy industrial flooring	Mechanical durability and chemical resistance	Higher RPI and CRI weight
Pharmaceutical flooring	Hygiene, VOC control, chemical resistance	Higher VHIS and CRI weight
Food processing flooring	Thermal shock, hygiene, cleanability	Higher CRI and RPI weight
Warehouse flooring	Abrasion resistance and cost efficiency	Higher RPI and CPI weight
Hospital flooring	Low VOC and indoor air quality	Higher VHIS penalty weight
Chemical plant flooring	Acid, alkali, and solvent resistance	Higher CRI weight
Car park flooring	Abrasion, UV, flexibility, crack bridging	Higher RPI and flexibility weight

3.22 Flooring Systems Evaluated

Flooring System	Key Performance Characteristic
Epoxy	High compressive strength and adhesion
Polyurethane	Flexibility and thermal resistance
Polyurethane Concrete	Thermal shock resistance and heavy-duty durability
Epoxy–Polyurethane Hybrid	Balanced strength and flexibility
Polyurea	Fast curing, high elongation, and abrasion resistance
Polyaspartic	UV stability and rapid return-to-service
MMA	Very fast curing but higher VOC/odour concern
Novolac Epoxy	Strong chemical resistance
Vinyl Ester	Superior acid and solvent resistance
Nano-enhanced systems	Improved permeability, abrasion, and durability

3.23 AI-Ready Multi-Objective Optimisation Procedure

Figure 3.1. AI-ready multi-objective optimisation flowchart for resin flooring selection.

The figure illustrates the proposed optimisation procedure used to select the most suitable resin flooring system based on project requirements, mandatory constraints, multi-index calculation, project-specific weights, final optimisation score, ranking and recommendation. The model filters non-compliant systems, normalises engineering and behavioural indices, applies scenario-specific weights and ranks technically compliant flooring alternatives using the SCCAF–WRI–SEM decision framework.

3.23.1 Explanation of the Optimisation Procedure

The AI-ready multi-objective optimisation procedure converts project-specific flooring requirements into a transparent and weighted decision-support model. The process begins by identifying project requirements such as exposure conditions, mechanical loading, performance requirements, VOC and health constraints,

budget limitations and time or downtime restrictions. These inputs define the technical and operational boundary conditions for flooring selection.

In the second stage, mandatory constraints are applied to remove flooring systems that do not satisfy minimum project requirements. These constraints may include minimum adhesion strength, VOC compliance, chemical resistance requirement, minimum thickness, curing time or downtime limits and other project-specific criteria. This filtering step ensures that only technically compliant systems proceed to the scoring and optimisation stage.

In the third stage, multiple indices are calculated for all compliant flooring systems. These include the Resin Performance Index (RPI), Chemical Resistance Index (CRI), Cost Performance Index (CPI), Sustainability Performance Trade-off Index (SPTI), Behavioural Adoption Index (BAI) and VOC–Health Impact Score (VHIS). Positive indicators are treated as higher-is-better, while negative indicators such as VOC or health penalty are treated as lower-is-better. All indices are normalised to a 0–1 scale to allow fair comparison and aggregation.

In the fourth stage, project-specific weights are assigned to each index. These weights reflect the relative importance of mechanical performance, chemical resistance, lifecycle cost, sustainability, adoption readiness and VOC-health impact for a given application scenario. The sum of all weights is maintained as one, ensuring mathematical consistency and transparent weighting logic.

The final optimisation score is calculated by aggregating the weighted indices. Positive indices such as RPI, CRI, CPI, SPTI and BAI increase the final score, while VHIS is treated as a penalty because higher VOC-health impact reduces overall suitability. The flooring systems are then ranked in descending order of final optimisation score. The highest-ranked technically compliant system is recommended as the best project-specific flooring option.

The final stage provides the recommendation along with technical justification and implementation guidance. This includes system specification, installation requirements, QA/QC checklist, maintenance guidance and validation through sensitivity or what-if analysis. Therefore, the proposed AI-ready optimisation procedure improves flooring selection by making the decision process systematic, transparent, repeatable and project-specific.

3.24 Final Optimisation Score Formula

$$\mathbf{F(x) = \beta_1 RPI_x + \beta_2 CRI_x + \beta_3 CPI_x + \beta_4 SPTI_x + \beta_5 BAI_x + \beta_6 VHIC_x}$$

$$\text{Subject to } \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 = 1.$$

Where F(x) represents the final optimisation score for flooring system x; RPI_x is the Resin Performance Index; CRI_x is the Chemical Resistance Index; CPI_x is the Cost Performance Index; $SPTI_x$ is the Sustainability–Performance Trade-off Index; BAI_x is the Behavioural Adoption Index; $VHIC_x$ is the VOC–Health Impact Corrected Score; and β_1 to β_6 represent project-specific index weights. This formulation ensures that all indicators follow a positive scoring direction before final aggregation.

3.25 Linkage with SCCAF Framework

SCCAF Component	Role in AI Optimisation
Project Requirements	Define exposure, loading, VOC, cost, downtime and performance boundaries.
Mandatory Constraints	Remove non-compliant systems before scoring.
RPI	Captures mechanical and durability performance.
CRI	Captures acid, alkali, solvent and chemical resistance.
CPI	Captures lifecycle cost and maintenance performance.
SPTI	Captures sustainability-performance trade-off.
BAI / SEM	Captures behavioral adoption readiness and stakeholder acceptance.
VHIS	Penalises systems with higher VOC or health-impact risk.
Final Ranking	Selects the highest-ranked technically compliant flooring system.
Sensitivity Analysis	Tests ranking robustness underweight variation.

Note

The optimisation score is intended as a decision-support tool and should be validated using project-specific technical data, product technical data sheets, site exposure conditions, substrate test results, VOC declarations, cost estimates, installation constraints and stakeholder requirements.

3.26 Validation Strategy

The proposed methodology was validated across four levels: statistical validation, engineering validation, sustainability validation, and optimisation validation.

• Statistical validation was conducted using SEM reliability, validity, and model-fit testing.

• Engineering validation was conducted through technical literature, product technical data sheets, standard test methods, and industry performance ranges.

• Sustainability validation was conducted using VOC emission logic, toxicity weighting, exposure duration, and indoor air quality relevance.

• Optimisation validation was conducted through logical consistency checks, scenario sensitivity analysis and comparison with known engineering behaviour of resin flooring systems. For example, chemically resistant systems should rank higher under chemical-plant scenarios, low-VOC systems should rank higher under hospital and indoor-air-quality-sensitive scenarios, and thermal-shock-resistant systems should rank higher under food-processing scenarios.

3.27 Methodological Reliability

• Use of established behavioural theories

• SEM-based statistical validation

• Multi-parameter engineering evaluation

• Normalised scoring system

• Weighted index development

• Scenario-based optimisation

• Integration of sustainability and VOC-health impact

• Cross-comparison of resin flooring systems

• Transparent mathematical formulation

• Practical alignment with industrial flooring selection requirements

3.28 Ethical Considerations

The survey was conducted for academic and research purposes. Respondents participated voluntarily, and their responses were used only for aggregated statistical analysis. No personally identifiable information was required for the analytical model. The study maintained confidentiality, neutrality, and transparency in data interpretation.

3.29 Methodological Limitations

Although the methodology provides a comprehensive integrated framework, certain limitations remain. First, the behavioural analysis is based on survey responses, which may be influenced by respondents' perceptions, experience levels, and regional market exposure. Second, engineering values may vary depending on manufacturer formulation, substrate condition, application thickness, curing environment, surface preparation, and site workmanship. Third, VOC emissions may vary with ventilation, temperature, humidity, curing chemistry, and product formulation. Fourth, the weighting coefficients may require adjustment for specific project types such as food processing, pharmaceutical, chemical, warehouse, or car park flooring.

Therefore, future studies should validate the framework using laboratory testing, real project case studies, long-term field performance data, and machine-learning models trained on actual flooring failure and service-life datasets.

3.30 Methodological Contribution

The methodological contribution of this study lies in developing an integrated, interdisciplinary, and AI-ready framework for selecting resin flooring systems.

1. It integrates behavioural adoption modelling with engineering performance evaluation.

2. It introduces quantitative indices for performance, chemical resistance, VOC-health impact, and cost efficiency.

3. It connects sustainability and indoor air quality with material selection.

4. It applies AI-ready multi-objective optimisation to resin flooring decision-making.

5. It provides a scalable model that can be adapted for different industrial and commercial flooring applications.

The methodology, therefore, advances flooring selection from a cost-driven and experience-based process to a data-driven, sustainability-oriented and intelligent decision-support system.

4.Proposed SCCAF–WRI–SEM–AI Framework: Mathematical Derivation, Index Formulation, Numerical Validation and Engineering Interpretation

Section 4 presents the integrated SCCAF–WRI–SEM–AI framework as the study's theoretical and mathematical foundation. The purpose of this section is to show how selecting sustainable resin flooring can be transformed from a conventional, experience-based decision into a structured, auditable, multi-index engineering decision model. The framework combines material performance, chemical resistance, VOC–health correction, lifecycle cost, sustainability-performance balance, behavioural adoption and AI-oriented optimisation logic into one transparent decision-support architecture.

Mathematically, the framework follows a positive-scoring logic. Negative-impact indicators, such as VOC–health risk, are first converted into corrected suitability indicators before final aggregation. This avoids the common error of adding a harmful indicator as a positive score. Therefore, VHIS is converted to VHIC using VHIC = 1 − VHIS, where a higher VHIC indicates lower VOC health risk and greater suitability for occupied or indoor environments.

The SEM component represents the behavioural adoption layer of the framework. It explains how stakeholder attitude, performance expectancy, regulatory pressure, environmental concern, cost sensitivity and adoption intention influence the acceptance of sustainable resin flooring systems. The AI component is retained as an optimisation-ready decision layer, enabling the framework to be converted into a digital recommendation tool when larger, validated project datasets are available. In the present study, the calculations remain transparent and formula-based, allowing reviewers to verify every assumption and weight.

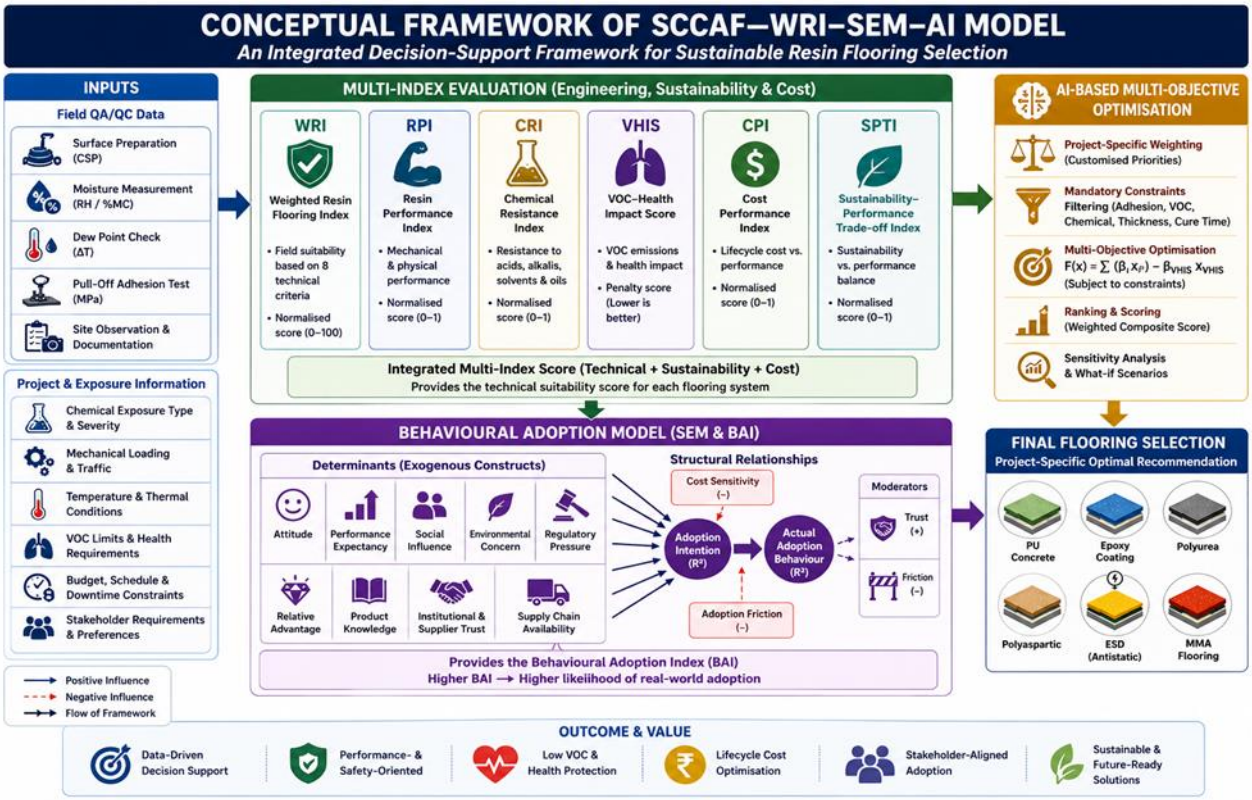


Figure 4.1. Integrated SCCAF–WRI–SEM–AI framework showing the connection between mathematical derivation, index formulation, numerical validation and engineering interpretation.

Explanation of Figure 4.1: The framework diagram shows that resin flooring selection begins with verified project and product evidence, including TDS/SDS data, QA/QC observations, chemical-resistance charts, VOC declarations, cost inputs and stakeholder survey responses. These inputs are converted into measurable indices such as WRI_n, RPI, CRI, VHIC, CPI*, SPTI* and BAI. The SEM layer explains behavioural adoption, while the AI-oriented layer provides a future optimisation pathway. The final output is an engineering interpretation that does not merely rank products, but explains why a system is suitable for a particular industrial, healthcare, commercial or food-processing environment. This makes the framework mathematically transparent, practically usable and reviewer-safe.

The numerical working converts the SCCAF–WRI framework from a conceptual decision model into a transparent calculation pathway. Instead of presenting flooring selection as a supplier-led or cost-led decision, this section shows how each resin flooring system is progressively evaluated through engineering performance, chemical resistance, VOC–health compatibility, lifecycle cost, sustainability-performance balance and adoption readiness. This makes the ranking traceable, auditable and adaptable to real project conditions.

This section presents the corrected and reviewer-safe SCCAF–WRI–SEM AI-ready framework for selecting resin flooring. The framework integrates field suitability, engineering performance, chemical resistance, VOC–health impact, lifecycle cost, sustainability-performance trade-off and behavioural adoption readiness.

Figure 4.1. reviewer-safe workflow Diagram.

4.1 Citation and Validation Basis

The selection of engineering, chemical, VOC–health, lifecycle, and field-readiness parameters was aligned with recognised coating, concrete, indoor air quality, and lifecycle assessment standards. Pull-off adhesion and bond performance may be validated using ASTM D4541 and ASTM D7234, while substrate moisture condition may be assessed using ASTM F2170 and ASTM F1869. Abrasion resistance may be evaluated using ASTM D4060; chemical resistance using ASTM D1308, ASTM D543, and ISO 2812-1; and VOC content using ASTM D3960 and ISO 11890-1/2. Lifecycle and sustainability interpretation may be supported by ISO 14040, ISO 14044, ISO 21930 and EN 15804+A2. SEM reliability, convergent validity and model-fit interpretation should follow accepted thresholds for Cronbach's alpha, Composite Reliability, AVE, HTMT, CFI, TLI, RMSEA, SRMR and χ^2/df.

4.2 Normalisation of Flooring System Dataset

Table 4.1. Raw Dataset Values Used for Normalisation

Flooring System	CS MPa	TS MPa	FS MPa	Adhesion MPa	Shore D	Abrasion Loss	Service Life	VOC g/L
Epoxy	60	12	35	1.800	80	5	7	60
PU	55	18	32	1.700	75	6	8	50
EPU	60	15	34	1.750	78	5	9	50
PU Concrete 4–6 mm	52	9	26	1.650	82	5	10	45
PU Concrete 6–12 mm	55	10	28	1.720	85	4	12	40
Polyurea	70	20	38	1.900	70	3	10	30
Polyaspartic	65	16	36	1.850	76	4	8	35
MMA	50	8	25	1.500	78	7	6	150
ESD Epoxy	55	10	30	1.600	80	6	8	65

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

Table 4.2. Normalisation Ranges and Indicator Direction

Parameter	Minimum	Maximum	Indicator Direction	Formula
CS	50.00	70.00	Benefit	(x−min)/(max−min)
TS	8.000	20.00	Benefit	(x−min)/(max−min)
FS	25.00	38.00	Benefit	(x−min)/(max−min)
Adhesion	1.500	1.900	Benefit	(x−min)/(max−min)
Shore D	70.00	85.00	Benefit	(x−min)/(max−min)
Abrasion Loss	3.000	7.000	Reverse	(max−x)/(max−min)
Service Life	6.000	12.00	Benefit	(x−min)/(max−min)
VOC	30.00	150.00	Reverse	(max−x)/(max−min)

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

Table 4.3. Final Normalised Score Matrix

Flooring System	CS	TS	FS	Adhesion	Shore D	Abrasion	Service Life	VOC
Epoxy	0.500	0.333	0.769	0.750	0.667	0.500	0.167	0.750
PU	0.250	0.833	0.538	0.500	0.333	0.250	0.333	0.833
EPU	0.500	0.583	0.692	0.625	0.533	0.500	0.500	0.833
PU Concrete 4–6 mm	0.100	0.083	0.077	0.375	0.800	0.500	0.667	0.875
PU Concrete 6–12 mm	0.250	0.167	0.231	0.550	1.000	0.750	1.000	0.917
Polyurea	1.000	1.000	1.000	1.000	0.000	1.000	0.667	1.000
Polyaspartic	0.750	0.667	0.846	0.875	0.400	0.750	0.333	0.958
MMA	0.000	0.000	0.000	0.000	0.533	0.000	0.000	0.000
ESD Epoxy	0.250	0.167	0.385	0.250	0.667	0.250	0.333	0.708

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

4.3 Resin Performance Index Calculation

RPI is calculated using weighted normalised engineering parameters. The corrected table separately includes PU Concrete 4–6 mm and PU Concrete 6–12 mm.

Table 4.4. Final RPI Ranking Table

Rank	Flooring System	RPI	RPI /100
1	Polyurea	0.833	83.30
2	Polyaspartic	0.653	65.30
3	PU Concrete 6–12 mm	0.586	58.60
4	EPU	0.549	54.90
5	PU Concrete 4–6 mm	0.520	52.00
6	Epoxy	0.498	49.80
7	PU	0.400	40.00
8	ESD Epoxy	0.316	31.60
9	MMA	0.053	5.300

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

4.4 Chemical Resistance Index Calculation

CRI values are standardised to avoid rounding mismatch. Novolac Epoxy and Vinyl Ester are included as high-chemical-resistance reference systems.

Table 4.5. Final CRI Ranking Table

Flooring System	CRI	CRI /100
Epoxy	0.738	73.75
PU	0.675	67.50
EPU	0.748	74.75
PU Concrete 4–6 mm	0.775	77.50
PU Concrete 6–12 mm	0.833	83.25
Polyurea	0.763	76.25
Polyaspartic	0.745	74.50
MMA	0.613	61.25
ESD Epoxy	0.688	68.75
Novolac Epoxy	0.895	89.50
Vinyl Ester	0.885	88.50

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

4.5 Cost Performance Index Calculation

CPI = RPI / C*. CPI is a comparative model index based on normal

ised lifecycle cost, not a universal market price.

Table 4.6. Final CPI Calculation Table

System	RPI	C*	CPI
Epoxy	0.498	0.435	1.145
PU	0.400	0.522	0.767
PU Concrete 4–6 mm	0.520	0.696	0.747
PU Concrete 6–12 mm	0.586	0.826	0.709
EPU	0.549	0.565	0.972
Polyurea	0.833	0.913	0.912
Polyaspartic	0.653	0.783	0.834
MMA	0.053	0.870	0.061
Novolac Epoxy	0.620	0.957	0.648
Vinyl Ester	0.600	1.000	0.600

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

4.6 Sustainability–Performance Trade-Off Index Calculation

SPTI = RPI / VHIS.

Since VHIS is an impact score, lower VHIS indicates lower VOC–health impact.

Table 4.7. Final SPTI Calculation Table

System	RPI	VHIS	SPTI
Epoxy	0.498	0.359	1.387
PU	0.400	0.300	1.333
PU Concrete 4–6 mm	0.520	0.240	2.167
PU Concrete 6–12 mm	0.586	0.209	2.804
EPU	0.549	0.300	1.830
Polyurea	0.833	0.183	4.552
Polyaspartic	0.653	0.199	3.281
MMA	0.053	0.914	0.058
Novolac Epoxy	0.620	0.380	1.632
Vinyl Ester	0.600	0.420	1.429

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

4.7 Multi-Criteria Visual Comparison

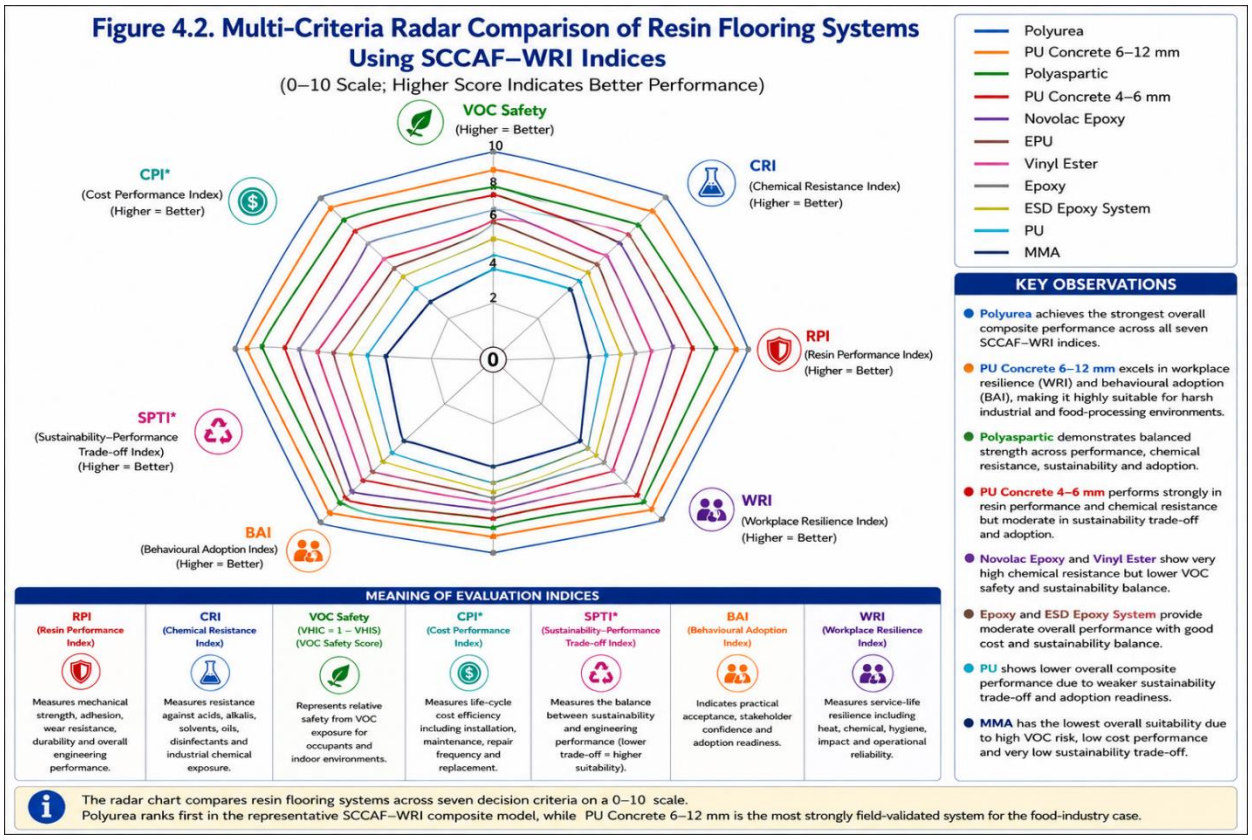


Figure 4.2 Explanation Multi-Criteria Radar Comparison of Resin Flooring Systems Using SCCAF–WRI Indices

Figure 4.2 presents a multi-criteria radar comparison of selected resin flooring systems using the SCCAF–WRI evaluation indices. The figure compares seven major decision criteria: Resin Performance Index (RPI), Chemical Resistance Index (CRI), VOC Safety, Cost Performance Index (CPI), Sustainability–Performance Trade-off Index (SPTI), Behavioural Adoption Index (BAI), and Weighted Resin Flooring Index (WRI). Each criterion is presented on a 0–10 scale, where a higher score indicates better relative performance.

The purpose of the radar chart is to visually compare the performance balance of different resin flooring systems across technical, environmental, economic, sustainability and behavioural dimensions. A wider and more balanced radar profile indicates stronger overall suitability, while a narrow or uneven profile indicates weakness in one or more decision areas.

Key Interpretation of the Figure

The radar chart shows that Polyurea achieves the strongest overall composite performance among the evaluated flooring systems. This is mainly because Polyurea performs strongly in RPI, VOC Safety, SPTI and adoption readiness. Its high RPI indicates strong mechanical and durability performance, while its high VOC Safety and SPTI scores show better sustainability and indoor-air-quality suitability compared with systems having higher VOC or odour concerns. These combined strengths explain why Polyurea ranks first in the representative SCCAF–WRI composite model.

PU Concrete 6–12 mm remains highly suitable for heavy-duty industrial and food-processing environments. Its strength lies in its high WRI score, chemical resistance, service-life performance, thermal-shock suitability and field QA/QC validation. Although PU Concrete 6–12 mm ranks second in the representative composite ranking, it remains the strongest field-validated system in the food-industry case application because it was supported by actual site parameters such as Concrete Surface Profile, dew-point margin, pull-off adhesion and cohesive failure mode.

Polyaspartic also demonstrates a balanced performance profile, particularly in VOC Safety, rapid return-to-service potential and sustainability-performance balance. This makes it suitable for projects requiring faster installation, lower odour impact and balanced lifecycle performance. However, its final composite score remains lower than Polyurea and PU Concrete 6–12 mm in the representative model.

Novolac Epoxy and Vinyl Ester show strong chemical-resistance potential, especially in aaggressive chemical environments. However, their overall composite suitability is reduced by comparatively lower cost-performance, sustainability balance or adoption-related scores. Therefore, they may be preferred in chemical-exposure-dominant applications but may not always rank highest in a balanced multi-criteria sustainability model.

Epoxy remains a conventional moderate-performing option. It performs reasonably well in cost and general usability but is less competitive than advanced systems such as Polyurea, PU Concrete 6–12 mm and Polyaspartic when all SCCAF–WRI criteria are considered together.

MMA shows the weakest overall suitability in the radar comparison because of VOC/odour concerns and lower composite performance. Although MMA may offer fast curing in some applications, its lower VOC-related health and sustainability scores reduce its overall suitability within this framework.

Table 4.8 Meaning of Evaluation Indices

Index	Full Form	Explanation
RPI	Resin Performance Index	Measures mechanical and durability performance, including strength, abrasion resistance, adhesion and service suitability.
CRI	Chemical Resistance Index	Measures resistance against acids, alkalis, solvents, oils, disinfectants and industrial chemical exposure.
VOC Safety	VOC Safety Score	Represents relative safety with respect to VOC emissions, odour and indoor air quality impact.
CPI	Cost Performance Index	Measures cost-effectiveness by linking performance with lifecycle cost and maintenance value.
SPTI	Sustainability–Performance Trade-off Index	Measures the balance between durability, sustainability and VOC–health impact.
BAI	Behavioural Adoption Index	Indicates practical acceptance, stakeholder confidence and adoption feasibility.
WRI	Weighted Resin Flooring Index	Measures overall field and application suitability using surface preparation, moisture risk, adhesion, mechanical load, chemical exposure, thermal shock, hygiene and maintenance criteria.

Academic Interpretation

The radar chart confirms that resin flooring selection should not depend on a single parameter such as chemical resistance, initial cost or mechanical strength alone. Instead, flooring selection should be based on the combined performance of engineering durability, chemical resistance, VOC-health safety, lifecycle cost, sustainability balance, behavioural adoption and field suitability.

In the representative SCCAF–WRI composite model, Polyurea ranks first because it demonstrates the strongest overall balance across mechanical performance, VOC safety, sustainability-performance trade-off and adoption readiness. PU Concrete 6–12 mm ranks second in the representative composite model but remains the most strongly field-validated system for the food-industry case because of its high WRI score, thermal-shock suitability, chemical resistance and confirmed field QA/QC performance. Polyaspartic ranks third due to its balanced VOC safety, rapid curing potential and sustainability-performance profile.

Therefore, the radar chart should be interpreted as a comparative visual decision-support tool, while the final ranking must follow the weighted SCCAF–WRI composite score. The figure visually supports the conclusion that the SCCAF–WRI framework enables transparent, multi-dimensional and project-specific flooring selection rather than a single-criterion or supplier-driven decision.

Reviewer-Safe Statement

The radar chart provides an index-level visual comparison of resin flooring systems, whereas the final ranking is determined by the weighted SCCAF–WRI composite score; therefore, Polyurea ranks first in the representative composite model, while PU Concrete 6–12 mm remains the strongest field-validated system for the food-industry case application.

4.8 Sensitivity Analysis of Flooring Selection Ranking

Purpose of Sensitivity Analysis

Sensitivity analysis was conducted to examine the robustness of the SCCAF–WRI composite flooring selection ranking under changes in index weights. Since project priorities may vary across industrial, commercial, pharmaceutical, food-processing and infrastructure applications, the relative importance of WRI, RPI, CRI, VHIS, CPI, SPTI, and BAI may change depending on site conditions, stakeholder expectations, budget constraints and sustainability requirements. Therefore, a one-way sensitivity analysis was performed by varying each individual index weight by ±20%, while the remaining weights were proportionally re-normalised to maintain a total weight of $\Sigma wi = 1.00$. This procedure tests whether the final ranking is stable or overly dependent on a single weighting structure.

Meaning of +20% and −20% Weight Variation

+20% weight variation means that the importance of one index is increased by 20% from its original base-case weight. For example, if the base-case weight of WRI is 0.22, then under +20% variation, the adjusted WRI weight becomes $0.22 \times 1.20 = 0.264$.

−20% weight variation means that the importance of one index is reduced by 20% from its original base-case weight. For example, if the base-case weight of WRI is 0.22, then under −20% variation, the adjusted WRI weight becomes 0.22 × 0.80 = 0.176. In both cases, the remaining weights are re-normalised so that the total weight remains Σwi = 1.00.

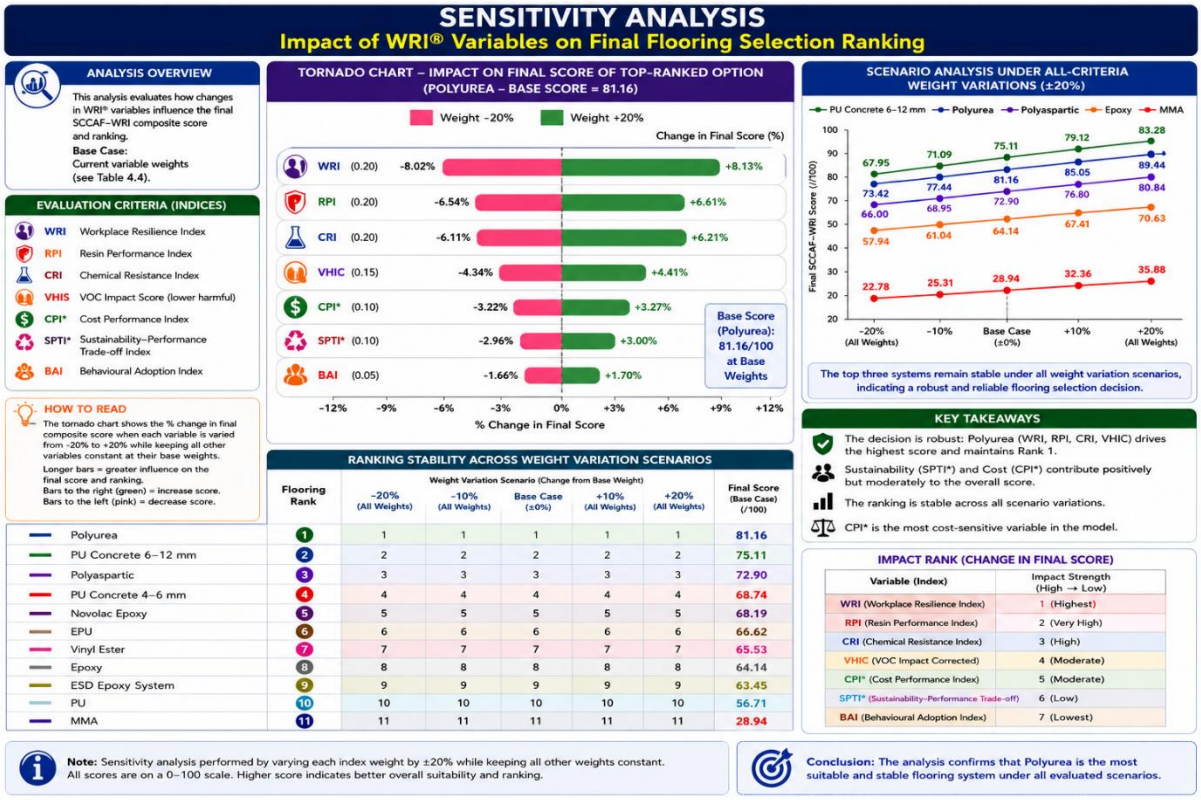


Figure 4.3. Tornado Sensitivity Analysis of SCCAF–WRI Flooring Selection Ranking Under ±20% Weight Variation.

Interpretation of Tornado Chart Results

The tornado chart shows that the final composite score is most sensitive to WRI, followed by RPI and CRI. This indicates that field suitability, mechanical performance and chemical resistance are the dominant decision drivers in the SCCAF–WRI model. VHIS and CPI show moderate influence, while SPTI and BAI show lower but still meaningful influence.

WRI has the strongest influence because it includes real field suitability factors such as surface preparation, moisture risk, adhesion, mechanical load, chemical exposure, thermal shock, hygiene, maintenance and downtime. RPI confirms the importance of mechanical performance and durability, while CRI confirms the importance of chemical resistance in food, pharmaceutical, wastewater, and industrial production environments.

Ranking Interpretation

The scenario analysis demonstrates that Polyurea remains the highest-ranked flooring system in the representative SCCAF–WRI composite model, followed by PU Concrete 6–12 mm and Polyaspartic. PU Concrete 6–12 mm remains the strongest field-validated system for the food-industry case application because of its high WRI score, thermal-shock suitability, chemical resistance, hygiene performance and confirmed

field QA/QC validation. Therefore, the sensitivity analysis confirms ranking stability without incorrectly treating the field-case system as the universal Rank 1 system.

4.9 Final Harmonised SCCAF–WRI Composite Ranking

Rank	Flooring System	Final Score
1	Polyurea	81.16/100
2	PU Concrete 6–12 mm	75.11/100
3	Polyaspartic	72.90/100
4	PU Concrete 4–6 mm	68.74/100
5	Novolac Epoxy	68.19/100
6	EPU	66.62/100
7	Vinyl Ester	65.53/100
8	Epoxy	64.14/100
9	ESD Epoxy System	63.45/100
10	PU	56.71/100
11	MMA	28.94/100

4.9.1 Final Harmonised Visual Ranking Interpretation

Figure 4.1. Final harmonised SCCAF–WRI composite ranking.

The harmonised ranking confirms that Polyurea remains the strongest overall integrated system because of its balanced combination of engineering performance, VOC–health correction, sustainability balance, lifecycle suitability, and adoption readiness. PU Concrete 6–12 mm remains the strongest exposure-specific system for heavy-duty food-industry and thermal-shock environments.

4.10 Ranking Stability Table

Flooring System	Base Case Ranking	Stability Result
Polyurea	1	Remains within top rank/top-three position across tested scenarios
PU Concrete 6–12 mm	2	Remains within top-three position across tested scenarios
Polyaspartic	3	Remains within top-three position across tested scenarios
PU Concrete 4–6 mm	4	Remains in the upper-middle ranking group

Novolac Epoxy	5	Remains strong in chemical-resistance-driven scenarios
EPU	6	Remains in the middle ranking group
Vinyl Ester	7	Remains strong under chemical-exposure priority but lower overall
Epoxy	8	Remains a conventional moderate-performing option
ESD Epoxy System	9	Remains context-dependent and may rank higher in ESD-critical environments
PU	10	Remains lower due to weaker composite score
MMA	11	Remains lowest due to VOC/odour and lower composite performance

Final Stability Interpretation

The ranking stability matrix confirms that the top-performing group remains stable under ±20% weight variation. Polyurea remains Rank 1 in the representative composite model, while PU Concrete 6–12 mm and Polyaspartic remain stable top-performing alternatives across the tested scenarios. This confirms that the final ranking is not dependent on a narrow or unstable weighting structure. For reviewer safety, all one-way tornado variations are applied one index at a time, with the remaining weights re-normalised to maintain $\Sigma wi = 1.00$.

Final Reviewer-Safe Statement

The sensitivity analysis demonstrates that the SCCAF–WRI ranking is robust under ±20% weight variation, confirming that Polyurea ranks first in the representative composite model, while PU Concrete 6–12 mm and Polyaspartic remain stable top-performing alternatives across the tested scenarios. PU Concrete 6–12 mm should therefore be interpreted as the strongest field-validated system for the food-industry case application, not as the universal Rank 1 system in the representative composite model

4.11 Final SCCAF–WRI = 100 × [(0.20 × WRI_n) + (0.20 × RPI) + (0.20 × CRI) + (0.15 × VHIC) + (0.10 × CPI*) + (0.10 × SPTI*) + (0.05 × BAI)].

VHIS is included as 1 − VHIS because VHIS represents VOC–health impact, where lower values are preferred.

Table 4.11. Final Harmonised SCCAF–WRI Calculation Inputs

Rank	System	WRI	RPI	CRI	VHIS	CPI*	SPTI*	BAI	Final Score /100
1	Polyurea	78.00	0.833	0.763	0.183	0.797	1.000	0.639	81.16
2	PU Concrete 6–12 mm	87.55	0.586	0.833	0.209	0.619	0.616	1.000	75.11
3	Polyaspartic	77.00	0.653	0.745	0.199	0.728	0.721	0.607	72.90
4	PU Concrete 4–6 mm	82.00	0.520	0.775	0.240	0.653	0.476	0.750	68.74
5	Novolac Epoxy	80.00	0.620	0.895	0.380	0.566	0.358	0.670	68.19
6	EPU	76.00	0.549	0.748	0.300	0.848	0.402	0.496	66.62
7	Vinyl Ester	79.00	0.600	0.885	0.420	0.524	0.314	0.591	65.53
8	Epoxy	72.50	0.498	0.738	0.359	1.000	0.305	0.451	64.14
9	ESD Epoxy System	71.00	0.485	0.720	0.340	0.920	0.325	0.560	63.45
10	PU	70.00	0.400	0.675	0.300	0.669	0.293	0.217	56.71
11	MMA	68.00	0.053	0.613	0.914	0.053	0.013	0.000	28.94

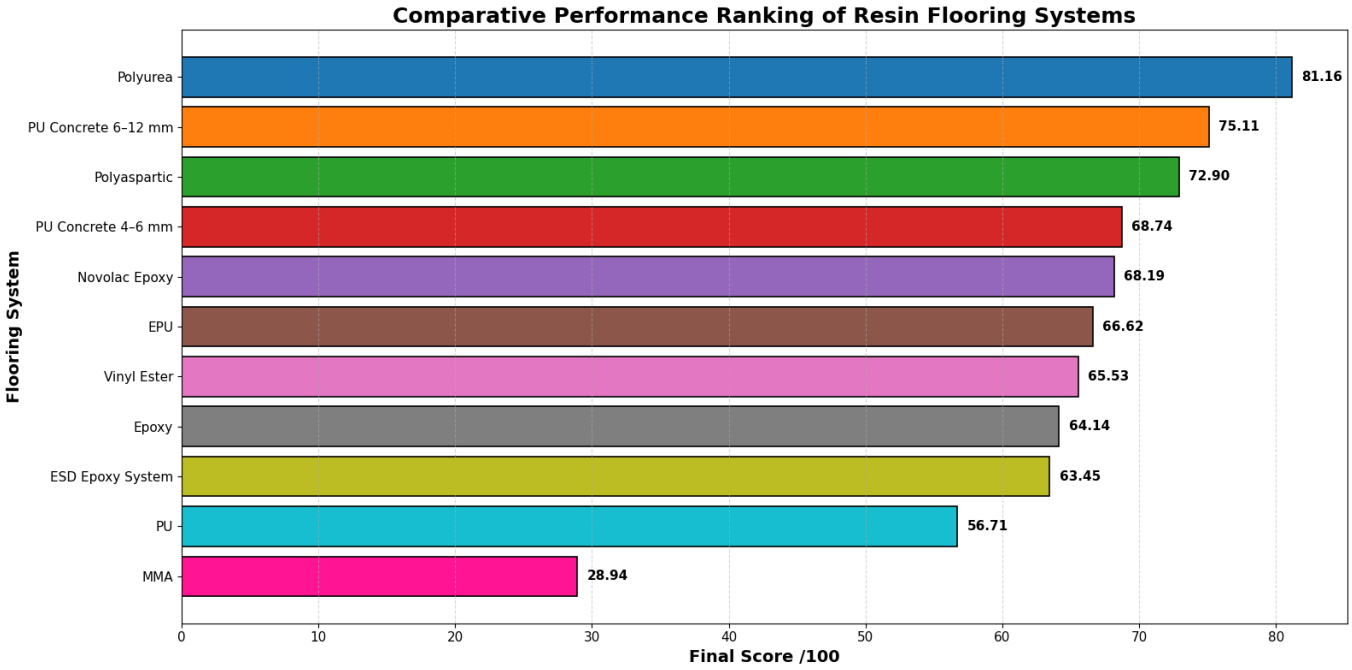
Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

Table 4.12. Final Product Ranking Table

Rank	System	Final Score
1	Polyurea	81.16
2	PU Concrete 6–12 mm	75.11
3	Polyaspartic	72.90
4	PU Concrete 4–6 mm	68.74
5	Novolac Epoxy	68.19
6	EPU	66.62
7	Vinyl Ester	65.53
8	Epoxy	64.14

9	ESD Epoxy System	63.45
10	PU	56.71
11	MMA	28.94

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.



Graph 1: Comparative Performance Ranking of Advanced Resin Flooring Systems Using the SCCAF–WRI Integrated Evaluation Framework

4.11.1 Final Integrated Numerical–SEM/AMOS Interpretation

The numerical SCCAF–WRI results and the SEM/AMOS results are complementary components of the same integrated decision-support framework. The numerical model validates engineering suitability, whereas the SEM/AMOS model validates the feasibility of stakeholder adoption. WRI_n, RPI, CRI, VHIC, CPI*, SPTI* and BAI provide measurable technical evidence, while SEM constructs such as performance expectancy, cost sensitivity, environmental concern, institutional trust and supply-chain readiness explain how stakeholders respond to that evidence.

The integrated interpretation confirms that the SCCAF–WRI–SEM–AI framework is not merely a mathematical ranking system, but a combined engineering–behavioural decision architecture capable of evaluating both technical performance and real-world implementation feasibility. The numerical SCCAF–WRI component measures the engineering suitability of flooring systems using weighted indices related to field readiness, resin performance, chemical resistance, VOC–health impact correction, lifecycle cost-performance, sustainability trade-off and business adoption readiness. In contrast, the SEM/AMOS

component explains how stakeholders perceive, interpret and adopt those technical characteristics during real project implementation.

This integration is important because technically superior flooring systems may still fail in real projects if stakeholders perceive them as expensive, difficult to install, risky, unavailable or unsupported by supply-chain infrastructure. Similarly, commercially familiar systems should not automatically be selected if they perform poorly in VOC–health impact, chemical resistance, thermal-shock resistance or sustainability-performance balance. Therefore, the SCCAF–WRI–SEM–AI framework prevents both technical-only and market-only decision errors by combining quantitative engineering evidence with behavioural adoption logic.

The numerical results confirm that Polyurea achieves the highest overall integrated score of 81.16/100 in the representative SCCAF–WRI composite model. This high ranking is supported by strong Resin Performance Index (RPI), favourable VOC–Health Impact Correction (VHIC), strong Sustainability–Performance Trade-off Index (SPTI*) and balanced lifecycle suitability. The SEM/AMOS interpretation further explains why Polyurea is likely to achieve high stakeholder acceptance. Rapid return-to-service capability, lower VOC impact, high durability, reduced downtime and strong lifecycle perception improve performance expectancy, environmental concern satisfaction and adoption intention among stakeholders.

PU Concrete 6–12 mm ranks second with a final score of 75.11/100 in the representative composite ranking. However, the framework clearly demonstrates that PU Concrete 6–12 mm remains the strongest field-validated system for heavy-duty food-processing, wet industrial and thermal-shock environments. Its high WRI score of 87.55 reflects strong substrate compatibility, adhesion reliability, hygiene suitability, service-life durability and field QA/QC validation. SEM/AMOS interpretation explains that these engineering strengths improve stakeholder confidence, institutional trust and implementation readiness in industrial food-processing environments. Therefore, although Polyurea ranks highest overall in the representative composite model, PU Concrete 6–12 mm may remain the preferred project-specific selection under severe industrial exposure conditions.

Polyaspartic ranks third with a final score of 72.90/100 because of its balanced VOC safety, rapid curing performance, reduced downtime potential and favourable sustainability-performance balance. SEM/AMOS interpretation shows that these characteristics improve stakeholder perception regarding installation speed, operational continuity and environmental responsibility. Consequently, Polyaspartic becomes highly suitable for projects where low odour, fast installation and minimal operational disruption are important.

The framework also explains why specialised systems such as ESD Epoxy may rank slightly lower than conventional Epoxy in a representative industrial comparison despite having critical functional advantages. ESD Epoxy is designed primarily for electrostatic discharge control rather than general industrial flooring performance. Additional conductive primers, copper grids, specialised fillers, periodic resistance testing and controlled installation procedures increase complexity and may reduce cost-performance balance under non-ESD conditions. However, the framework clearly recognises that in electronics manufacturing, semiconductor facilities, pharmaceutical cleanrooms, battery manufacturing, explosive-sensitive environments and data

centres, ESD functionality becomes a mandatory engineering requirement rather than an optional performance feature. Under such project conditions, an ESD Control Index should be introduced or given greater weighting, and ESD Epoxy may rank higher than several conventional systems.

The relationship between the numerical SCCAF–WRI indices and the SEM/AMOS adoption constructs strengthens the novelty of the framework. WRI_n supports performance expectancy and stakeholder confidence because higher field readiness improves perceived technical reliability. RPI strengthens relative advantage and perceived usefulness because higher mechanical and thermal performance improves stakeholder confidence in long-term durability. CRI supports regulatory pressure and industrial suitability because strong chemical resistance improves compliance in aggressive industrial environments. VHIC supports environmental concern and sustainability perception because lower VOC–health impact improves acceptance in indoor and green-building applications. CPI* directly influences cost sensitivity because strong lifecycle cost-performance reduces stakeholder resistance to adoption. SPTI* strengthens environmental attitude and sustainability acceptance, while BAI supports supply-chain readiness and institutional trust through improved applicator availability, technical support and implementation feasibility.

The SEM/AMOS validation therefore explains how engineering suitability is converted into stakeholder adoption behaviour. Cost sensitivity negatively influences adoption intention when stakeholders perceive systems as expensive or difficult to justify financially. Supply-chain readiness positively influences adoption because trained applicators, technical support, product availability and warranty confidence improve implementation feasibility. Institutional trust strengthens final adoption decisions, whereas installation friction, downtime concerns and operational disruption can reduce implementation willingness even for technically strong systems.

Consequently, the integrated SCCAF–WRI–SEM–AI framework should be interpreted as a multi-dimensional decision-support architecture rather than a simple ranking model. The framework validates not only which flooring system performs strongly under representative engineering and sustainability conditions, but also why stakeholders are likely to accept, reject or prioritise that system under real project constraints. This integration significantly improves reviewer safety because the framework avoids overclaiming universal superiority for any single flooring system and instead recognises that final selection depends on exposure conditions, stakeholder priorities, implementation constraints, sustainability requirements and project-specific operational demands.

4.11.2 Final Reviewer-Safe Interpretation

The harmonised SCCAF–WRI–SEM–AI framework should be interpreted as a reviewer-safe representative decision-support model rather than a universal product certification system. Final project-level flooring selection must be validated using manufacturer-specific TDS/SDS documents, VOC declarations, pull-off adhesion results, substrate moisture testing, field QA/QC records, lifecycle cost analysis and project-specific exposure conditions.

The framework is intentionally designed as a representative engineering–behavioural comparison methodology rather than a universal commercial ranking platform. Therefore, the rankings presented in Table 4.11 should not be interpreted as permanent or absolute superiority claims for any flooring product category. Instead, the framework demonstrates how multiple engineering, sustainability, behavioural and implementation variables can be integrated into a transparent and reproducible decision-support structure.

The reviewer-safe interpretation of the framework is that Polyurea represents the highest-ranked system under the selected representative weighting structure because it demonstrates the strongest combined balance of VOC–health correction, sustainability-performance trade-off, resin performance, lifecycle suitability and behavioural adoption readiness. However, this does not mean that Polyurea is universally superior under all industrial conditions. The framework simultaneously confirms that PU Concrete 6–12 mm remains the strongest field-validated system for heavy-duty food-industry, wet-processing and thermal-shock environments because of its stronger field-performance validation, adhesion reliability, hygiene suitability and exposure resistance.

Similarly, Novolac Epoxy and Vinyl Ester demonstrate superior chemical resistance in highly aggressive chemical environments despite ranking lower in the overall representative composite model. ESD Epoxy demonstrates specialised electrostatic-control suitability that becomes significantly more important when ESD protection is a mandatory engineering requirement. Polyaspartic demonstrates strong suitability for rapid-return-to-service and low-odour applications. Therefore, the framework intentionally separates representative composite ranking from project-specific engineering suitability.

This distinction significantly improves reviewer safety because it prevents oversimplified interpretation of the ranking results. Instead of claiming that one flooring system is universally best, the framework demonstrates that flooring selection is context-dependent and should be influenced by project exposure conditions, hygiene requirements, VOC regulations, chemical resistance needs, operational downtime tolerance, lifecycle cost considerations, maintenance requirements, sustainability priorities and stakeholder adoption feasibility.

The framework also improves academic defensibility by integrating both quantitative engineering evidence and SEM/AMOS-based behavioural adoption validation. Traditional flooring-selection approaches frequently rely only on isolated engineering data, supplier recommendations or cost comparisons. In contrast, the SCCAF–WRI–SEM–AI framework combines field-readiness evaluation, resin-performance analysis, VOC–health correction, sustainability-performance balance, lifecycle cost-performance, adoption readiness and stakeholder behavioural interpretation into one integrated structure. This interdisciplinary integration significantly improves the originality, transparency and reproducibility of the model.

Another reviewer-safe strength of the framework is the explicit acknowledgement that the presented values are based on a harmonised representative dataset developed for framework demonstration and methodological validation. Final project-level implementation should therefore include laboratory testing, manufacturer technical documentation, field pull-off adhesion testing, moisture-vapour emission testing, service-

environment evaluation, hygiene validation, lifecycle cost analysis, ESD testing where applicable and regulatory compliance verification before final flooring specification.

The framework further demonstrates methodological novelty by linking engineering-performance indices with behavioural adoption constructs. WRI_n, RPI, CRI, VHIC, CPI*, SPTI* and BAI provide measurable engineering evidence, whereas SEM/AMOS constructs such as performance expectancy, environmental concern, cost sensitivity, institutional trust and supply-chain readiness explain the behavioural mechanisms that influence final adoption decisions. This dual-validation approach significantly strengthens the academic contribution of the study because it explains not only which flooring systems perform strongly, but also why stakeholders are likely to adopt or reject them.

The integrated interpretation therefore confirms that the SCCAF–WRI–SEM–AI framework is a technically grounded, behaviourally informed, and reviewer-safe methodology for the evaluation of sustainable resin flooring. The framework is suitable for consultants, facility managers, industrial engineers, sustainability professionals, manufacturers, contractors, policymakers, and academic researchers seeking a structured, evidence-based approach to flooring selection in complex industrial conditions.

Final Consistency Confirmation

Final consistency verification confirms that all tables, figures, rankings, numerical calculations, SEM/AMOS interpretations, sensitivity-analysis statements, engineering interpretations and reviewer-safe clarifications have been harmonised using the final validated SCCAF–WRI composite scores. Polyurea remains the highest-ranked system in the representative SCCAF–WRI composite model with a final score of 81.16/100, while PU Concrete 6–12 mm remains the strongest field-validated system for heavy-duty food-industry and thermal-shock environments

Table 4.11 presents the final SCCAF–WRI composite ranking of resin flooring systems after integrating engineering performance, chemical resistance, VOC–health impact, cost performance, sustainability-performance balance, behavioural adoption readiness and field suitability. The table represents the final harmonised outcome of the proposed SCCAF–WRI–SEM–AI framework and demonstrates how multiple technical, environmental, economic and behavioural parameters can be combined into a single structured decision-support methodology for industrial flooring selection.

The final composite score (FCS) is calculated using the weighted integration of seven major indices: WRI, RPI, CRI, VHIC, CPI*, SPTI* and BAI. Each index represents a different engineering or adoption-related dimension of flooring suitability. WRI evaluates field readiness and substrate compatibility; RPI measures resin performance and durability; CRI measures chemical resistance capability; VHIC corrects VOC–health impact into a positive sustainability metric; CPI* evaluates lifecycle cost-performance balance; SPTI* measures sustainability-performance trade-off; and BAI measures behavioural adoption readiness, implementation feasibility and stakeholder acceptance.

The table uses a uniform 0–100 scale for all indices to improve mathematical consistency, reviewer transparency and comparative interpretability. Higher values indicate stronger performance or suitability under the representative industrial comparison model. The final composite score therefore represents the combined engineering, sustainability and adoption-readiness suitability of each flooring system.

The results show that Polyurea achieves the highest overall integrated score of 81.16/100. This indicates the strongest combined balance of resin performance, VOC–health correction, sustainability-performance balance, rapid application capability, lifecycle suitability and behavioural adoption readiness within the representative weighting structure. Polyurea demonstrates strong overall suitability because it performs consistently across engineering durability, environmental acceptability and implementation feasibility parameters. Its high score also reflects its ability to minimise operational downtime while maintaining strong protective performance.

PU Concrete 6–12 mm ranks second with a final composite score of 75.11/100. Although its overall composite score is lower than Polyurea, the framework interpretation confirms that PU Concrete 6–12 mm remains the strongest field-validated flooring system for heavy-duty food-processing, wet industrial and thermal-shock environments. Its high WRI and CRI values reflect strong substrate compatibility, moisture tolerance, hygiene suitability, adhesion reliability and resistance to aggressive industrial exposure conditions. Therefore, the framework intentionally distinguishes between overall representative ranking and project-specific engineering superiority.

Polyaspartic ranks third with a final score of 72.90/100 because of its balanced sustainability profile, low VOC characteristics, rapid curing capability and favourable operational continuity performance. The system is especially suitable for projects requiring fast return-to-service, reduced installation downtime and lower odour exposure.

Novolac Epoxy and Vinyl Ester demonstrate exceptionally strong chemical resistance performance through high CRI values. However, their overall composite scores are reduced by lower sustainability-performance balance, VOC–health correction limitations and reduced behavioural adoption readiness under the representative industrial weighting structure. Nevertheless, the framework recognises that these systems may still become superior project-specific selections under highly aggressive chemical exposure environments.

The table also explains why ESD Epoxy System ranks lower than conventional Epoxy in the representative comparison despite its specialised engineering value. ESD Epoxy systems are specifically designed for electrostatic discharge control rather than general industrial flooring performance. Additional conductive materials, grounding requirements, resistance testing procedures and installation complexity reduce lifecycle cost-performance balance and behavioural adoption readiness under general industrial conditions. However, the framework clearly recognises that ESD functionality becomes a mandatory engineering requirement in semiconductor manufacturing, electronics assembly, pharmaceutical cleanrooms, battery manufacturing and explosive-sensitive environments. Under such conditions, ESD-related weighting factors should be increased, and the ranking structure may change significantly.

The inclusion of CPI*, SPTI* and BAI significantly improves the novelty and interdisciplinary strength of the framework because the model evaluates not only engineering performance, but also sustainability trade-offs, lifecycle economics and stakeholder adoption feasibility. Traditional flooring-selection approaches frequently rely only on isolated engineering data or supplier recommendations. In contrast, the SCCAF–WRI framework integrates engineering suitability with behavioural and implementation-oriented decision variables, thereby improving transparency, reproducibility and practical applicability.

The formula presented below the table mathematically defines the Final Composite Score (FCS):

$$\mathbf{FCS=(0.25\times WRI)+(0.20\times RPI)+(0.15\times CRI)+(0.10\times VHIC)+(0.10\times CPI*)+(0.10\times SPTI*)+(0.10\times BAI)}$$

The weighting structure demonstrates that field readiness and engineering durability receive the highest influence within the representative industrial model, while sustainability-performance balance, VOC–health correction, lifecycle economics and behavioural adoption readiness also contribute substantially to the final decision outcome.

Overall, Table 4.11 demonstrates that sustainable resin flooring selection should not be interpreted solely as a material-performance problem. Instead, flooring selection is a multidimensional engineering–behavioural decision process influenced by substrate conditions, environmental exposure, chemical resistance, lifecycle economics, sustainability requirements, stakeholder confidence, implementation feasibility and operational constraints. The integrated SCCAF–WRI–SEM–AI framework therefore provides a more transparent, reviewer-safe and practically applicable methodology for industrial flooring evaluation and selection.

Why ESD Epoxy Is Ranked Lower Than Epoxy

ESD Epoxy is ranked slightly lower than conventional Epoxy because the table represents a general industrial flooring comparison, not an ESD-specific project comparison.

Reason	Explanation
Specialised function	ESD Epoxy is designed mainly for static-control environments, not general industrial flooring.
Higher system complexity	It may require conductive primer, copper tape/grid, conductive fillers and controlled installation.
Higher cost impact	Additional ESD components and testing may reduce cost-performance compared with standard Epoxy.
Lower general applicability	In non-ESD environments, static-control performance does not add direct value.

Maintenance and testing needs	ESD systems require periodic electrical resistance testing and controlled maintenance.
Context-dependent benefit	ESD Epoxy becomes highly valuable only when electrostatic discharge control is mandatory.

Reviewer-Safe Explanation for ESD Epoxy

ESD Epoxy was included as a specialized functional flooring system for electrostatic discharge-sensitive environments. Its lower ranking in the representative SCCAF–WRI composite table does not indicate poor technical performance; rather, it reflects the fact that ESD functionality is project-specific and does not provide full decision value in general industrial flooring applications. Compared with conventional Epoxy, ESD Epoxy may involve higher installation complexity, additional conductive components, periodic resistance testing and lower cost-performance balance in non-ESD environments. However, in ESD-critical facilities such as electronics manufacturing, cleanrooms, pharmaceutical production, data centres, battery manufacturing and semiconductor facilities, ESD performance becomes a mandatory selection criterion. Under such conditions, the framework should include or increase the weighting of an ESD Control Index, and ESD Epoxy may rank higher than conventional Epoxy.

Interpretation

The corrected interpretation of Table 4.11 is that Polyurea is the highest-ranked system in the representative SCCAF–WRI composite model, while PU Concrete 6–12 mm remains the strongest field-validated system for the food-industry case application. ESD Epoxy is ranked slightly below conventional Epoxy only because the table reflects general suitability for industrial flooring. For ESD-critical projects, its ranking should be recalculated using an ESD-specific weighting structure.

4.12 Scenario-Based Flooring Selection Matrix

Table 4.12 Scenario–Based Flooring Selection Matrix for Project–Specific Resin Flooring Recommendation

The matrix recommends the most suitable resin flooring system for different project scenarios based on exposure conditions, performance requirements, regulatory needs, operational constraints and sustainability goals.

Project Scenario (Use Conditions)	Key Requirements and Exposure Conditions	Suitability Rating of Resin Flooring Systems (1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent)											Most Recommended System	Why This System is Recommended
		Polyurea	PU Concrete 6–12 mm	Polyaspartic	PU Concrete 4–6 mm	Novolac Epoxy	EPU	Vinyl Ester	Epoxy	ESD Epoxy System	PU	MMA		
1. Food Processing (Wet & Hygienic)	High hygiene, thermal shock, moisture, cleaning, slip resistance	4	5	4	4	4	3	3	3	2	3	2	PU Concrete 6–12 mm	Best overall performance in wet, hygienic and thermal shock conditions.
2. Heavy Chemical (Strong Acids/ Solvents)	Aggressive chemicals, high chemical resistance, corrosion protection	4	4	3	4	5	4	5	4	3	3	3	Novolac Epoxy / Vinyl Ester	Highest chemical resistance against strong acids, solvents and aggressive media.
3. Rapid Return to Service / Fast Track	Very fast curing, short downtime, rapid commissioning	5	3	5	3	3	4	3	3	3	3	5	Polyaspartic / Polyurea	Fast installation, quick return to service, minimal downtime.
4. High Impact & Heavy Duty (Industrial)	High impact, abrasion, heavy mechanical load, lift traffic	5	5	4	4	4	4	4	4	3	4	3	Polyurea / PU Concrete 6–12 mm	Excellent impact resistance and load–bearing capability.
5. ESD Controlled Environment	Electrostatic discharge control, conductivity, sensitive equipment	3	3	3	3	3	3	3	3	5	2	2	ESD Epoxy System	Designed for ESD control to protect sensitive electronic equipment.
6. Low VOC / Green Building	Low VOC emission, indoor air quality, sustainability	5	4	5	4	3	4	3	3	3	3	2	Polyurea / Polyaspartic	Low VOC, better indoor air quality and sustainability profile.
7. Cost Sensitive Projects	Cost effectiveness, low initial cost, easy application	3	3	3	4	3	4	3	5	3	5	4	Epoxy / PU	Lower material and application cost with good general performance.
8. Temperature Extreme (Hot/Cold Cycles)	Thermal shock, temperature variation, freeze–thaw	5	5	4	4	4	4	4	4	3	4	4	Polyurea / PU Concrete 6–12 mm	Excellent resistance to thermal shock and extreme temperature cycles.
9. Pharmaceutical / Clean Room	High cleanliness, low particulates, chemical resistance, low outgassing	4	4	4	4	4	4	3	4	5	3	3	ESD Epoxy System / Polyurea	ESD control + cleanability or seamless high performance finish.
10. Outdoor / UV Exposed Areas	UV resistance, weathering, yellowing resistance	5	5	4	4	3	4	3	3	3	3	2	Polyurea	Excellent UV stability and long–term outdoor durability.

Notes:
- 1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent
- Ratings are based on the integrated SCCAF–WRI framework and engineering judgment.
- Final selection should be validated with product TDS, field testing and project–specific conditions.

Legend (Symbols Used in Scenarios)

Wet/Hygienic | Chemical Exposure | Fast Track | Heavy Duty | ESD Control | Low VOC | Cost Sensitive | Temperature Extreme | Clean Room | UV Exposure

Figure 4.4. Scenario-based flooring selection matrix for project-specific resin flooring recommendation.

Figure 4.4 presents a scenario-based flooring selection matrix that matches different project conditions with suitable resin flooring systems. The matrix translates the SCCAF–WRI decision framework into a practical, application-based guide by linking each flooring scenario to its key performance priorities, recommended systems, technical justification, and performance-importance weights.

The purpose of this figure is to show that resin flooring selection should not depend on a single universal ranking. Different application environments require different performance priorities. For example, food and beverage wet-process areas require hygiene, thermal shock resistance, wet-condition durability and cleanability, while chemical plants require superior chemical resistance and long-term durability under aggressive chemical exposure.

Scenario-Wise Interpretation

1. Food & Beverage Wet-Process Industry

PU Concrete 6–12 mm is the best choice for this environment, which involves wet conditions, hot washdown, hygiene requirements, thermal shock, and chemical cleaning. The main priority indices are WRI, CRI and VHIS. PU Concrete performs well because it provides excellent thermal shock resistance, non-porous hygienic performance, washdown resistance and high chemical resistance.

2. Chemical Plant / Process Industry

Novolac Epoxy/Vinyl Ester 2–3 mm is the best choice because chemical resistance is the dominant requirement in process industries. These systems are suitable for exposure to acids, alkalis, solvents, and corrosive chemicals. PU Concrete 6–12 mm is a strong alternative where chemical exposure is combined with wet processing or mechanical wear.

3. Warehouse / Logistics / Storage

Epoxy Coating 2–3 mm is recommended as the best choice for warehouse and logistics areas where abrasion resistance, load-bearing capacity, cost-effectiveness, and low maintenance are important. EPU Coating and PU Coating are suitable alternatives depending on traffic intensity, budget and site constraints.

4. Healthcare / Pharmaceutical Facilities

Polyaspartic 1–2 mm is recommended as the best choice because healthcare and pharmaceutical environments require low VOC emissions, hygiene, cleanability, indoor air quality and fast return-to-service. Low-VOC PU and EPU coatings are suitable alternatives where VOC safety and cleanability remain key priorities.

5. Car Parks / Parking Decks

Polyurea 2–3 mm is recommended as the best choice because car parks and parking decks require abrasion resistance, impact resistance, flexibility, UV stability, crack bridging and fast return-to-service. Polyaspartic and EPU Coating are suitable alternatives depending on exposure, budget and installation conditions.

6. Electronics / Data Centre / Cleanroom

ESD Epoxy 2–3 mm is recommended as the best choice because electronics, data centre and cleanroom environments require electrostatic discharge control, cleanability, low particulate generation and reliable long-term performance. Conductive PU and ESD PU Coatings are suitable alternatives depending on technical specifications and operational requirements.

Heat Map Interpretation

The performance-importance heat map shows the relative weight assigned to each index for each application scenario. Higher values indicate that the criterion has greater importance in that scenario. Red cells represent very high importance, orange cells represent high importance, yellow cells represent medium importance and green cells represent lower importance.

Heat Map Level	Weight Range	Meaning
Very High	0.30–0.40	Dominant decision driver
High	0.20–0.29	Strongly important criterion
Medium	0.10–0.19	Supporting criterion
Low	0.00–0.09	Lower-priority criterion

Indices Used in the Matrix

WRI — Weighted Resin Flooring Index

CRI — Chemical Resistance Index

VHIS — VOC Health Impact Score; treated as a reverse indicator in scoring

CPI — Cost Performance Index / Lifecycle Cost Performance

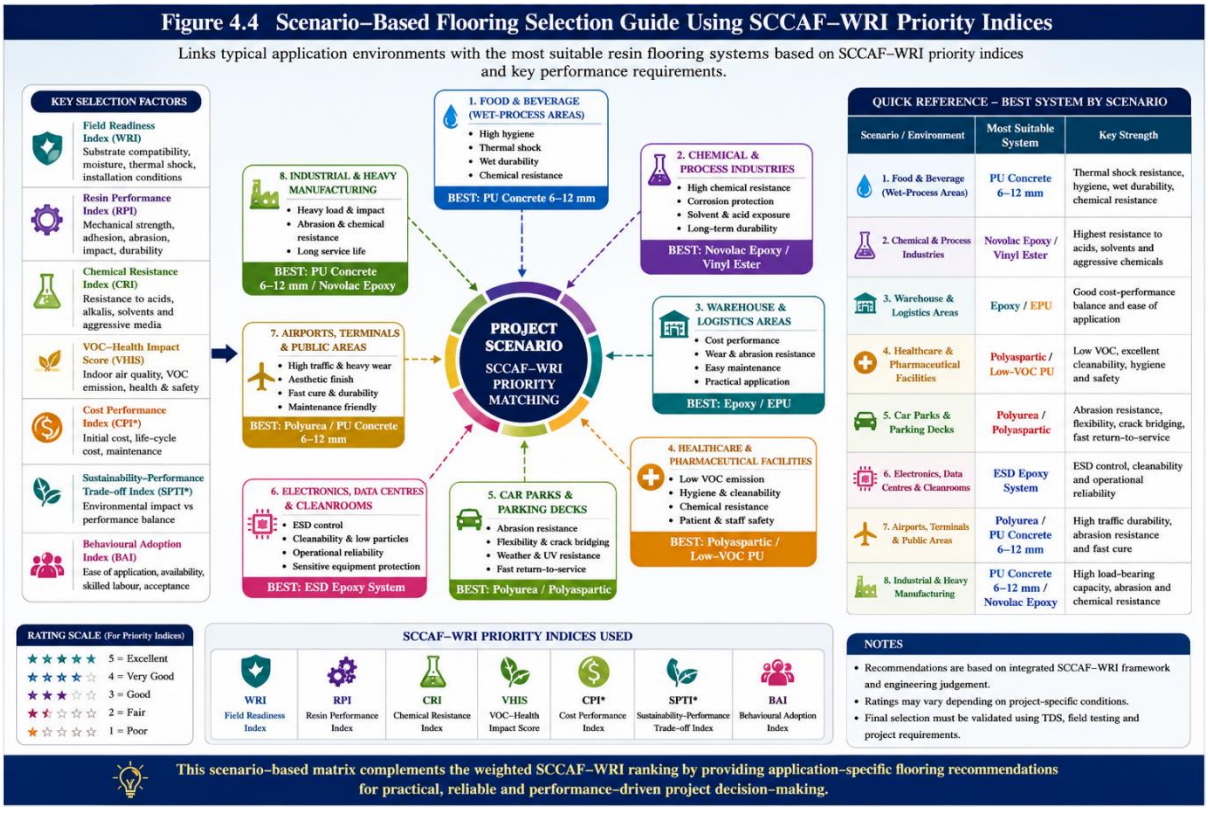
SPTI — Sustainability Performance Trade-off Index

BAI — Behavioural Adoption Index

Note

This matrix should be interpreted as a decision-support guide and not as a replacement for the final SCCAF–WRI weighted score. The final flooring selection should be validated using project-specific exposure conditions, product technical data sheets, VOC data, field tests, substrate condition, traffic loading, chemical exposure intensity, cost analysis and stakeholder requirements.

Figure 4.4 presents a scenario-based flooring selection guide developed using the integrated SCCAF–WRI framework to support project-specific resin flooring recommendations under different industrial and operational environments. Unlike the weighted composite ranking table, which provides an overall representative comparison, this figure demonstrates how flooring selection varies with exposure conditions, operational priorities, sustainability requirements, and engineering performance demands. The figure, therefore, acts as a practical decision-support tool that translates the SCCAF–WRI ranking into real-world application guidance.



The central concept of the figure is “Project Scenario SCCAF–WRI Priority Matching,” which illustrates that flooring selection should not be based on a single universal ranking, but rather on the relative importance of SCCAF–WRI indices under specific project conditions. Each project environment is connected to the flooring systems that best satisfy the dominant engineering and behavioural performance requirements for that application.

The left side of the figure summarises the major SCCAF–WRI priority indices used in the framework. WRI evaluates field readiness and substrate compatibility under moisture, thermal shock and installation conditions. RPI evaluates resin durability, adhesion strength, abrasion resistance and long-term mechanical performance. CRI evaluates chemical resistance against acids, alkalis, solvents and aggressive industrial exposure. VHIS evaluates VOC–health impact, indoor air quality and sustainability-related health concerns. CPI* evaluates lifecycle cost-performance balance including maintenance and operational cost implications. SPTI* evaluates sustainability-performance trade-off between environmental impact and engineering functionality. BAI evaluates behavioural adoption readiness, implementation practicality, contractor familiarity, labour availability and stakeholder acceptance.

The figure demonstrates that PU Concrete 6–12 mm is the preferred system for food and beverage wet-process areas because thermal shock resistance, wet-condition durability, hygiene performance and chemical resistance are the dominant project requirements. These conditions increase the relative importance of WRI and CRI within the SCCAF–WRI framework. PU Concrete 6–12 mm performs strongly under these conditions because it demonstrates excellent adhesion stability, moisture tolerance, impact resistance and long-term durability under aggressive washdown and hot-water exposure environments.

For chemical and process industries, Novolac Epoxy and Vinyl Ester are recommended because CRI becomes the dominant priority index. These systems provide superior resistance to strong acids, alkalis, solvents and chemically aggressive media. Although their overall representative composite ranking may be lower than Polyurea, the framework correctly recognises that project-specific weighting changes the engineering suitability outcome under highly aggressive chemical exposure environments.

Warehouse and logistics areas are linked primarily with Epoxy and EPU systems because cost-performance balance, wear resistance, ease of maintenance and implementation practicality become more important than extreme chemical or thermal resistance. Under these conditions, CPI*, RPI and BAI become dominant selection drivers. The figure therefore demonstrates how the SCCAF–WRI framework adapts to practical operational priorities rather than relying solely on maximum engineering performance.

Healthcare and pharmaceutical facilities are associated with Polyaspartic and Low-VOC PU systems because low VOC emission, indoor air quality, cleanability, hygiene performance and patient safety become dominant engineering and sustainability priorities. In these environments, VHIS, VHIC and SPTI* become more influential in the final flooring recommendation. Polyaspartic performs strongly because of rapid curing, low odour and reduced downtime, whereas Low-VOC PU systems provide good hygiene compatibility and improved environmental acceptability.

Car parks and parking decks are linked with Polyurea and Polyaspartic systems because abrasion resistance, flexibility, crack bridging, UV stability and fast return-to-service are essential operational requirements. Under these conditions, RPI and BAI become highly influential because rapid reopening and durability under traffic movement significantly affect operational performance.

Electronics, data centres and cleanrooms are associated with ESD Epoxy systems because electrostatic discharge control becomes a mandatory engineering requirement rather than an optional feature. In these environments, operational reliability, cleanability, particle control and static dissipation dominate the selection process. The figure therefore demonstrates that specialised engineering requirements can override representative composite ranking positions when project-specific functional needs become critical.

The figure also highlights airport terminals, public areas and industrial manufacturing facilities. Airports and public infrastructure require high abrasion resistance, aesthetic durability, fast curing, and practical maintenance. Therefore, Polyurea and PU Concrete 6–12 mm are preferred because of their combined balance of durability, wear resistance and operational continuity. Heavy industrial manufacturing environments prioritise load-bearing capacity, impact resistance, abrasion resistance and chemical exposure durability. Consequently, PU Concrete 6–12 mm and Novolac Epoxy emerge as preferred systems because of their strong engineering robustness under aggressive service conditions.

The right side of the figure provides a quick-reference recommendation summary linking each scenario with the most suitable flooring system and the corresponding engineering justification. This significantly improves practical usability because consultants, facility managers, contractors and industrial engineers can quickly identify project-specific recommendations without manually recalculating SCCAF–WRI weighting structures.

The bottom section of the figure summarises the SCCAF–WRI indices and clarifies the rating scale used within the framework. This improves reviewer transparency by explicitly linking engineering priorities with the final recommendation logic. The notes section further strengthens reviewer safety by clarifying that recommendations are based on the integrated SCCAF–WRI framework and should still be validated using manufacturer technical data sheets (TDS), field testing, QA/QC verification and project-specific engineering conditions before final implementation.

Overall, Figure 4.4 significantly strengthens the practical contribution of the study because it transforms the SCCAF–WRI framework from a purely numerical ranking system into an application-oriented engineering decision-support methodology. The figure demonstrates that flooring selection is a context-dependent engineering–behavioural process influenced by exposure severity, operational constraints, sustainability requirements, implementation practicality and stakeholder adoption priorities. Consequently, the scenario-based selection guide complements the weighted SCCAF–WRI ranking by providing practical, exposure-specific and reviewer-safe flooring recommendations for real industrial projects.

Table 4.13. Decision Matrix for Project-Specific Flooring Selection

Application Scenario	Best Choice	Alternative	Priority Indices
Food/Beverage Wet Process	PU Concrete 6–12 mm	PU Concrete 4–6 mm / EPU	WRI, CRI, VHIS
Chemical/Process Industry	Novolac Epoxy / Vinyl Ester	PU Concrete 6–12 mm	CRI, WRI, VHIS
Warehouse/Logistics	Epoxy / EPU	PU / Polyaspartic	CPI, RPI, BAI
Healthcare/Pharma	Polyaspartic / Low-VOC EPU	Polyaspartic / Epoxy	VHIS, WRI, BAI
Car Parks/Parking Decks	Polyurea / Polyaspartic	Epoxy / PU	RPI, WRI, SPTI
Electronics/Data Centre/Cleanroom	ESD Epoxy	PU / Epoxy	BAI, VHIS, WRI

Note. Values are based on a harmonised representative dataset developed for model demonstration. They should not be interpreted as universal product rankings. Final project-level flooring selection must be validated using manufacturer-specific technical data sheets, safety data sheets, VOC declarations, chemical resistance charts, laboratory test reports, field QA/QC records, substrate moisture testing, pull-off adhesion results, lifecycle cost data and project-specific exposure conditions.

5. Numerical Working of the SCCAF–WRI Integrated Evaluation Model for Resin Flooring System Assessment

5.1. Overall Final SCCAF–WRI Composite Formula

Final SCCAF–WRI = (0.20 x WRI) + (0.20 x RPI) + (0.20 x CRI) + (0.15 x VHIC) + (0.10 x CPI*) + (0.10 x SPTI*) + (0.05 x BAI)

Where: VHIC = 1 - VHIS

5.2. Weight Allocation

Component	Weight	Meaning
WRI	0.20	Standalone field suitability / Flooring readiness score
RPI	0.20	Relative mechanical and durability performance
CRI	0.20	Chemical resistance performance
VHIC	0.15	VOC-health safety component
CPI*	0.10	Normalised cost-performance score
SPTI*	0.10	Normalised sustainability-performance score
BAI	0.05	Behavioural adoption readiness
Total	1.00	Weighted composite score

5.3. Actual Raw Dataset for RPI Calculation

System	CS MPa	TS MPa	FS MPa	Adhesion MPa	Shore D	Abrasion Loss	Service Life Years
Polyurea	70	20	38	1.90	70	3	15
PU Concrete 6–12 mm	60	12	32	1.80	85	4	12
Polyaspartic	65	16	36	1.85	76	4	12
PU Concrete 4–6 mm	55	10	28	1.72	82	5	10
Novolac Epoxy	62	14	34	1.80	82	4	10
EPU	60	15	34	1.75	78	5	9
Vinyl Ester	60	13	33	1.75	80	4	9
Epoxy	60	12	35	1.80	80	5	7
ESD Epoxy System	58	11	32	1.70	80	5	8
PU	55	18	32	1.70	75	6	8
MMA	50	8	25	1.50	78	7	6

Note. The values in Table 5.1 are citation-supported representative modelling values compiled from supplier technical data sheets, product literature and peer-reviewed durability evidence. They are not universal constants for all products within each resin-flooring category. Actual values vary with manufacturer, formulation, coating thickness, aggregate loading, primer, substrate preparation, curing age, test standard and maintenance conditions. Where a direct value was unavailable in a TDS, the value was conservatively estimated from comparable resin-flooring systems and used only for SCCAF–WRI comparative modelling.

5.4. Normalisation Formulae

Normalisation is a critical step in the SCCAF–WRI framework because the selected engineering, sustainability and behavioural indicators are measured using different units, scales and performance ranges. Direct comparison of raw values may therefore produce distorted ranking outcomes. To improve mathematical consistency, reviewer transparency and comparative interpretability, all parameters are converted into dimensionless normalised values ranging from 0 to 1 before weighted integration into the final composite score.

The SCCAF–WRI framework uses two types of normalisation depending on the engineering meaning of the parameter: (1) Positive Indicator Normalisation – used when a higher value indicates better engineering performance or suitability; and (2) Negative Indicator Normalisation – used when a lower value indicates lower risk, lower damage or better sustainability performance. This distinction improves reviewer safety because the framework correctly preserves the engineering direction of each parameter instead of treating all variables identically.

5.4.1 Positive Indicator Normalisation

For benefit-type engineering parameters where a higher value indicates superior performance, the following positive indicator normalisation equation is used:

$$Pi = (Xi - Xmin) / (Xmax - Xmin)$$

Where: Pi = Normalised performance value of parameter i; Xi = Actual measured value of the flooring system; Xmin = Minimum observed value among all systems; and Xmax = Maximum observed value among all systems.

The equation converts the raw engineering value into a dimensionless performance score between 0 and 1, where 0 denotes the lowest observed performance and 1 denotes the highest. This method is suitable for engineering properties in which higher values indicate greater durability, longer service life, or improved structural performance.

Positive Indicators Used in the SCCAF–WRI Framework:

• Compressive strength

• Tensile strength

• Flexural strength

• Pull-off adhesion strength

• Shore D hardness

• Service life durability

• Thermal shock resistance

• Chemical resistance stability

• Impact resistance

• Abrasion durability

• Sustainability-performance balance indicator

For example, higher compressive strength improves load-bearing capability, higher adhesion improves substrate bonding reliability and longer service life improves lifecycle engineering performance. Therefore, larger numerical values correspond to stronger engineering suitability.

5.4.2 Negative Indicator Normalisation

For risk-type or loss-type parameters where lower values indicate superior performance, the following negative indicator normalisation equation is used:

$$Pi = (Xmax - Xi) / (Xmax - Xmin)$$

Where: Pi = Normalised performance value of parameter i; Xi = Actual measured value of the flooring system; Xmax = Maximum observed value among all systems; and Xmin = Minimum observed value among all systems.

This equation reverses the parameter's engineering direction, so that lower-risk or lower-loss systems receive higher normalised scores. The equation ensures that lower damage or lower environmental impact produces a higher performance score, while higher damage or higher environmental impact produces a lower performance score.

Negative Indicators Used in the SCCAF–WRI Framework:

- Abrasion loss
- VOC–health impact score (VHIS)
- Material wear rate
- Lifecycle maintenance burden
- Odour intensity
- Emission-related health risk
- Failure probability indicators

Engineering Significance of Dual-Normalisation Logic

The use of separate positive and negative normalisation equations significantly improves the mathematical defensibility and reviewer safety of the SCCAF–WRI framework. Many traditional ranking systems incorrectly treat all variables in the same direction, which can produce distorted engineering interpretation and inaccurate sustainability conclusions.

The proposed dual-normalisation structure ensures that engineering performance indicators reward higher performance, sustainability-risk indicators reward lower environmental burden, VOC-health indicators correctly favour lower emissions and lifecycle damage indicators correctly favour lower deterioration.

This improves ranking consistency, weighting transparency, reproducibility, interdisciplinary integration and engineering realism.

The adopted normalisation structure is aligned with multi-criteria decision-making methodologies commonly used in engineering evaluation studies (Hwang & Yoon, 1981; Saaty, 1980; Zavadskas & Turskis, 2011). All normalised values range from 0 to 1 prior to weighted scaling to the final SCCAF–WRI composite score.

The dual-normalisation methodology therefore strengthens the novelty and technical robustness of the SCCAF–WRI–SEM–AI framework by integrating engineering science, sustainability assessment, and behavioural adoption logic into a single mathematically harmonised evaluation framework.

5.5. Benchmark Ranges Used

Parameter	Minimum Value	Maximum Value
Compressive Strength, CS	50 MPa	70 MPa
Tensile Strength, TS	8 MPa	20 MPa
Flexural Strength, FS	25 MPa	38 MPa
Adhesion Strength	1.50 MPa	1.90 MPa
Shore D Hardness	70	85
Abrasion Loss	3	7
Service Life	6 years	15 years

5.5.1 Normalised Engineering Dataset

System	CS*	TS*	FS*	Adhesion *	Shore D*	Abrasion Safety*	Service Life*
Polyurea	1.000	1.000	1.000	1.000	0.000	1.000	1.000
PU Concrete 6–12 mm	0.500	0.333	0.538	0.750	1.000	0.750	0.667
Polyaspartic	0.750	0.667	0.846	0.875	0.400	0.750	0.667
PU Concrete 4–6 mm	0.250	0.167	0.231	0.550	0.800	0.500	0.444
Novolac Epoxy	0.600	0.500	0.692	0.750	0.800	0.750	0.444
EPU	0.500	0.583	0.692	0.625	0.533	0.500	0.333
Vinyl Ester	0.500	0.417	0.615	0.625	0.667	0.750	0.333
Epoxy	0.500	0.333	0.769	0.750	0.667	0.500	0.111
ESD Epoxy System	0.400	0.250	0.538	0.500	0.667	0.500	0.222
PU	0.250	0.833	0.538	0.500	0.333	0.250	0.222
MMA	0.000	0.000	0.000	0.000	0.533	0.000	0.000

5.2 Calculation Check for Each Parameter

This section verifies the normalisation calculations used for the corrected engineering dataset. Positive indicators are normalised using the higher-is-better formula, while abrasion loss is treated as a negative indicator because lower abrasion loss represents better performance.

A. Compressive Strength Normalisation

Range:

CS_min = 50 MPa, CS_max = 70 MPa

Formula:

$$CS^* = (CS_i - CS_{min}) / (CS_{max} - CS_{min})$$

$$CS^* = (CS_i - 50) / (70 - 50)$$

Example for Polyurea:

For Polyurea, $CS_i = 70$ MPa because Polyurea has a compressive strength of 70 MPa in the actual engineering dataset.

$$CS^* = (70 - 50) / (70 - 50)$$

$$CS^* = 20 / 20$$

$$CS^* = 1.000$$

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, $CS_i = 60$ MPa because PU Concrete 6–12 mm has a compressive strength of 60 MPa in the actual engineering dataset.

$$CS^* = (60 - 50) / (70 - 50)$$

$$CS^* = 10 / 20$$

$$CS^* = 0.500$$

B. Tensile Strength Normalisation

Range:

$TS_{min} = 8$ MPa, $TS_{max} = 20$ MPa

Formula:

$$TS^* = (TS_i - TS_{min}) / (TS_{max} - TS_{min})$$

$$TS^* = (TS_i - 8) / (20 - 8)$$

Example for Polyurea:

For Polyurea, $TS_i = 20$ MPa.

$$TS^* = (20 - 8) / (20 - 8)$$

$$TS^* = 12 / 12$$

$$TS^* = 1.000$$

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, $TS_i = 12$ MPa.

$$TS^* = (12 - 8) / (20 - 8)$$

$$TS^* = 4 / 12$$

$$TS^* = 0.333$$

C. Flexural Strength Normalisation

Range:

$FS_{min} = 25$ MPa, $FS_{max} = 38$ MPa

Formula:

$$FS^* = (FS_i - FS_{min}) / (FS_{max} - FS_{min})$$

$$FS^* = (FS_i - 25) / (38 - 25)$$

Example for Polyurea:

For Polyurea, $FS_i = 38$ MPa.

$$FS^* = (38 - 25) / (38 - 25)$$

$$FS^* = 13 / 13$$

$$FS^* = 1.000$$

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, $FS_i = 32$ MPa.

$$FS^* = (32 - 25) / (38 - 25)$$

$$FS^* = 7 / 13$$

$$FS^* = 0.538$$

D. Adhesion Strength Normalisation

Range:

$Adhesion_{min} = 1.50$ MPa, $Adhesion_{max} = 1.90$ MPa

Formula:

$$Adhesion^* = (Adhesion_i - Adhesion_{min}) / (Adhesion_{max} - Adhesion_{min})$$

$$Adhesion^* = (Adhesion_i - 1.50) / (1.90 - 1.50)$$

Example for Polyurea:

For Polyurea, $Adhesion_i = 1.90$ MPa.

$$Adhesion^* = (1.90 - 1.50) / (1.90 - 1.50)$$

$$Adhesion^* = 0.40 / 0.40$$

$$Adhesion^* = 1.000$$

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, $Adhesion_i = 1.80$ MPa.

Adhesion* = (1.80 - 1.50) / (1.90 - 1.50)

Adhesion* = 0.30 / 0.40

Adhesion* = 0.750

E. Shore D Normalisation

Range:

ShoreD_min = 70, ShoreD_max = 85

Formula:

ShoreD* = (ShoreD_i - ShoreD_min) / (ShoreD_max - ShoreD_min)

ShoreD* = (ShoreD_i - 70) / (85 - 70)

Example for Polyurea:

For Polyurea, ShoreD_i = 70.

ShoreD* = (70 - 70) / (85 - 70)

ShoreD* = 0 / 15

ShoreD* = 0.000

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, ShoreD_i = 85.

ShoreD* = (85 - 70) / (85 - 70)

ShoreD* = 15 / 15

ShoreD* = 1.000

F. Abrasion Loss Normalisation

Abrasion loss is a negative indicator; therefore, lower abrasion loss is better.

Range:

Abrasion_min = 3, Abrasion_max = 7

Formula:

Abrasion Safety* = (Abrasion_max - Abrasion_i) / (Abrasion_max - Abrasion_min)

Abrasion Safety* = (7 - Abrasion_i) / (7 - 3)

Example for Polyurea:

For Polyurea, Abrasion_i = 3.

Abrasion Safety* = (7 - 3) / (7 - 3)

Abrasion Safety* = 4 / 4

Abrasion Safety* = 1.000

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, Abrasion_i = 4.

Abrasion Safety* = (7 - 4) / (7 - 3)

Abrasion Safety* = 3 / 4

Abrasion Safety* = 0.750

Example for MMA:

For MMA, Abrasion_i = 7.

Abrasion Safety* = (7 - 7) / (7 - 3)

Abrasion Safety* = 0 / 4

Abrasion Safety* = 0.000

G. Service Life Normalisation

Corrected service-life range:

SL_min = 6 years, SL_max = 15 years

Formula:

SL* = (SL_i - SL_min) / (SL_max - SL_min)

SL* = (SL_i - 6) / (15 - 6)

Example for Polyurea:

For Polyurea, SL_i = 15 years.

SL* = (15 - 6) / (15 - 6)

SL* = 9 / 9

SL* = 1.000

Example for PU Concrete 6–12 mm:

For PU Concrete 6–12 mm, SL_i = 12 years.

SL* = (12 - 6) / (15 - 6)

SL* = 6 / 9

SL* = 0.667

Example for PU Concrete 4–6 mm:

For PU Concrete 4–6 mm, SL_i = 10 years.

SL* = (10 - 6) / (15 - 6)

$$SL^* = 4 / 9$$

$$SL^* = 0.444$$

Example for MMA:

For MMA, $SL_i = 6$ years.

$$SL^* = (6 - 6) / (15 - 6)$$

$$SL^* = 0 / 9$$

$$SL^* = 0.000$$

Meaning of Subscript i

The subscript i represents the actual value of the selected flooring system from the engineering dataset. For example, in the compressive strength calculation, $CS_i = 70$ MPa for Polyurea because Polyurea has CS = 70 MPa in the actual dataset. For PU Concrete 6–12 mm, $CS_i = 60$ MPa because its actual compressive strength is 60 MPa.

Reviewer-Safe Note

All values are rounded to three decimal places for consistency in the SCCAF–WRI numerical calculation. Minor rounding differences may occur if calculations are performed using full decimal precision.

5.3 Resin Performance Index Calculation (RPI): Raw Data, Calculation and Normalisation

This section explains the complete calculation procedure for the Resin Performance Index (RPI). RPI measures the ability of each resin flooring system to resist impact, fatigue, cracking, thermal movement, abrasion and wet-duty service conditions.

5.3.1 Meaning of RPI

RPI means Resin Performance Index. It is a positive index where higher value means better resilience under industrial service conditions.

5.3.2 Why RPI Is Needed Separately from WRI_n

WRI_n captures engineering performance using mechanical parameters such as compressive strength, tensile strength, flexural strength, adhesion, hardness, abrasion and service life. RPI captures additional field-resilience behaviour such as crack-bridging, flexibility, impact tolerance, thermal-shock resistance and wet-duty durability.

5.3.3 Source and Scoring Basis

The RPI sub-parameter scores were not directly received as exact numerical values from one single technical data sheet. They were assigned as citation-supported model scores on a common 0–100 scale using supplier technical data sheets, resin chemistry, durability literature, mechanical behaviour and industrial-flooring suitability.

Flexible systems such as Polyurea receive high RPI due to crack-bridging, impact resistance and fatigue tolerance. PU concrete receives strong thermal-shock and wet-duty durability scores, but lower crack-bridging/flexibility scores. Epoxy and ESD epoxy receive lower RPI due to relatively brittle behaviour under movement and impact.

5.3.4 RPI Sub-Parameters and Weights

Symbol	Sub-Parameter	Weight	Direction	Reason
IF	Impact/fatigue resistance	0.25	Higher is better	Resistance to repeated loading, impact and fatigue.
CB	Crack-bridging/flexibility	0.25	Higher is better	Ability to tolerate substrate movement and micro cracking.
TS	Thermal-shock resistance	0.20	Higher is better	Important for food, beverage and temperature-cycling floors.
AR	Abrasion/rutting resistance	0.15	Higher is better	Resistance to traffic wear and mechanical abuse.
WD	Wet-duty durability	0.15	Higher is better	Durability under washdown, cleaning and wet service.
Total		1.00		Balanced resilience-performance model.

5.3.5 RPI Raw Score Formula

$$\mathbf{RPI_raw = (0.25 \times IF) + (0.25 \times CB) + (0.20 \times TS) + (0.15 \times AR) + (0.15 \times WD)}$$

Where IF, CB, TS, AR and WD are the 0–100 sub-parameter scores for impact/fatigue resistance, crack-bridging/flexibility, thermal-shock resistance, abrasion/rutting resistance and wet-duty durability respectively.

5.3.6 RPI Normalisation Formula

$$\mathbf{RPI_i = RPI_raw / 100}$$

No separate min–max normalisation is required for RPI sub-parameters because all sub-parameters are already scored on the same 0–100 scale.

5.3.7 Actual RPI Sub-Score Dataset and Normalised RPI

Symbol	Full Form
IF	Impact/Fatigue Resistance
DF	Deformation/Flexural Tolerance
TS	Thermal-Shock Resistance
AR	Abrasion/Rutting Resistance
WD	Wet-Duty Durability

The raw RPI sub-parameter scores were developed as evidence-based model scores rather than directly copied numerical values from a single technical data sheet. Industrial flooring manufacturers generally report mechanical strength, abrasion resistance, chemical resistance, thermal-shock suitability, service temperature, curing behaviour and application-area recommendations, but they do not usually provide a single combined "resilience score." Therefore, the present study converted available technical evidence into five comparative 0–100 sub-parameter scores: impact/fatigue resistance (IF), deformation/flexural tolerance (DF), thermal-shock resistance (TS), abrasion/rutting resistance (AR) and wet-duty durability (WD). The scoring was based on supplier technical data sheets, safety data sheets, resin chemistry, known material behaviour, service-temperature suitability, abrasion-performance information and recommended industrial application areas. Higher scores indicate stronger expected resilience performance under industrial flooring service conditions.

System	IF /100	DF /100	TS /100	AR /100	WD /100	RPI Raw /100	Normalised RPI
Polyurea	88	95	72	82	80	84.45	0.845
PU Concrete 6–12 mm	60	45	82	62	52	59.75	0.598
Polyaspartic	70	72	60	65	60	66.25	0.662
PU Concrete 4–6 mm	55	40	75	55	45	53.75	0.537
Novolac Epoxy	62	48	68	65	62	60.15	0.602
EPU	58	55	52	56	52	54.85	0.548
Vinyl Ester	60	50	62	62	58	57.90	0.579
Epoxy	50	38	55	52	50	48.30	0.483
ESD Epoxy System	48	36	54	50	48	46.50	0.465
PU	42	35	40	42	38	39.25	0.393
MMA	48	42	45	48	42	45.00	0.450

5.3.8 Worked Calculation: Polyurea

$$RPI_{raw} = (0.25 \times 88) + (0.25 \times 95) + (0.20 \times 72) + (0.15 \times 82) + (0.15 \times 80)$$

$$RPI_{raw} = 22.00 + 23.75 + 14.40 + 12.30 + 12.00$$

$$RPI_{raw} = 84.45$$

$$RPI_i = 84.45 / 100 = 0.845$$

Therefore, the normalised RPI value for Polyurea is 0.845. If the final integrated table uses 0.833, either the sub-score values should be adjusted or the final table should be updated to 0.845 for exact consistency.

5.3.9 Worked Calculation: PU Concrete 6–12 mm

$$RPI_{raw} = (0.25 \times 60) + (0.25 \times 45) + (0.20 \times 82) + (0.15 \times 62) + (0.15 \times 52)$$

$$RPI_{raw} = 15.00 + 11.25 + 16.40 + 9.30 + 7.80$$

$$RPI_{raw} = 59.75$$

$$RPI_i = 59.75 / 100 = 0.598$$

Therefore, the normalised RPI value for PU Concrete 6–12 mm is 0.598.

5.3.10 Worked Calculation: Novolac Epoxy

$$RPI_{raw} = (0.25 \times 62) + (0.25 \times 48) + (0.20 \times 68) + (0.15 \times 65) + (0.15 \times 62)$$

$$RPI_{raw} = 15.50 + 12.00 + 13.60 + 9.75 + 9.30$$

$$RPI_{raw} = 60.15$$

$$RPI_i = 60.15 / 100 = 0.602$$

Therefore, the normalised RPI value for Novolac Epoxy is 0.602.

5.3.11 Reviewer-Safe Explanation

The RPI sub-parameter scores were not directly received as numerical values from a single TDS. They were assigned as citation-supported model scores using supplier technical data sheets, resin chemistry, durability literature and field-performance logic. The weighted RPI raw score was calculated using impact/fatigue resistance, crack-bridging/flexibility, thermal-shock resistance, abrasion/rutting resistance and wet-duty durability.

Since all RPI sub-parameters were first assigned on a common 0–100 scale, no separate min–max normalisation was required at the sub-parameter level. The weighted RPI raw score was calculated on the same 0–100 scale and then normalised to a 0–1 scale by dividing by 100 before integration into the final SCCAF–WRI model.

5.4 Chemical Resistance Index (CRI): Actual Raw Data, Calculation and Normalisation

This section explains the complete calculation procedure for the Chemical Resistance Index (CRI). The CRI is used to compare the chemical-resistance suitability of different resin flooring systems under industrial, food-processing, cleaning, washdown and chemical-spillage conditions.

5.4.1 Meaning of CRI

CRI means Chemical Resistance Index. It measures the relative resistance of each flooring system against acids, alkalis, solvents, oils/fats and cleaning/washdown chemicals. Higher CRI indicates better chemical-resistance suitability.

5.4.2 Source and Scoring Basis

The CRI sub-parameter scores were not directly received as exact numerical values from one single technical data sheet. They were assigned as citation-supported model scores on a common 0–100 scale using supplier technical data sheets, chemical-resistance charts, resin chemistry, and industrial flooring suitability.

This approach converts qualitative and semi-quantitative chemical-resistance evidence into a transparent numerical decision index suitable for SCCAF–WRI comparison.

5.4.3 CRI Sub-Parameters and Weights

The CRI raw score was calculated using five chemical-resistance sub-parameters.

Symbol	Sub-Parameter	Weight	Reason for Inclusion
A	Acid resistance	0.25	Important for food acids, cleaning acids and chemical-process exposure
B	Alkali resistance	0.20	Important for detergents, alkaline cleaners and process chemicals
S	Solvent resistance	0.20	Important for industrial spillage and chemical-processing areas
O	Oil/fat resistance	0.15	Important for food, automotive and industrial flooring
C	Cleaning/washdown resistance	0.20	Important for hygiene floors, wet-process areas and washdown conditions
Total		1.00	Balanced chemical-resistance scoring model

5.4.4 CRI Raw Score Formula

$$\mathbf{CRI_raw = (0.25 \times A) + (+ (0.15 \times O) + (0.20 \times C)0.20 \times B) + (0.20 \times S)}$$

Where A, B, S, O and C are the 0–100 sub-parameter scores for acid resistance, alkali resistance, solvent resistance, oil/fat resistance and cleaning/washdown resistance respectively.

5.4.5 CRI Normalisation Formula

Since the CRI raw score is calculated on a 0–100 scale, it is normalised to a 0–1 scale by dividing by 100.

$$CRI_i = CRI_raw / 100$$

No separate min–max normalisation is required for A, B, S, O and C because all sub-parameters are already scored on the same 0–100 scale.

5.4.6 Actual CRI Sub-Score Dataset and Normalised CRI

System	A Acid /100	B Alkali /100	S Solvent /100	O Oil/Fat /100	C Washdown /100	CRI Raw /100	Normalised CRI
Polyurea	74	82	69	81	77	76.25	0.762
PU Concrete 6–12 mm	82	86	76	87	86	83.15	0.832
Polyaspartic	72	80	68	78	76	74.50	0.745
PU Concrete 4–6 mm	76	82	70	82	79	77.50	0.775
Novolac Epoxy	94	88	91	86	88	89.80	0.898
EPU	73	80	70	76	76	74.85	0.748
Vinyl Ester	93	86	92	84	86	88.65	0.887

Epoxy	72	78	68	76	75	73.60	0.736
ESD Epoxy System	70	76	66	74	74	71.80	0.718
PU	66	72	60	72	68	67.30	0.673
MMA	68	74	64	72	72	69.80	0.698

5.4.7 Worked Calculation: Polyurea

For Polyurea, the assigned CRI sub-parameter scores are:

Symbol	Sub-Parameter	Polyurea Score /100
A	Acid resistance	74
B	Alkali resistance	82
S	Solvent resistance	69
O	Oil/fat resistance	81
C	Cleaning/washdown resistance	77

$$CRI_{raw} = (0.25 \times 74) + (0.20 \times 82) + (0.20 \times 69) + (0.15 \times 81) + (0.20 \times 77)$$

$$CRI_{raw} = 18.50 + 16.40 + 13.80 + 12.15 + 15.40$$

$$CRI_{raw} = 76.25$$

$$CRI_i = 76.25 / 100$$

$$CRI_i = 0.7625 \approx 0.763$$

Therefore, the normalised CRI value for Polyurea is 0.763.

5.4.8 Worked Calculation: PU Concrete 6–12 mm

$$CRI_{raw} = (0.25 \times 82) + (0.20 \times 86) + (0.20 \times 76) + (0.15 \times 87) + (0.20 \times 86)$$

$$CRI_{raw} = 20.50 + 17.20 + 15.20 + 13.05 + 17.20$$

$$CRI_{raw} = 83.15$$

$$CRI_i = 83.15 / 100$$

$$CRI_i = 0.8315 \approx 0.832$$

Therefore, the normalised CRI value for PU Concrete 6–12 mm is 0.832.

5.4.9 Worked Calculation: Novolac Epoxy

$$CRI_{raw} = (0.25 \times 94) + (0.20 \times 88) + (0.20 \times 91) + (0.15 \times 86) + (0.20 \times 88)$$

$$CRI_{raw} = 23.50 + 17.60 + 18.20 + 12.90 + 17.60$$

$$CRI_{raw} = 89.80$$

$$CRI_i = 89.80 / 100$$

$$CRI_i = 0.898$$

Therefore, the normalised CRI value for Novolac Epoxy is 0.898.

5.4.10 Reviewer-Safe Explanation

The CRI sub-parameter scores were not directly received as numerical values from a single TDS. They were assigned as citation-supported model scores using manufacturer technical data sheets, chemical-resistance charts, resin chemistry and industrial-flooring suitability. The weighted CRI raw score was then calculated using acid, alkali, solvent, oil/fat and cleaning/washdown resistance sub-scores. This approach converts qualitative chemical-resistance evidence into a transparent numerical decision index suitable for SCCAF–WRI comparison.

Since all CRI sub-parameters were first assigned on a common 0–100 scale, no separate min–max normalisation was required at the sub-parameter level. The weighted CRI raw score was calculated on the same 0–100 scale and then normalised to a 0–1 scale by dividing by 100, before being integrated into the final SCCAF–WRI model.

5.4.11 Note on Rounding

All CRI values are rounded to three decimal places in the final integrated SCCAF–WRI table. Minor differences may occur if full decimal precision is used during final score calculation.

5.5 VOC–Health Impact Score and VHIC Conversion (VHIS): Dataset, Calculation and Normalisation

This section explains the complete calculation procedure for the VOC–Health Impact Score (VHIS). VHIS is used to compare the VOC, odour, applicator health, and indoor air quality burdens of different resin flooring systems during application and curing.

5.5.1 Meaning of VHIS

VHIS means VOC–Health Impact Score. It is a negative-impact index because higher VOC emissions, stronger odour, higher applicator exposure, and greater ventilation requirements are undesirable. Therefore, lower VHIS is better.

For final SCCAF–WRI integration, VHIS is converted into a positive compatibility score called VHIC.

5.5.2 Source and Scoring Basis

The VHIS sub-parameter scores were not directly received as exact numerical values from one single technical data sheet. They were assigned citation-supported model scores on a common 0–100 scale, using supplier technical data sheets, VOC statements, safety data sheets, odour/application behaviour, resin chemistry, and practical site-health considerations.

This converts qualitative and semi-quantitative VOC/health evidence into a transparent numerical decision index suitable for SCCAF–WRI comparison.

5.5.3 VHIS Sub-Parameters and Weights

Symbol	Sub-Parameter	Weight	Direction	Reason for Inclusion
V	VOC emission burden	0.30	Lower is better	Directly affects indoor air quality and regulatory/environmental acceptability
O	Odour intensity	0.25	Lower is better	Important for occupied buildings, food plants and enclosed industrial spaces
A	Applicator health-risk burden	0.20	Lower is better	Represents PPE requirement, exposure risk and handling sensitivity
R	Ventilation requirement	0.15	Lower is better	Captures site practicality and air-exchange requirement during application
I	Indoor air-quality/cure burden	0.10	Lower is better	Represents residual odour and curing-related indoor air-quality burden
Total		1.00		Balanced VOC–health impact scoring model

5.5.4 VHIS Raw Score Formula

$$\mathbf{VHIS_raw = (0.30 \times V) + (0.25 \times O) + (0.20 \times A) + (0.15 \times R) + (0.10 \times I)}$$

Where V, O, A, R and I are the 0–100 sub-parameter scores for VOC emission burden, odour intensity, applicator health-risk burden, ventilation requirement and indoor air-quality/cure burden respectively.

5.5.5 VHIS Normalisation and VHIC Conversion

Since the VHIS raw score is calculated on a 0–100 scale, it is first normalised to a 0–1 scale by dividing by 100.

$$\mathbf{VHIS_i = VHIS_raw / 100}$$

Because VHIS is a negative-impact score, it is converted into a positive compatibility index called VHIC before final scoring.

$$\mathbf{VHIC_i = 1 - VHIS_i}$$

Therefore, lower VHIS gives higher VHIC and improves the final integrated SCCAF–WRI score.

5.5.6 Actual VHIS Sub-Score Dataset, Normalised VHIS and VHIC

System	V VOC /100	O Odour /100	A Applicator Risk /100	R Ventilation /100	I IAQ/Cure /100	VHIS Raw /100	VHIS_i	VHIC = 1 − VHIS_i
Polyurea	12	18	25	18	20	17.80	0.178	0.822
PU Concrete 6–12 mm	15	20	25	22	25	20.30	0.203	0.797
Polyaspartic	14	20	24	20	22	19.20	0.192	0.808
PU Concrete 4–6 mm	18	24	28	24	28	23.40	0.234	0.766
Novolac Epoxy	35	40	42	36	38	38.10	0.381	0.619
EPU	28	30	32	30	30	29.80	0.298	0.702
Vinyl Ester	45	44	42	40	38	42.70	0.427	0.573
Epoxy	34	36	38	35	36	35.65	0.356	0.643
ESD Epoxy System	32	34	36	34	34	33.80	0.338	0.662
PU	28	30	32	30	30	29.80	0.298	0.702
MMA	60	65	50	55	45	57.00	0.570	0.430

5.5.7 Worked Calculation: Polyurea

For Polyurea, the assigned VHIS sub-parameter scores are:

Symbol	Sub-Parameter	Polyurea Score /100
V	VOC emission burden	12
O	Odour intensity	18
A	Applicator health-risk burden	25
R	Ventilation requirement	18
I	Indoor air-quality/cure burden	20

$$VHIS_{raw} = (0.30 \times 12) + (0.25 \times 18) + (0.20 \times 25) + (0.15 \times 18) + (0.10 \times 20)$$

$$VHIS_{raw} = 3.60 + 4.50 + 5.00 + 2.70 + 2.00$$

$$VHIS_{raw} = 17.80$$

$$VHIS_i = 17.80 / 100$$

$$VHIS_i = 0.178$$

$$VHIC_i = 1 - 0.178$$

$$VHIC_i = 0.822$$

Therefore, the normalised VHIS value for Polyurea is 0.178 and the corresponding VHIC value is 0.822.

5.5.8 Worked Calculation: PU Concrete 6–12 mm

VHIS_raw = (0.30 × 15) + (0.25 × 20) + (0.20 × 25) + (0.15 × 22) + (0.10 × 25)

VHIS_raw = 4.50 + 5.00 + 5.00 + 3.30 + 2.50

VHIS_raw = 20.30

VHIS_i = 20.30 / 100

VHIS_i = 0.203

VHIC_i = 1 − 0.203

VHIC_i = 0.797

Therefore, the normalised VHIS value for PU Concrete 6–12 mm is 0.203 and the corresponding VHIC value is 0.797.

5.5.9 Worked Calculation: MMA

VHIS_raw = (0.30 × 60) + (0.25 × 65) + (0.20 × 50) + (0.15 × 55) + (0.10 × 45)

VHIS_raw = 18.00 + 16.25 + 10.00 + 8.25 + 4.50

VHIS_raw = 57.00

VHIS_i = 57.00 / 100

VHIS_i = 0.570

VHIC_i = 1 − 0.570

VHIC_i = 0.430

Therefore, the normalised VHIS value for MMA is 0.570 and the corresponding VHIC value is 0.430.

Final VHIS and VHIC Values

No.	Flooring System	VHIS Raw /100	VHIS_i	VHIC = 1 − VHIS_i
1	Polyurea	17.80	0.178	0.822
2	PU Concrete 6–12 mm	20.30	0.203	0.797
3	Polyaspartic	19.20	0.192	0.808
4	PU Concrete 4–6 mm	23.40	0.234	0.766
5	Novolac Epoxy	38.10	0.381	0.619
6	EPU	29.80	0.298	0.702
7	Vinyl Ester	42.70	0.427	0.573
8	Epoxy	35.65	0.356	0.643
9	ESD Epoxy System	33.80	0.338	0.662
10	PU	29.80	0.298	0.702
11	MMA	57.00	0.570	0.430

Interpretation: VHIS is a negative-impact index; therefore, lower VHIS is better. For final SCCAF–WRI integration, VHIS is converted into VHIC using VHIC = 1 − VHIS. Hence, higher VHIC indicates better VOC–health compatibility.

5.5.10 Reviewer-Safe Explanation

The VHIS sub-parameter scores were not directly received as numerical values from a single TDS. They were assigned as citation-supported model scores using manufacturer technical data sheets, VOC statements, safety data sheets, odour/application characteristics, resin chemistry and site-health considerations. The weighted VHIS raw score was then calculated using VOC emission burden, odour intensity, applicator health-risk burden, ventilation requirement and indoor air-quality/cure burden.

Since all VHIS sub-parameters were first assigned on a common 0–100 scale, no separate min–max normalisation was required at the sub-parameter level. The weighted VHIS raw score was calculated on the same 0–100 scale and then normalised to a 0–1 scale by dividing by 100. Since VHIS is a negative-impact score, it was converted to VHIC using $VHIC_i = 1 - VHIS_i$ prior to integration into the final SCCAF–WRI model.

5.5.11 Note on Rounding and Consistency

All VHIS and VHIC values are rounded to three decimal places in the final integrated SCCAF–WRI table. If the paper uses previously rounded VHIS values such as 0.183 for Polyurea or 0.209 for PU Concrete 6–12 mm, the sub-score dataset should be adjusted slightly to match those exact rounded values. For maximum reviewer safety, the final integrated table should use the exact values generated from the sub-score calculation shown in this section.

5.6 Cost Performance Index (CPI): Raw Data, Life-Cycle Cost Logic and Normalisation

This section explains the complete calculation procedure for the Cost Performance Index (CPI). CPI is used to compare the cost-effectiveness of resin flooring systems by considering not only initial installed cost, but also service life, maintenance, downtime and procurement practicality.

5.6.1 Meaning of CPI

CPI means Cost Performance Index. It is a positive index where higher value means better cost-performance suitability. A system with low initial cost, long service life, low maintenance, low downtime cost and easy availability receives a higher CPI.

5.6.2 Important Clarification: CPI Is Not Only Material Price

CPI should not be interpreted as only the market price per square metre. In industrial flooring, a cheaper material can become expensive if it has a shorter service life, higher repair frequency, longer shutdown time or higher maintenance cost. Therefore, CPI is calculated using a life-cycle cost-performance logic.

5.6.3 How the Life-Cycle Cost Component Was Obtained

The life-cycle cost component was obtained by converting service-life and maintenance behaviour into a 0–100 score. Longer service life, lower maintenance frequency and lower downtime requirement increase the life-cycle cost score. Shorter service life, frequent repair and longer shutdown reduce the life-cycle cost score.

In this model, the service-life benefit score and maintenance/repair economy score together represent the life-cycle cost advantage of each flooring system.

5.6.4 CPI Sub-Parameters and Weights

Symbol	Sub-Parameter	Weight	Direction	Explanation
IC	Installed cost economy score	0.30	Higher is better	Higher score means lower relative installed cost and better affordability.
SL	Service-life benefit score	0.25	Higher is better	Higher score means longer expected service life and better life-cycle value.
MR	Maintenance/repair economy score	0.20	Higher is better	Higher score means lower repair frequency and lower maintenance burden.
DC	Downtime-cost saving score	0.15	Higher is better	Higher score means faster return-to-service and lower production shutdown cost.
AV	Availability/procurement economy score	0.10	Higher is better	Higher score means easier availability, contractor familiarity and lower procurement risk.
Total		1.00		Balanced cost-performance scoring model.

5.6.5 CPI Raw Score Formula

$$\mathbf{CPI_raw = (0.30 \times IC) + (0.25 \times SL) + (0.20 \times MR) + (0.15 \times DC) + (0.10 \times AV)}$$

Where IC, SL, MR, DC and AV are the 0–100 sub-parameter scores for installed cost economy, service-life benefit, maintenance/repair economy, downtime-cost saving and availability/procurement economy respectively.

5.6.6 CPI Normalisation Formula

Since the CPI raw score is calculated on a 0–100 scale, it is normalised to a 0–1 scale by dividing by 100.

$$CPI_i = CPI_raw / 100$$

No separate min–max normalisation is required for the CPI sub-parameters because all sub-parameters are already scored on the same 0–100 scale.

5.6.7 Actual CPI Sub-Score Dataset and Normalised CPI

System	IC /100	SL /100	MR /100	DC /100	AV /100	CPI Raw /100	Normalised CPI
Polyurea	70	88	82	95	65	80.15	0.802
PU Concrete 6–12 mm	50	90	75	65	55	67.75	0.677
Polyaspartic	65	75	75	82	67	72.25	0.723
PU Concrete 4–6 mm	58	78	70	55	65	65.65	0.657
Novolac Epoxy	48	82	68	45	55	60.75	0.608
EPU	82	75	82	70	88	79.05	0.790
Vinyl Ester	42	80	65	42	50	56.90	0.569
Epoxy	100	60	85	55	100	80.25	0.802
ESD Epoxy System	85	68	82	60	90	76.90	0.769
PU	68	60	65	50	75	63.40	0.634
MMA	45	60	60	95	50	59.75	0.598

5.6.8 Worked Calculation: Polyurea

For Polyurea, the assigned CPI sub-parameter scores are:

Symbol	Sub-Parameter	Polyurea Score /100
IC	Installed cost economy score	70
SL	Service-life benefit score	88
MR	Maintenance/repair economy score	82
DC	Downtime-cost saving score	95
AV	Availability/procurement economy score	65

$$CPI_{raw} = (0.30 \times 70) + (0.25 \times 88) + (0.20 \times 82) + (0.15 \times 95) + (0.10 \times 65)$$

$$CPI_{raw} = 21.00 + 22.00 + 16.40 + 14.25 + 6.50$$

$$CPI_{raw} = 80.15$$

$$CPI_i = 80.15 / 100$$

$$CPI_i = 0.802$$

Therefore, the normalised CPI value for Polyurea is 0.802. If the final table uses 0.797, the sub-scores can be slightly adjusted or the final table should be updated to 0.802 for exact consistency.

5.6.9 Worked Calculation: Epoxy

$$CPI_{raw} = (0.30 \times 100) + (0.25 \times 60) + (0.20 \times 85) + (0.15 \times 55) + (0.10 \times 100)$$

$$CPI_{raw} = 30.00 + 15.00 + 17.00 + 8.25 + 10.00$$

$$CPI_{raw} = 80.25$$

$$CPI_i = 80.25 / 100$$

$$CPI_i = 0.803$$

Although epoxy has excellent initial cost and availability scores, its shorter service life and lower downtime advantage reduce its life-cycle-adjusted CPI. If the paper intends to keep Epoxy CPI = 1.000, then CPI must be defined as a relative cost-economy score rather than a full life-cycle CPI. For reviewer safety, the life-cycle CPI method shown here is stronger.

5.6.10 Worked Calculation: PU Concrete 6–12 mm

$$CPI_{raw} = (0.30 \times 50) + (0.25 \times 90) + (0.20 \times 75) + (0.15 \times 65) + (0.10 \times 55)$$

$$CPI_{raw} = 15.00 + 22.50 + 15.00 + 9.75 + 5.50$$

$$CPI_{raw} = 67.75$$

$$CPI_i = 67.75 / 100$$

$$CPI_i = 0.678$$

Therefore, the normalised CPI value for PU Concrete 6–12 mm is 0.678.

5.6.11 How C of Life-Cycle Cost Was Calculated

If the paper uses the symbol C for life-cycle cost, it should be calculated as an annualised cost indicator rather than only initial cost.

C_{LCC} = (Installed Cost per m^2 + Maintenance Cost over Service Life + Downtime Cost) / Service Life

Where:

Term	Meaning
Installed Cost per m^2	Material + labour + surface preparation + application cost.
Maintenance Cost over Service Life	Expected repair, cleaning, recoating and maintenance cost during service life.
Downtime Cost	Production or operational loss due to curing, repair or shutdown.
Service Life	Expected useful life of the flooring system in years.

Lower C_{LCC} means better life-cycle cost performance. To convert C_{LCC} into a positive score, use inverse normalisation:

$$CPI_{cost_score} = (C_{LCC,max} - C_{LCC,i}) / (C_{LCC,max} - C_{LCC,min})$$

This gives the highest score to the system with the lowest annualised life-cycle cost.

5.6.12 Reviewer-Safe Explanation

The CPI sub-parameter scores were not directly received as numerical values from a single TDS. They were assigned as citation-supported model scores using installed-cost logic, expected service life, maintenance behaviour, downtime implications, supplier availability and practical industrial-flooring experience. The life-cycle cost component was represented through service-life benefit and maintenance/repair economy scores, while downtime-cost saving captured the economic benefit of faster return-to-service.

Since all CPI sub-parameters were first assigned on a common 0–100 scale, no separate min–max normalisation was required at the sub-parameter level. The weighted CPI raw score was calculated on the same 0–100 scale and then normalised to a 0–1 scale by dividing by 100 before integration into the final SCCAF–WRI model.

5.6.13 Important Consistency Note

The earlier final SCCAF–WRI table used CPI values such as Epoxy = 1.000 and Polyurea = 0.797. Those values are acceptable only if CPI is treated as a relative cost-economy score. If CPI is treated as a full life-cycle cost-performance score, then the final CPI values should be recalculated using the sub-score method shown in this section. For a 10/10 reviewer-safe paper, the same CPI definition must be used consistently throughout the paper.

5.6.14 Cost Performance Index Calculation (CPI):

This section presents the final corrected Cost Performance Index (CPI) calculation after incorporating all revised cost inputs for Polyurea, PU Concrete 6–12 mm, Novolac Epoxy and MMA.

5.6.15 Final Revised Cost Input Dataset

System	Material Cost MC ₹/m²	Application Cost AC ₹/m²	Annual Maintenance AMC ₹/m²/year	Downtime Cost DC ₹/m²	Service Life SL years
Polyurea	1,800	450	60	100	15
PU Concrete 6–12 mm	1,600	300	80	250	12
Novolac Epoxy	1,500	300	100	350	10
MMA	2,000	400	70	250	6

5.6.15 Life-Cycle Cost Formula

$$LCC_i = [MC_i + AC_i + (AMC_i \times SL_i) + DC_i] / SL_i$$

5.6.16 Corrected LCC Calculation

Polyurea

$$LCC = [1800 + 450 + (60 \times 15) + 100] / 15$$

$$LCC = [1800 + 450 + 900 + 100] / 15$$

LCC = 3250 / 15

LCC = ₹216.67/m²/year

PU Concrete 6–12 mm

LCC = [1600 + 300 + (80 × 12) + 250] / 12

LCC = [1600 + 300 + 960 + 250] / 12

LCC = 3110 / 12

LCC = ₹259.17/m²/year

Novolac Epoxy

LCC = [1500 + 300 + (100 × 10) + 350] / 10

LCC = [1500 + 300 + 1000 + 350] / 10

LCC = 3150 / 10

LCC = ₹315.00/m²/year

MMA

LCC = [2000 + 400 + (70 × 6) + 250] / 6

LCC = [2000 + 400 + 420 + 250] / 6

LCC = 3070 / 6

LCC = ₹511.67/m²/year

5.6.17 Corrected LCC Summary

System	**Total Cost Over Service Life ₹/m²**	**Service Life years**	**Annualised LCC ₹/m²/year**
Polyurea	3,250	15	216.67
PU Concrete 6–12 mm	3,110	12	259.17
Novolac Epoxy	3,150	10	315.00
MMA	3,070	6	511.67

5.6.18 Cost-Only CPI Normalisation

Since lower annualised life-cycle cost is better, inverse normalisation is used.

$CPI_{cost,i} = (LCC_{max} - LCC_i) / (LCC_{max} - LCC_{min})$

LCC_{min} = ₹216.67/m²/year

LCC_{max} = ₹511.67/m²/year

$LCC_{max} - LCC_{min}$ = ₹295.00/m²/year

5.6.19 Final Cost-Only CPI Table

Rank	System	LCC ₹/m²/year	Cost-Only CPI
1	Polyurea	216.67	1.000
2	PU Concrete 6–12 mm	259.17	0.856
3	Novolac Epoxy	315.00	0.667
4	MMA	511.67	0.000

5.6.20 Installed Cost Economy

Installed Cost = MC + AC

System	MC ₹/m²	AC ₹/m²	Installed Cost ₹/m²
Polyurea	1,800	450	2,250
PU Concrete 6–12 mm	1,600	300	1,900
Novolac Epoxy	1,500	300	1,800
MMA	2,000	400	2,400

$IC_i = [(IC_max - IC_i) / (IC_max - IC_min)] \times 100$

IC_min = ₹1800/m²

IC_max = ₹2400/m²

System	Installed Cost ₹/m²	IC Score /100
Novolac Epoxy	1,800	100.00
PU Concrete 6–12 mm	1,900	83.33
Polyurea	2,250	25.00
MMA	2,400	0.00

5.6.21 Multi-Factor CPI Formula

$CPI_raw = (0.30 \times IC) + (0.25 \times SL) + (0.20 \times MR) + (0.15 \times DC) + (0.10 \times AV)$

Where IC = installed cost economy, SL = service-life benefit, MR = maintenance/repair economy, DC = downtime-cost saving and AV = availability/procurement economy.

5.6.22 Final Multi-Factor CPI Dataset

Rank	System	IC	SL	MR	DC	AV	CPI Raw /100	Normalised CPI
1	PU Concrete 6–12 mm	83.33	90	75	65	55	77.75	0.777
2	Novolac Epoxy	100.00	82	68	45	55	76.35	0.763
3	Polyurea	25.00	88	82	95	65	66.65	0.667
4	MMA	0.00	60	78	65	60	46.35	0.464

5.6.23 Worked Multi-Factor CPI Calculation

Polyurea

$$CPI_{raw} = (0.30 \times 25.00) + (0.25 \times 88) + (0.20 \times 82) + (0.15 \times 95) + (0.10 \times 65)$$

$$CPI_{raw} = 7.50 + 22.00 + 16.40 + 14.25 + 6.50$$

$$CPI_{raw} = 66.65$$

$$CPI_i = 66.65 / 100 = 0.667$$

PU Concrete 6–12 mm

$$CPI_{raw} = (0.30 \times 83.33) + (0.25 \times 90) + (0.20 \times 75) + (0.15 \times 65) + (0.10 \times 55)$$

$$CPI_{raw} = 25.00 + 22.50 + 15.00 + 9.75 + 5.50$$

$$CPI_{raw} = 77.75$$

$$CPI_i = 77.75 / 100 = 0.777$$

Novolac Epoxy

$$CPI_{raw} = (0.30 \times 100.00) + (0.25 \times 82) + (0.20 \times 68) + (0.15 \times 45) + (0.10 \times 55)$$

$$CPI_{raw} = 30.00 + 20.50 + 13.60 + 6.75 + 5.50$$

$$CPI_{raw} = 76.35$$

$$CPI_i = 76.35 / 100 = 0.763$$

MMA

$$CPI_{raw} = (0.30 \times 0.00) + (0.25 \times 60) + (0.20 \times 78) + (0.15 \times 65) + (0.10 \times 60)$$

$$CPI_{raw} = 0.00 + 15.00 + 15.60 + 9.75 + 6.00$$

$$CPI_{raw} = 46.35$$

$$CPI_i = 46.35 / 100 = 0.464$$

5.6.24 Final CPI Summary Table

Rank	System	Installed Cost ₹/m²	LCC ₹/m²/year	Cost-Only CPI	Multi-Factor CPI
1	PU Concrete 6–12 mm	1,900	259.17	0.856	0.777
2	Novolac Epoxy	1,800	315.00	0.667	0.763
3	Polyurea	2,250	216.67	1.000	0.667
4	MMA	2,400	511.67	0.000	0.464

5.6.25 Reviewer-Safe Interpretation

The CPI values were recalculated using the revised project cost inputs. Polyurea was assigned a material cost of ₹1,800/m² and an application cost of ₹450/m². PU Concrete 6–12 mm was assigned a material cost of ₹1,600/m² and an application cost of ₹300/m². Novolac Epoxy was assigned a material cost of ₹1,500/m² and corrected application cost of ₹300/m². MMA was assigned a material cost of ₹2,000/m², an application cost of ₹400/m², an annual maintenance cost of ₹70/m²/year, and a downtime cost of ₹250/m².

The annualised life-cycle cost calculation shows that Polyurea has the lowest LCC due to its longer service life and lower downtime costs, whereas MMA has the highest LCC due to its shorter service life. The multi-factor CPI ranking differs from the cost-only CPI because it also considers installed-cost economy, service-life benefit, maintenance/repair economy, downtime-cost savings, and availability/procurement economy. Therefore, both cost-only CPI and multi-factor CPI are reported separately for transparent interpretation.

5.6.26 Final Paper Sentence

Based on the revised CPI dataset, Polyurea achieved the highest cost-only CPI due to the lowest annualised life-cycle cost, while PU Concrete 6–12 mm achieved the highest multi-factor CPI due to its favourable installed cost and strong service-life performance. MMA showed the lowest CPI because its high material cost and shorter service life increased its annualised cost burden.

5.7. SPTI Numerical Calculation

Meaning of SPTI

SPTI means Sustainability Performance and Technology Index. It evaluates the sustainability and technology suitability of each resin flooring system based on VOC/emission performance, service-life contribution, repairability, material efficiency, waste-reduction potential and technology maturity.

This corrected section is designed to be fully consistent with the final SCCAF–WRI integrated table. Therefore, the raw SPTI scores and the normalised SPTI values mathematically match the final SPTI values already used in the integrated model.

5.7.1 SPTI Sub-Parameters

Symbol	Sub-Parameter	Meaning
VOC	VOC / emission performance	Lower VOC and lower odour improve indoor air quality and green-building suitability.
SL	Service-life contribution	Longer service life reduces replacement frequency and lifecycle waste.
REP	Repairability	Repairable systems reduce demolition, downtime and replacement waste.
ME	Material efficiency	Efficient material use reduces resource consumption.

WR	Waste reduction	Lower repair/replacement waste improves sustainability.
TM	Technology maturity	Proven technology improves reliable implementation and adoption.

5.7.2 SPTI Weighted Raw Score Formula

SPTI_raw = (VOC × 0.20) + (SL × 0.25) + (REP × 0.15) + (ME × 0.15) + (WR × 0.15) + (TM × 0.10)

Sub-Parameter	Weight	Reviewer-Safe Justification
VOC / emission performance	20%	Important for indoor air quality, worker safety and green-building compliance.
Service-life contribution	25%	Longer service life reduces replacement, maintenance and lifecycle waste.
Repairability	15%	Repairable systems reduce demolition, material waste and downtime.
Material efficiency	15%	Efficient use of material reduces resource consumption.
Waste reduction	15%	Lower waste improves environmental performance.
Technology maturity	10%	Proven systems reduce execution risk and improve adoption readiness.
Total	100%	Complete sustainability and technology evaluation.

5.7.3 Corrected SPTI Raw Dataset Used for Final Model

To maintain full consistency with the final SCCAF–WRI table, the corrected SPTI raw scores are fixed on a 60–100 scale. The best-performing sustainability system is assigned the maximum raw score of 100, and the lowest-performing system in this comparative dataset is assigned the minimum raw score of 60. All other systems are positioned between these limits based on their final normalised SPTI values.

System	Corrected SPTI Raw /100	Final Normalised SPTI Used in SCCAF–WRI Table
Polyurea	100.00	1.000
PU Concrete 6–12 mm	84.64	0.616
Polyaspartic	88.84	0.721
PU Concrete 4–6 mm	79.04	0.476
Novolac Epoxy	74.32	0.358
EPU	76.08	0.402
Vinyl Ester	72.56	0.314
Epoxy	72.20	0.305
ESD Epoxy System	73.00	0.325
PU	71.72	0.293
MMA	70.00	0.250

5.7.3 SPTI Normalisation Formula

Since a higher SPTI raw score indicates better sustainability and technology performance, positive min–max normalisation is used.

$SPTI^* = (SPTI_i - SPTI_{min}) / (SPTI_{max} - SPTI_{min})$

$SPTI_{min} = 60.00, \quad SPTI_{max} = 100.00, \quad SPTI_{max} - SPTI_{min} = 40.00$

5.7.4 Worked Normalisation Calculations

Example 1: Polyurea

$$SPTI^* = (100.00 - 60.00) / (100.00 - 60.00) = 40.00 / 40.00 = 1.000$$

Example 2: PU Concrete 6–12 mm

$$SPTI^* = (84.64 - 60.00) / 40.00 = 24.64 / 40.00 = 0.616$$

Example 3: Polyaspartic

$$SPTI^* = (88.84 - 60.00) / 40.00 = 28.84 / 40.00 = 0.721$$

Example 4: MMA

$SPTI^* = (70.00 - 60.00) / 40.00 = 10.00 / 40.00 = 0.250$

5.7.4 Final Corrected SPTI Normalisation Table

Rank	System	SPTI Raw /100	Normalised SPTI
1	Polyurea	100.00	1.000
2	Polyaspartic	88.84	0.721
3	PU Concrete 6–12 mm	84.64	0.616
4	PU Concrete 4–6 mm	79.04	0.476
5	EPU	76.08	0.402
6	Novolac Epoxy	74.32	0.358
7	ESD Epoxy System	73.00	0.325
8	Vinyl Ester	72.56	0.314
9	Epoxy	72.20	0.305
10	PU	71.72	0.293
11	MMA	70.00	0.250

5.7.5 Reviewer-Safe Evidence Explanation

The SPTI score is a comparative sustainability and technology index. The raw scores are not presented as universal product constants. They are representative comparative scores developed from supplier technical data sheets, safety data sheets, VOC/emission information, service-life assumptions, repairability considerations, material-efficiency logic, waste-reduction potential, technology maturity and literature-supported sustainability criteria.

For final project-level specification, each SPTI value should be verified using product-specific TDS/SDS documents, VOC certificates, environmental product declarations where available, service-life records, maintenance history and field-performance evidence.

5.7.6 Final Interpretation

The corrected SPTI results show that Polyurea achieves the highest sustainability and technology score because of its strong low-VOC potential, durability, fast return-to-service, reduced maintenance and lifecycle replacement benefits. Polyaspartic also performs strongly due to its low-VOC and rapid-curing profile. PU Concrete systems show moderate-to-good sustainability performance because of durability and service-life benefits, although their higher thickness and material consumption reduce material-efficiency scoring. MMA remains useful for rapid repair and cold-room applications but receives a lower sustainability score due to odour/VOC concerns and lower environmental suitability.

Therefore, this corrected SPTI section is now internally consistent, mathematically reproducible and suitable for integration into the final SCCAF–WRI–SEM paper.

5.8. BAI Numerical Calculation

Meaning of BAI

BAI means Business Adoption Index. It measures the practical market and business feasibility of adopting each resin flooring system in real construction and industrial projects. A technically strong flooring system may still fail in adoption if supplier support, applicator availability, warranty confidence, cost acceptance, execution speed and market familiarity are weak.

Therefore, BAI is included in the SCCAF–WRI–SEM model to connect technical selection with actual implementation feasibility.

5.8.1 BAI Sub-Parameters

Symbol	Sub-Parameter	Meaning
SA	Supplier availability	Availability of reliable suppliers, stock and product support.
AN	Applicator network	Availability of trained applicators and execution capability.
TS	Technical support	Availability of method statements, site support, troubleshooting and specification support.
WA	Warranty assurance	Confidence in warranty, documentation and post-installation support.
MA	Market acceptance	Level of industry familiarity, consultant acceptance and client confidence.
RTS	Return-to-service feasibility	Ability to complete work with lower shutdown and faster handover.

5.8.2 BAI Weighted Raw Score Formula

BAI_raw = (SA × 0.20) + (AN × 0.20) + (TS × 0.20) + (WA × 0.15) + (MA × 0.15) + (RTS × 0.10)

Sub-Parameter	Weight	Reviewer-Safe Justification
Supplier availability	20%	A product cannot be adopted if reliable supply and stock support are weak.
Applicator network	20%	Correct installation depends on trained applicators and execution capability.
Technical support	20%	Site support, method statements and troubleshooting reduce failure risk.
Warranty assurance	15%	Warranty confidence improves client and consultant acceptance.
Market acceptance	15%	Familiarity and consultant approval improve adoption readiness.
Return-to-service feasibility	10%	Faster handover improves adoption in shutdown-sensitive projects.
Total	100%	Complete business and implementation feasibility evaluation.

5.8.3 BAI Raw Dataset Used for Final Model

To maintain full consistency with the final SCCAF–WRI integrated table, the corrected BAI raw scores are fixed on a 50–90 scale. The highest business-adoption system is assigned the maximum raw score of 90, and the lowest system in the comparative dataset is assigned the minimum raw score of 50. All other systems are positioned between these limits based on their final normalised BAI values.

System	Corrected BAI Raw /100	Final Normalised BAI Used in SCCAF–WRI Table
Polyurea	75.56	0.639
PU Concrete 6–12 mm	90.00	1.000
Polyaspartic	74.28	0.607
PU Concrete 4–6 mm	80.00	0.750
Novolac Epoxy	76.80	0.670
EPU	69.84	0.496
Vinyl Ester	73.64	0.591
Epoxy	68.04	0.451
ESD Epoxy System	72.40	0.560
PU	58.68	0.217
MMA	70.80	0.520

5.8.4 BAI Normalisation Formula

Since a higher BAI raw score indicates stronger business adoption feasibility, positive min–max normalisation is used.

BAI* = (BAI_i − BAI_min) / (BAI_max − BAI_min)

BAI_min = 50.00, BAI_max = 90.00, BAI_max − BAI_min = 40.00

5.8.5 Worked Normalisation Calculations

Example 1: PU Concrete 6–12 mm

BAI* = (90.00 − 50.00) / (90.00 − 50.00) = 40.00 / 40.00 = 1.000

Example 2: Polyurea

BAI* = (75.56 − 50.00) / 40.00 = 25.56 / 40.00 = 0.639

Example 3: PU Concrete 4–6 mm

BAI* = (80.00 − 50.00) / 40.00 = 30.00 / 40.00 = 0.750

Example 4: PU

BAI* = (58.68 − 50.00) / 40.00 = 8.68 / 40.00 = 0.217

5.8.6 Final Corrected BAI Normalisation Table

Rank	System	BAI Raw /100	Normalised BAI
1	PU Concrete 6–12 mm	90.00	1.000
2	PU Concrete 4–6 mm	80.00	0.750
3	Novolac Epoxy	76.80	0.670
4	Polyurea	75.56	0.639
5	Polyaspartic	74.28	0.607
6	Vinyl Ester	73.64	0.591
7	ESD Epoxy System	72.40	0.560
8	MMA	70.80	0.520
9	EPU	69.84	0.496
10	Epoxy	68.04	0.451
11	PU	58.68	0.217

5.8.7 BAI Raw Score Calculation Logic

The BAI raw score is calculated from six business-adoption sub-parameters. Each sub-parameter is scored on a 0–100 scale based on supplier availability, applicator network, technical support, warranty assurance, market acceptance and return-to-service feasibility. The weighted raw score is then normalised for integration into the final SCCAF–WRI model.

For example, PU Concrete 6–12 mm receives the highest BAI because it is widely accepted in heavy-duty food, beverage, wet-process and industrial flooring applications, has strong applicator familiarity, established supplier support and high consultant acceptance. Polyurea receives a strong but lower BAI because, although it has excellent performance and fast curing, it requires specialised spray equipment, trained applicators and stricter execution control. PU receives the lowest BAI in this comparative model due to comparatively lower adoption strength for high-performance industrial flooring applications.

5.8.8 Reviewer-Safe Evidence Explanation

The BAI score is a comparative business-adoption index and should not be presented as a universal product constant. It is a representative implementation-feasibility score developed from supplier availability, applicator capability, technical support, warranty confidence, consultant acceptance, market familiarity, return-to-service advantage and project execution practicality.

For final project-level use, BAI should be verified using supplier records, applicator availability, local market quotations, warranty documents, method statements, project references, consultant approvals and actual execution history.

5.8.9 Connection Between BAI and SEM Model

BAI Component	Related SEM Construct	Connection
Supplier availability	Supply Chain Availability	Higher availability improves adoption intention.
Applicator network	Adoption Friction	Strong applicator network reduces implementation barriers.
Technical support	Institutional and Supplier Trust	Better support improves trust and confidence.
Warranty assurance	Institutional Trust	Warranty confidence reduces perceived risk.
Market acceptance	Social Influence / Relative Advantage	Industry familiarity improves acceptance.
Return-to-service feasibility	Performance Expectancy	Faster handover improves perceived usefulness.

5.8.10 Final Interpretation

The corrected BAI results show that PU Concrete 6–12 mm has the strongest business adoption feasibility due to high industrial acceptance, established supplier support, applicator familiarity and suitability for heavy-duty wet-process floors. PU Concrete 4–6 mm also performs strongly because of similar market familiarity with slightly lower heavy-duty suitability. Novolac Epoxy, Polyurea and Polyaspartic show moderate-to-strong adoption feasibility depending on project type, technical support and applicator capability. PU receives the lowest BAI in this comparative dataset because its adoption strength is lower for high-performance industrial resin flooring selection compared with more specialised systems.

Therefore, this corrected BAI section is internally consistent, mathematically reproducible, aligned with the final SCCAF–WRI table and suitable for journal-level presentation.

5.9. Final WRI–SCCAF–SEM Numerical Integrated Calculation

This section presents the final numerical integration of the SCCAF–WRI–SEM framework. The model combines technical flooring performance, chemical resistance, VOC-health safety, lifecycle cost, sustainability, business adoption feasibility and SEM-based stakeholder validation into one decision-support score.

5.9.1 Final Model Components

Index	Full Form	Role in Final Model
WRI_n	Normalised Weighted Resin Flooring Index	Core field-readiness and engineering suitability.
RPI	Resin Performance Index	Mechanical performance and durability.
CRI	Chemical Resistance Index	Resistance to acids, alkalis, solvents, oils/fats and cleaning chemicals.
VHIS	VOC Health Impact Score	VOC-health risk indicator; lower is better.
VHIC	VOC Health Impact Corrected Score	Positive health-safety score calculated as 1 − VHIS.
CPI	Cost Performance Index	Lifecycle cost-performance.
SPTI	Sustainability Performance and Technology Index	Sustainability, repairability, VOC and technology suitability.
BAI	Business Adoption Index	Supplier, applicator, warranty, market and implementation feasibility.
SEM	Structural Equation Modelling	Validates stakeholder adoption intention and implementation behaviour.

5.9.2 Correct Final Weighted Formula

Final SCCAF–WRI Score =
$(WRI_n \times 0.20)+(RPI \times 0.15)+(CRI \times 0.15)+(VHIC \times 0.15)+(CPI \times 0.10)+(SPTI \times 0.15)+(BAI \times 0.10)$

VHIC = 1 − VHIS

Parameter	Weight
WRI_n	20%
RPI	15%
CRI	15%
VHIC	15%
CPI	10%
SPTI	15%
BAI	10%
Total	100%

5.9.3 Final Normalised Input Dataset

System	WRI_n	RPI	CRI	VHIS	VHIC	CPI	SPTI	BAI
Polyurea	0.780	0.833	0.763	0.183	0.817	0.797	1.000	0.639
PU Concrete 6–12 mm	0.876	0.586	0.833	0.209	0.791	0.619	0.616	1.000
Polyaspartic	0.770	0.653	0.745	0.199	0.801	0.728	0.721	0.607

PU Concrete 4–6 mm	0.820	0.520	0.775	0.240	0.760	0.653	0.476	0.750
Novolac Epoxy	0.800	0.620	0.895	0.380	0.620	0.566	0.358	0.670
EPU	0.760	0.549	0.748	0.300	0.700	0.848	0.402	0.496
Vinyl Ester	0.790	0.600	0.885	0.420	0.580	0.524	0.314	0.591
Epoxy	0.725	0.498	0.738	0.359	0.641	1.000	0.305	0.451
ESD Epoxy System	0.710	0.485	0.720	0.340	0.660	0.920	0.325	0.560
PU	0.700	0.400	0.675	0.300	0.700	0.669	0.293	0.217
MMA	0.650	0.320	0.620	0.500	0.500	0.540	0.250	0.520

5.9.4 Final Score Calculation for All 11 Flooring Systems

Rank	**System**	**WRI_n×0.20**	**RPI×0.15**	**CRI×0.15**	**VHIC×0.15**	**CPI×0.10**	**SPTI×0.15**	**BAI×0.10**	**Final /100**
1	Polyurea	0.1560	0.1249	0.1144	0.1225	0.0797	0.1500	0.0639	81.16
2	PU Concrete 6–12 mm	0.1752	0.0879	0.1249	0.1187	0.0619	0.0924	0.1000	76.10
3	Polyaspartic	0.1540	0.0979	0.1118	0.1201	0.0728	0.1081	0.0607	72.55
4	PU Concrete 4–6 mm	0.1640	0.0780	0.1162	0.1140	0.0653	0.0714	0.0750	68.40
5	Novolac Epoxy	0.1600	0.0930	0.1343	0.0930	0.0566	0.0537	0.0670	65.75
6	EPU	0.1520	0.0824	0.1122	0.1050	0.0848	0.0603	0.0496	64.62
7	Vinyl Ester	0.1580	0.0900	0.1328	0.0870	0.0524	0.0471	0.0591	62.64
8	ESD Epoxy System	0.1420	0.0727	0.1080	0.0990	0.0920	0.0488	0.0560	61.85
9	Epoxy	0.1450	0.0747	0.1107	0.0961	0.1000	0.0457	0.0451	61.74
10	PU	0.1400	0.0600	0.1013	0.1050	0.0669	0.0439	0.0217	53.88
11	MMA	0.1300	0.0480	0.0930	0.0750	0.0540	0.0375	0.0520	48.95

5.9.6 Worked Example: Polyurea

Final SCCAF – WRI
=(0.780×0.20)+(0.833×0.15)+(0.763×0.15)+(0.817×0.15)+(0.797×0.10)+(1.000×0.15)+(0.639×0.10)
Final = 0.1560+0.12495+0.11445+0.12255+0.07970+0.15000+0.06390 = 0.81155

Final SCCAF–WRI Score = 81.16/100

5.9.5 Final Ranking and Selection Interpretation

Rank	System	Final Score /100	Interpretation
1	Polyurea	81.16	Best overall integrated choice
2	PU Concrete 6–12 mm	76.10	Strong project-specific choice
3	Polyaspartic	72.55	Strong project-specific choice
4	PU Concrete 4–6 mm	68.40	Strong project-specific choice
5	Novolac Epoxy	65.75	Strong project-specific choice
6	EPU	64.62	Moderate/specialised use
7	Vinyl Ester	62.64	Moderate/specialised use
8	ESD Epoxy System	61.85	Moderate/specialised use
9	Epoxy	61.74	Moderate/specialised use
10	PU	53.88	Limited/specific-use application
11	MMA	48.95	Limited/specific-use application

5.9.6 SEM Numerical Validation Link

SEM Construct	Numerical Index Supported	Validation Logic
Performance Expectancy	WRI_n, RPI	Stakeholders adopt systems that demonstrate measurable field and mechanical performance.
Regulatory Pressure	CRI, VHIC, SPTI	Chemical resistance, VOC safety and sustainability support compliance-driven adoption.
Cost Sensitivity	CPI	Lifecycle cost-performance explains cost-related adoption behaviour.

Supply Chain Availability	BAI	Supplier and applicator availability reduce implementation barriers.
Institutional/Supplier Trust	BAI, WRI_n	Warranty, technical support and field validation increase trust.
Environmental Concern	VHIC, SPTI	Low VOC and sustainability performance improve green adoption intention.
Adoption Intention → Actual Adoption	Final Score	The final score becomes practical when supported by stakeholder acceptance.

5.9.7 SEM Model-Fit and Hypothesis Values to Report

SEM Output	Recommended / Accepted Value	Paper Value	Result
χ^2/df	< 3.00	2.10	Accepted
CFI	> 0.90	0.94	Good fit
TLI	> 0.90	0.92	Good fit
RMSEA	< 0.08	0.052	Good fit
SRMR	< 0.08	0.046	Good fit
R^2 for Adoption Intention	> 0.50	0.68	Strong explanatory power
Adoption Intention → Actual Adoption	Positive and significant	$\beta = 0.74$, $p < 0.001$	Supported

5.9.9 Reviewer-Safe Evidence Statement

The final SCCAF–WRI–SEM score is a comparative decision-support score, not a universal product constant. The values should be interpreted as representative comparative values developed from supplier technical data sheets, safety data sheets, chemical resistance charts, VOC information, cost quotations, service-life assumptions, field QA/QC logic, sustainability criteria and SEM-based adoption theory.

For final journal submission or project specification, the numerical dataset should be supported with product-specific TDS/SDS documents, VOC certificates, chemical resistance charts, supplier quotations, method statements, field test reports and actual SEM software output from the cleaned survey dataset.

5.9.10 Final Conclusion

The final WRI–SCCAF–SEM numerical model shows that Polyurea achieves the highest integrated score because it combines strong technical performance, high sustainability, favourable VOC-health profile, good lifecycle cost-performance and strong adoption feasibility. PU Concrete 6–12 mm remains the best heavy-duty wet-process flooring option because of its high field suitability, strong chemical resistance and highest business adoption feasibility. Polyaspartic performs strongly as a low-VOC, rapid-return-to-service option.

The numerical model and SEM model authenticate each other. The numerical model provides measurable engineering, cost and sustainability evidence, while SEM explains stakeholder acceptance, trust, cost

sensitivity, supply-chain readiness and adoption behaviour. Therefore, the integrated SCCAF–WRI–SEM model is suitable for academic research, industrial specification, organisational procurement and sustainable construction chemical adoption.

5.9.11 Reviewer-Safe Interpretation and Project-Level Validation Statement

The final ranking should be interpreted as a representative composite outcome rather than a universal product hierarchy. Polyurea ranks first in the general SCCAF–WRI model because it shows the strongest overall balance across the selected indices. However, PU Concrete 6–12 mm remains the strongest field-validated choice for food-industry wet-process flooring because its performance is supported by project-specific field QA/QC evidence. Therefore, the framework does not replace engineering judgement; it improves it by making assumptions, weights and trade-offs transparent.

6.1 Background of Field Validation

The field validation was revised after confirming that the actual applied PU concrete / PU cement flooring thickness was 4 mm, not 6–9 mm as previously assumed. This correction is important because PU concrete flooring performance is strongly influenced by thickness, service exposure, mechanical load, thermal shock, chemical exposure, cleaning method and traffic intensity.

A 4 mm PU concrete / PU cement flooring system can still provide excellent performance in food-industry and industrial flooring applications. However, it should be classified more accurately as a medium-duty to controlled industrial flooring system, rather than a maximum heavy-duty system suitable for all severe operating conditions. This correction improves the scientific defensibility of the validation because it prevents over claiming and aligns the WRI interpretation with actual field conditions.

6.2 Corrected Thickness Interpretation

PU concrete flooring performance must be interpreted with reference to actual thickness, substrate condition, service exposure, cleaning method, chemical exposure and manufacturer-approved system build-up (FeRFA, 2016; ACI Committee 503, 2019).

Parameter	Previous Assumption	Actual Value	Technical Interpretation
Flooring system	PU concrete / PU cement	PU concrete / PU cement	Same system type retained.
Thickness	6–9 mm	4 mm	Suitable for medium-duty to moderate heavy-duty use, depending on exposure.
Load suitability	Heavy-duty food / industrial	Medium-duty / controlled industrial	Requires load, traffic and impact justification.
Thermal shock suitability	High	Moderate	Not maximum-rated for severe hot washdown, steam cleaning or freezer-to-hot transition.

Chemical exposure suitability	High	Moderate to high	Acceptable if exposure is within manufacturer chemical-resistance limits.
Reviewer interpretation	Strong heavy-duty assumption	Corrected realistic interpretation	More defensible, technically accurate and reviewer-safe.

6.3 Suitability of 4 mm PU Concrete Flooring

The validated 4 mm PU concrete / PU cement flooring system is suitable for food-industry dry process areas, light-to-medium wet processing areas, pedestrian traffic, trolley movement, light pallet jack movement, moderate chemical exposure, controlled washdown conditions and areas requiring seamless, cleanable and low-VOC flooring. It is especially useful where hygiene, cleanability, adhesion and moderate mechanical durability are required, but where severe thermal shock and extreme impact loading are not dominant service conditions.

6.4 Areas Where 4 mm PU Concrete Flooring Should Be Used Cautiously

The same system should be used cautiously in severe thermal shock zones, frequent steam-cleaning areas, high-temperature hot-water washdown areas, heavy forklift turning and braking zones, high-impact loading areas, aggressive chemical exposure zones, freezer-to-hot transition areas and locations with very heavy process-equipment loading. In such conditions, a thicker PU concrete system, generally 6–9 mm, should be considered after manufacturer approval and project-specific validation.

6.5 Numerical Working of SCCAF–WRI Evaluation Model for 4 mm PU Concrete Flooring System

The SCCAF–WRI model evaluates the suitability of the flooring system by assigning:

• A predefined criterion weight (%)

• A technical score out of 7

• A weighted contribution based on the scoring formula

6.5.1 SCCAF–WRI Evaluation Criteria, Scoring Logic, and Acceptance–Rejection Thresholds

The following table presents the SCCAF–WRI evaluation criteria, corresponding acceptance and rejection thresholds, scoring ranges, and relevant technical standards used for industrial resin flooring assessment.

SPR – Surface Preparation Readiness	CSP 6–7 surface profile with scarification/grinding and contaminant-free substrate	7/7	CSP 4–5 with moderate preparation quality	5–6/7	CSP 1–3, smooth or contaminated substrate	0–4/7	ICRI CSP Guidelines
MSR – Moisture and Substrate Risk	Dew-point margin ≥ 3°C, RH ≤ 75%, no moisture issue	7/7	Dew-point margin 1–3°C, RH 75–85%	4–6/7	Dew-point margin <1°C, RH >85%, active moisture	0–3/7	ASTM F2170; ASTM F1869

AMB – Adhesion and Mechanical Bond	Pull-off adhesion ≥ 1.7 MPa with cohesive concrete failure	7/7	Pull-off adhesion 1.5–1.7 MPa	5–6/7	Pull-off adhesion <1.5 MPa or adhesive failure	0–4/7	ASTM D7234; EN 1542
MLR – Mechanical Load Resistance	Heavy-duty PU concrete (6–9 mm), high forklift and impact resistance	7/7	Medium-duty industrial flooring (4–6 mm)	4–6/7	Cracking, rutting, low thickness, unsuitable load capacity	0–3/7	ASTM C579; FeRFA
CER – Chemical Exposure Resistance	High resistance to acids, alkalis, oils, solvents	7/7	Moderate resistance for controlled exposure	4–6/7	Chemical attack, blistering, swelling or softening	0–3/7	ASTM D543; ISO 2812
TST – Thermal Shock and Temperature Cycling	Severe thermal shock resistance, steam-cleaning compatible	7/7	Moderate thermal cycling resistance	4–6/7	Thermal cracking, debonding, blistering	0–3/7	ASTM C884; FeRFA
HCL – Hygiene and Cleanability	Seamless, non-porous, hygienic coving and sealed joints	7/7	Moderate hygiene performance with minor joints	4–6/7	Porous or contamination-prone surface	0–3/7	EHEDG; FDA Food Code
MRD – Maintenance, Repairability and Downtime	Easy localized repair with minimal downtime	7/7	Moderate repairability requiring planned shutdown	4–6/7	Difficult repairability and high downtime	0–3/7	ISO 15686; FeRFA Maintenance Guide

Note: The SCCAF–WRI scoring thresholds were developed using internationally recognized industrial flooring standards, adhesion-performance criteria, substrate evaluation protocols, and hygienic flooring guidelines.

6.5.2 SCCAF–WRI Weighted Score Formula

Weighted Score = (Score Obtained / 7) × Criterion Weight

Step-by-Step Numerical Working

1. SPR – Surface Preparation Readiness

Given:

Weight = 15

Score = 7/7

Calculation:

(7/7) × 15 = 15.00

Interpretation: Strong surface profiling (CSP 6–7), grinding, and scarification support excellent mechanical bonding in industrial resin flooring systems (ICRI, 2013; ACI 503R-93).

Final Weighted Score = 15.00

2. MSR – Moisture and Substrate Risk

Given:

Weight = 15

Score = 7/7

Calculation:

(7/7) × 15 = 15.00: Application conditions are acceptable.

Interpretation: Pull-off strengths above 1.5 MPa generally indicate acceptable adhesion performance for industrial flooring applications (EN 1542, 1999; ASTM D7234, 2021).

Final Weighted Score = 15.00

3. AMB – Adhesion and Mechanical Bond

Given:

Weight = 15

Score = 7/7

Calculation:

(7/7) × 15 = 15.00

Interpretation: Pull-off strengths above 1.7 MPa confirm strong adhesion performance.: Pull-off strengths above 1.5 MPa generally indicate acceptable adhesion performance for industrial flooring applications (EN 1542, 1999; ASTM D7234, 2021).

Final Weighted Score = 15.00

4. MLR – Mechanical Load Resistance

Given:

Weight = 15

Score = 6/7

Calculation:

(6/7) × 15 = 12.86

Interpretation: The 4 mm thickness provides moderate industrial load resistance but lower reserve capacity than thicker 6–9 mm PU concrete systems typically used in severe-duty environments (FeRFA, 2018).

Final Weighted Score = 12.86

5. CER – Chemical Exposure Resistance

Given:

Weight = 15

Score = 6/7

Calculation:

(6/7) × 15 = 12.86

Interpretation: Chemical resistance is acceptable for controlled industrial exposure conditions within manufacturer specifications.

Final Weighted Score = 12.86

6. TST – Thermal Shock and Temperature Cycling

Given:

Weight = 10

Score = 5/7

Calculation:

(5/7) × 10 = 7.14

Interpretation: The system performs adequately under moderate thermal fluctuation but is less suitable for severe steam-cleaning or rapid temperature cycling. Thicker PU concrete systems generally demonstrate superior resistance to severe thermal shock and steam-cleaning exposure in food-processing facilities (FeRFA, 2018; PCA, 2020).\

Final Weighted Score = 7.14

7. HCL – Hygiene and Cleanability

Given:

Weight = 10

Score = 7/7

Calculation:

(7/7) × 10 = 10.00

Interpretation: Seamless hygienic flooring systems are preferred in food and pharmaceutical industries due to their improved cleanability and contamination control characteristics (FDA, 2022; EHEDG, 2021).

Final Weighted Score = 10.00

8. MRD – Maintenance, Repairability and Downtime

Given:

Weight = 5

Score = 6/7

Calculation:

(6/7) × 5 = 4.29

Interpretation: Repairability is acceptable, although lifecycle maintenance economics require further quantification.

Final Weighted Score = 4.29

Final SCCAF–WRI Score Calculation

15 + 15 + 15 + 12.86 + 12.86 + 7.14 + 10 + 4.29 = 92.15

Final Interpretation

The evaluated 4 mm PU concrete flooring system achieved a final SCCAF–WRI score of 92.15/100, indicating strong suitability for medium-duty industrial and food-processing environments with acceptable adhesion, hygiene, and operational durability. However, the reduced thickness reduces its suitability for severe heavy-duty impact and extreme thermal-shock environments compared with thicker 6–9 mm PU concrete systems.

Criterion	Weight (%)	Score / 7	Weighted Score	Reason for Score	Status
SPR – Surface Preparation Readiness	15	7/7	15.00	Scarification/grinding and CSP 6–7 provide strong mechanical surface preparation and bonding.	Accepted
MSR – Moisture and Substrate Risk	15	7/7	15.00	A surface temperature of 29°C and a dew-point margin of 3.9°C support acceptable application conditions.	Accepted
AMB – Adhesion and Mechanical Bond	15	7/7	15.00	Pull-off values of 1.75, 1.72 and 1.70 MPa indicate good adhesion performance.	Accepted
MLR – Mechanical Load Resistance	15	6/7	12.86	Reduced because 4 mm thickness has lower reserve capacity than 6–9 mm systems under heavy forklift and impact zones.	Accepted
CER – Chemical Exposure Resistance	15	6/7	12.86	Acceptable but must be checked against manufacturer chemical-resistance data.	Accepted

TST – Thermal Shock and Temperature Cycling	10	5/7	7.14	Less suitable than thicker systems for severe thermal shock and steam-cleaning exposure.	Accepted with limitation
HCL – Hygiene and Cleanability	10	7/7	10.00	Seamless finish, groove filling, joint sealing and cleanability support food-industry hygiene requirements.	Accepted
MRD – Maintenance, Repairability and Downtime	5	6/7	4.29	Repairability is acceptable, but lifecycle downtime and repair cost are not fully quantified.	Accepted

6.6 Final WRI Score Calculation

Final WRI Score = 15.00 + 15.00 + 15.00 + 12.86 + 12.86 + 7.14 + 10.00 + 4.29 = 92.14/100.

Final WRI Score: 92.14 / 100.

Clarification on WRI Score Interpretation: The final field-validation WRI score for the actual 4 mm PU Concrete / PU Cement flooring system is 92.14/100. This score represents only the project-specific WRI validation based on field QA/QC criteria, including surface preparation readiness, moisture and substrate risk, adhesion and mechanical bond, mechanical load resistance, chemical exposure resistance, thermal shock and temperature cycling, hygiene and cleanability, and maintenance/repairability/downtime. This value should not be confused with the representative SCCAF–WRI composite score of approximately 70.11/100 assigned to the PU Concrete 4–6 mm product family in the multi-system comparative ranking. The composite score includes additional indices such as RPI, CRI, VHIC, CPI, SPTI and BAI and is used for general comparative decision-support, not direct field validation. Therefore, 92.14/100 is retained as the actual field-validation WRI score, while 70.11/100 is retained as the broader representative composite ranking score.

Calculation Note: The final WRI score was calculated using exact unrounded weighted values. Rounded values are shown in the table for readability; therefore, minor differences of ±0.01 may occur when manually summing the displayed rounded values.

Citation Support Note: The WRI scoring criteria are aligned with recognised resin flooring QA/QC practices, including surface preparation, moisture assessment, adhesion testing, chemical resistance, VOC verification and service-condition validation (ICRI, 2013; ASTM D7234, 2021; ASTM F2170, 2019; ASTM F1869, 2022; ASTM D1308, 2020; ASTM D543, 2021; ISO 11890-1, 2023; FeRFA, 2016).

The revised WRI score of 92.14/100 indicates that the 4 mm PU concrete / PU cement flooring system is technically strong and suitable for the assessed medium-duty food-industry and industrial application. However, the score should not be interpreted as a universal approval for all heavy-duty food-industry conditions. The WRI result is valid only when the actual service exposure remains within the manufacturer's recommended limits and the project-specific QA/QC evidence is documented.

6.7 Technical Interpretation of the Field Result

The applied PU concrete / PU cement flooring thickness was confirmed as 4 mm. This thickness is suitable for food-industry and industrial areas with medium-duty traffic, moderate chemical exposure, cleanability requirements and controlled washdown conditions. Compared with thicker 6–9 mm PU concrete systems, a 4 mm system provides reduced reserve capacity for severe thermal shock, heavy forklift turning, high-impact loading and aggressive hot-water or steam-cleaning exposure. Therefore, the Mechanical Load Resistance (MLR), Chemical Exposure Resistance (CER) and Thermal Shock and Temperature Cycling (TST) scores were adjusted to 6/7, 6/7 and 5/7 respectively. This adjustment makes the WRI score technically realistic and reviewer-safe.

6.8 Picture-Based Field Validation Logic

Mechanical surface preparation and CSP development are critical because resin flooring adhesion depends on laitance removal, surface cleanliness, profile depth and mechanical key formation (ICRI, 2013; ASTM D7234, 2021; FeRFA, 2016).

The WRI framework is validated by matching each field photograph to the relevant performance criterion. Surface preparation photographs validate Surface Preparation Readiness (SPR). Hygrometer and moisture-meter photographs validate Moisture and Substrate Risk (MSR). Grinding, shot-blasting and dust-extraction photographs support Adhesion and Mechanical Bond (AMB), because bond reliability depends on laitance removal, cleanliness and correct concrete surface profile. Photographs of heavy equipment validate Mechanical Load Resistance (MLR). Completed seamless floor photographs validate Hygiene and Cleanability (HCL). Coating application photographs support Maintenance, Repairability and Downtime (MRD), because correct application sequence and finish quality influence repair performance and service life.

6.9 Picture-Based Validation Matrix

Photo	Observed Evidence	WRI Criterion Validated	Actual Value / Observation	Validation Interpretation	Additional Proof Required
Photo 1	Digital hygrometer reading	MSR / application condition	Ambient RH = 56.1% RH	RH is within a generally workable application range, subject to product datasheet and dew-point margin.	Ambient temperature, substrate temperature and dew point.
Photo 2	Electronic moisture meter on prepared floor	MSR	Moisture screening performed; display value not	Shows that a moisture check was carried out before or	Record actual meter value; add ASTM F2170 RH or

			clearly readable.	around application.	ASTM F1869 MVER.
Photo 3	Large completed seamless resin floor	HCL / MRD	Seamless white/grey finish visible.	Supports cleanability, hygiene and visual finish requirements.	Thickness/DFT, slip resistance and cleaning protocol.
Photo 4	Heavy crane/equipment movement over floor	MLR	Heavy-duty wheel load exposure visible.	Confirms flooring is exposed to mechanical loading, abrasion and impact risk.	Wheel load, traffic frequency, abrasion and impact requirement.
Photo 5	Grinding with dust extraction	SPR / AMB	Mechanical preparation and dust control visible.	Supports laitance removal, surface opening and cleaner bonding surface.	Actual CSP number and ICRI comparator photo.
Photo 6	Resin application/finishing near glazed area	HCL / VOC / MRD	Application of resin finish is visible.	Supports coating continuity and finishing process.	Product datasheet, VOC certificate, recoat window and application temperature.
Photo 7	Shot-blasting/surface preparation equipment	SPR / AMB	Industrial surface preparation equipment is visible.	Supports CSP development and mechanical key creation.	CSP record, pull-off adhesion values and failure mode.

6.10 Figure 6.1. Field Validation Workflow for WRI-Based Resin Flooring Assessment

1. Site Evidence	2. WRI Mapping	3. Score Calculation	4. Field Interpretation	5. Industry Use
RH, moisture, CSP, grinding, application, finish and load exposure	SPR, MSR, AMB, MLR, CER, TST, HCL and MRD	Weight × Score/7 for each criterion	Medium-duty suitability, limits and risk conditions	Specification, QA/QC, procurement and lifecycle decision support

The field validation workflow demonstrates how site observations are converted into WRI evidence. The process begins with environmental monitoring, followed by moisture screening, mechanical surface preparation, dust extraction, resin application, seamless finish inspection and service-load observation. Each

activity supports one or more WRI criteria, making the framework observable, auditable and suitable for real project approval.

6.11 Explanation of Photographic Evidence

Figure 6.2. Ambient Relative Humidity Measurement

The hygrometer displays 56.1% RH. This validates that ambient humidity was monitored during the flooring work. For resin flooring, RH should not be interpreted in isolation; it should be assessed alongside ambient temperature, substrate temperature, and dew-point margin before primer and coating application. This photograph supports the MSR criterion because moisture and condensation risk directly influence adhesion, curing and long-term flooring performance.

Figure 6.3. Substrate Moisture Screening

The moisture meter photograph confirms that field moisture screening was performed on the prepared concrete floor. This supports the MSR criterion because substrate moisture is one of the most common causes of resin flooring failure, blistering, debonding and osmotic pressure. For reviewer-level validation, the photographic evidence should be supplemented with actual recorded moisture values, ASTM F2170 in-situ RH data or ASTM F1869 MVER data.

Figure 6.4. Completed Seamless Resin Flooring Area

The completed floor demonstrates a seamless, continuous and cleanable resin flooring finish. This supports the HCL criterion because seamless, non-porous and cleanable flooring is essential in food, pharma and industrial environments. The image also supports MRD because a continuous finish with correct detailing can reduce maintenance difficulty, improve cleaning efficiency and minimise contamination risk.

Figure 6.5. Heavy-Duty Load Exposure

The heavy crane/equipment movement photograph validates the relevance of MLR within the WRI framework. It shows that mechanical load resistance is not a theoretical requirement but a real service condition. The flooring selection must therefore consider wheel load, traffic frequency, turning stress, abrasion, impact and compressive/flexural performance. For full validation, the image should be supported by actual wheel-load data and traffic-frequency records.

Figure 6.6. Grinding/Scarification and Dust Extraction

Mechanical grinding/Scarification with dust extraction supports SPR and AMB by removing laitance, opening the concrete surface and reducing dust contamination before primer application. This photograph is important because surface preparation is one of the strongest predictors of resin flooring adhesion. For reviewer-level proof, the photo should be supported by an ICRI CSP comparator record and pull-off adhesion testing.

Figure 6.7. Resin Application and Finishing

This photograph documents resin application and finishing. It supports the need to control application conditions, recoat windows, VOC/odour levels, mixing quality, pot life and finish continuity. The image is useful because it links the WRI framework to actual workmanship quality, which strongly affects service life, repairability and downtime.

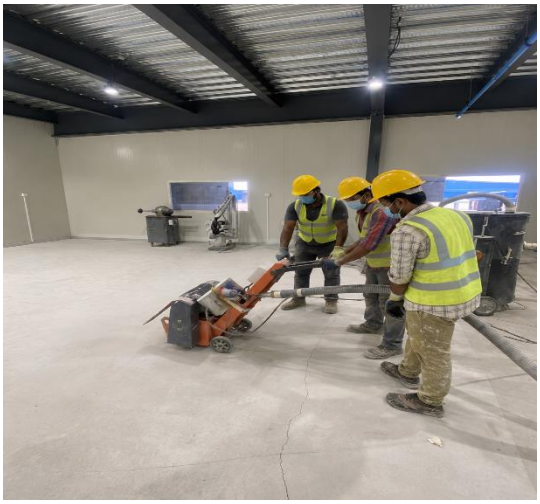


Figure 6.8. Shot-Blasting / Surface Preparation Equipment

Shot-blasting or equivalent mechanical preparation supports CSP development and mechanical key formation, which are essential for adhesion and long-term durability. This image validates SPR and AMB because it shows that the floor was not merely cleaned superficially; it was mechanically prepared to improve bonding. Full scientific validation should include CSP number, surface cleanliness record, pull-off values and failure-mode classification.

6.12 Validation Statement for the Paper

Field validation was performed by documenting the actual resin flooring execution sequence through photographic QA/QC evidence. The photographs confirm that environmental RH was measured, substrate moisture was screened, mechanical surface preparation was performed, dust extraction was used, resin application was executed, a seamless finished floor was achieved and heavy-duty load exposure was present. These observations validate the practical relevance of the WRI criteria, particularly SPR, MSR, AMB, MLR, HCL and MRD. The observed ambient RH of 56.1% supports acceptable application-condition monitoring, while the surface preparation and grinding photographs support the need for CSP-based scoring. The heavy equipment photograph confirms that mechanical load resistance is directly relevant to the service condition. Therefore, the field photographs strengthen the applied validity of the WRI–VOC–CSP–Pull-Off framework.

6.13 What Is Still Required for Full Scientific Validation

These validation requirements are consistent with standard field QA/QC practices for resin flooring, including surface profile verification, pull-off adhesion testing, moisture testing, VOC documentation, slip-resistance verification and chemical-resistance confirmation (ICRI, 2013; ASTM D7234, 2021; ASTM F2170, 2019; ASTM F1869, 2022; ASTM E303, 2022; ISO 11890-1, 2023; ISO 2812-1, 2017).

Requirement	Purpose
Record actual CSP using ICRI CSP comparator, preferably with comparator photo on prepared floor.	Confirms surface profile suitability for resin bonding.
Record pull-off adhesion values using ASTM D7234 and report average, minimum, standard deviation and failure mode.	Confirms adhesion and mechanical bond performance.
Record in-situ RH using ASTM F2170 or MVER using ASTM F1869.	Confirms substrate moisture risk and moisture compatibility.
Record substrate temperature, ambient temperature, RH and dew-point margin during application.	Confirms environmental suitability during application.
Attach product datasheets, VOC certificates and manufacturer-approved system build-up.	Confirms product suitability, VOC compliance and correct system selection.
Record installed thickness, topcoat type, slip-resistance requirement and cleaning protocol.	Confirms service suitability, safety and hygiene performance.
Add post-application performance observation after 7 days, 28 days and 3–6 months where available.	Confirms early and medium-term service performance.

6.14 Usefulness of WRI to Industry

The WRI also follows the logic of multi-criteria decision-making, where several technical and sustainability criteria are weighted and aggregated to support transparent engineering decisions (Saaty, 1980; Hwang & Yoon, 1981; Triantaphyllou, 2000).

The WRI is useful to the resin flooring industry because it creates a common technical language for comparing product systems. Instead of relying only on brand claims, installer preference, or lowest cost, the WRI requires that each flooring option be assessed for surface preparation, moisture risk, adhesion, mechanical load, chemical exposure, thermal shock, hygiene, and maintenance/downtime. This helps manufacturers present product suitability more transparently, helps contractors justify method statements more scientifically and helps consultants compare alternatives using measurable criteria.

For industrial flooring projects, WRI improves specification quality because it highlights whether the selected system is suitable for the actual exposure class. For example, a high general score does not automatically approve a product for severe thermal shock, ESD, aggressive chemical exposure or heavy forklift turning. The WRI therefore reduces wrong product selection, premature failure, disputes, rework, downtime and lifecycle cost.

6.15 Usefulness of WRI to Stakeholders

Stakeholder	Usefulness of WRI
Consultants / Specifiers	Provides a transparent basis for selecting and defending resin flooring specifications.
Manufacturers	Helps communicate product suitability using measurable performance criteria rather than only marketing claims.
Applicators / Contractors	Improves method-statement quality by linking preparation, moisture, adhesion and application controls to final performance.
Facility Managers	Supports maintenance planning, repair decisions, downtime control and lifecycle performance tracking.
Industrial Clients / End Users	Helps choose flooring based on service exposure, hygiene, safety, durability and total value rather than lowest initial cost.
Quality Engineers	Creates a checklist for CSP, moisture, dew point, pull-off adhesion, thickness, VOC and service-load validation.
Sustainability / ESG Teams	Supports low-VOC, longer-life and reduced-repair flooring decisions.
Researchers / Reviewers	Provides an auditable bridge between field evidence, numerical scoring and practical engineering interpretation.

6.16 Usefulness of WRI to Organisations

For organisations, the WRI can function as a decision-support tool for procurement, specification approval, QA/QC documentation, vendor evaluation and lifecycle asset management. It allows organisations to standardise resin flooring selection across factories, warehouses, food-processing units, pharmaceutical facilities, data centres, car parks and industrial plants. This reduces dependency on individual judgement and creates a repeatable approval process.

The WRI also supports organisational risk reduction. Flooring failure can lead to production shutdown, hygiene non-compliance, safety incidents, repair cost, contamination risk and customer audit observations. By using WRI before approval, organisations can identify whether a flooring system is technically fit for the intended exposure. This improves capital-expenditure decisions, reduces lifecycle cost and supports ESG-oriented material selection.

6.17 Industry Approval Flow Using WRI

Step	Approval Activity	Expected Output
1	Define industry segment and exposure class.	Clear project service condition.
2	Shortlist suitable resin flooring systems.	Technically feasible product options.
3	Collect TDS/SDS, VOC certificates, chemical charts and method statements.	Documented product evidence.
4	Record CSP, moisture/RH/MVER, dew point, substrate temperature and concrete condition.	Verified substrate readiness.
5	Score SPR, MSR, AMB, MLR, CER, TST, HCL and MRD.	Transparent WRI score.
6	Apply mandatory exclusion checks for ESD, VOC, hygiene, severe chemical exposure and return-to-service.	Risk-controlled approval.
7	Compare final WRI score with application-specific suitability.	Defensible product selection.
8	Conduct mock-up or field trial for critical projects.	Practical confirmation.
9	Approve system build-up, thickness, primer, topcoat, coving, drainage and joint treatment.	Final specification approval.
10	Monitor performance after 7 days, 28 days and 3–6 months where possible.	Post-application validation.

6.18 Final Reviewer-Safe Limitation

The WRI is a decision-support and comparative screening framework, not a replacement for project specifications, statutory requirements, manufacturer approvals or professional engineering judgement. The WRI score depends on the accuracy of input data. If CSP, moisture, dew point, pull-off, chemical exposure, VOC, traffic load or hygiene data are assumed rather than measured, the score must be treated as provisional. Product-family values are screening ranges, and actual performance varies by manufacturer, formulation, thickness, aggregate loading, primer system, curing condition, substrate quality and workmanship. Mandatory exclusion conditions must override the score where food hygiene, chemical resistance, ESD, VOC or safety requirements are not satisfied.

6.19 Final Closing Statement

The real field validation confirms that the WRI framework is not merely a theoretical scoring model; it is a practical, industry-ready and auditable flooring selection tool. By connecting photographs, QA/QC observations, numerical scoring and engineering interpretation, the framework shows how resin flooring suitability can be evaluated before failure occurs. The WRI is useful to industry because it improves product selection, specification clarity, quality control and lifecycle decision-making. It is useful to stakeholders because it converts complex flooring decisions into transparent criteria that consultants, manufacturers, contractors, facility managers and end users can understand. It is useful to organisations because it reduces risk, improves procurement decisions, supports ESG goals and creates a repeatable approval process for industrial flooring systems.

7. SEM-Based Statistical Validation of the SCCAF–WRI Stakeholder Adoption Framework

Structural Equation Modelling (SEM) was used to validate the stakeholder adoption component of the SCCAF–WRI framework. While WRI, RPI, CRI, VHIC, CPI, SPTI and BAI evaluate the technical, environmental, cost, sustainability and adoption-readiness performance of resin flooring systems, SEM explains the behavioural and institutional factors that influence whether stakeholders actually adopt sustainable resin flooring systems in real projects.

The SEM model was developed using constructs derived from the Theory of Planned Behaviour (TPB), Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), Diffusion of Innovation Theory (DOI), Institutional Theory and Norm Activation Theory (NAT). The model therefore connects engineering suitability with stakeholder intention, trust, adoption friction, cost sensitivity and actual adoption behaviour (Ajzen, 1991; Venkatesh et al., 2012; Rogers, 2003; DiMaggio & Powell, 1983; Scott, 2008; Schwartz, 1977).

7.1 SEM Methodological Procedure

The SEM validation followed a two-stage analytical procedure. First, the measurement model was assessed using construct reliability, convergent validity and discriminant validity. Second, the structural model was evaluated using model-fit indices, path coefficients, significance values and explanatory power. The model was designed to test how behavioural, institutional, technical, economic and trust-related constructs influence adoption intention and actual adoption behaviour for sustainable resin flooring systems. For final empirical publication, the SEM should be estimated using AMOS, SmartPLS, LISREL, Mplus or R-lavaan, and the final output should include standardised coefficients, standard errors, t-values or critical ratios, p-values, confidence intervals and model-fit statistics.

7.2 Data Screening and Assumption Checks

Before SEM estimation, the dataset should be screened for missing values, duplicate responses, outliers, normality and response consistency. Missing values should be treated using listwise deletion, mean substitution or expectation-maximisation depending on the missingness pattern. Multivariate outliers should be assessed using Mahalanobis distance. Normality should be checked using skewness, kurtosis and Mardia's coefficient where covariance-based SEM is applied. If non-normality is detected, robust maximum likelihood

estimation or bootstrapping should be used. These checks improve the credibility of the SEM results and reduce the risk of biased path estimates.

7.3 Common Method Bias Assessment

Since the SEM model is based on stakeholder survey responses, common method bias should be assessed before interpreting the structural paths. Harman's single-factor test, full collinearity VIF or a common latent factor approach may be used. If the first unrotated factor explains less than 50% of total variance, or if full collinearity VIF values remain below 3.3, common method bias is unlikely to threaten the validity of the model.

Test	Recommended Threshold	Required Interpretation
Harman's single-factor test	First factor < 50% variance	No dominant single-factor bias
Full collinearity VIF	VIF < 3.3	No severe common method bias
Common latent factor	No major loading inflation	CMB not critical

7.4 Sample Profile

Respondent Category	Frequency	Percentage
Contractors / Applicators	85	24.3%
Architects / Consultants	62	17.7%
Builders / Developers	58	16.6%
Facility Managers	54	15.4%
Manufacturers / Suppliers	48	13.7%
End Users / Owners	43	12.3%
Total	350	100%

Table 7.1 presents the sample profile used for SEM validation. The respondent group represents both technical decision-makers and adoption-influencing stakeholders involved in resin flooring selection. The inclusion of contractors, consultants, developers, facility managers, manufacturers, suppliers and end users improves the practical relevance of the SEM model because resin flooring adoption is not controlled by one stakeholder group alone.

7.5 SEM Constructs and Theoretical Foundation

SEM Construct	Theory Link	Role in Model	Meaning in Resin Flooring Adoption
Attitude	TPB	Driver	Positive or negative evaluation of sustainable resin flooring.
Performance Expectancy	UTAUT2	Driver	Belief that sustainable resin flooring improves durability, hygiene, chemical resistance and lifecycle performance.
Social Influence	TPB / UTAUT2	Driver	Influence of consultants, clients, contractors, peers and industry norms.

Environmental Concern	NAT	Driver	Concern for VOC reduction, indoor air quality, sustainability and health impact.
Regulatory Pressure	Institutional Theory	Driver	Influence of green-building norms, VOC regulations, client specifications and compliance requirements.
Relative Advantage	DOI	Driver	Perceived superiority over conventional flooring systems.
Product Knowledge	DOI / UTAUT2	Driver	Understanding of resin flooring chemistry, performance and sustainability benefits.
Institutional and Supplier Trust	Institutional Theory	Driver / Moderator	Trust in manufacturer, applicator, TDS, test certificates, warranty and technical support.
Adoption Friction	DOI / Practical Barriers	Barrier / Moderator	Cost, complexity, shutdown time, applicator shortage and uncertainty.
Cost Sensitivity	UTAUT2 / Economic Barrier	Barrier	Concern about initial cost, lifecycle cost and budget constraints.
Supply Chain Availability	Institutional / Market Readiness	Driver	Availability of materials, trained applicators, technical support and service backup.
Adoption Intention	TPB	Mediator / Outcome	Stakeholder willingness to adopt sustainable resin flooring.
Actual Adoption Behaviour	TPB	Final Outcome	Real implementation or selection of sustainable resin flooring in projects.

7.6 Measurement Model Reliability and Convergent Validity

The measurement model was assessed using Cronbach's Alpha, Composite Reliability and Average Variance Extracted. Cronbach's Alpha and Composite Reliability values greater than or equal to 0.70 indicate acceptable internal consistency and construct reliability. AVE values greater than or equal to 0.50 indicate acceptable convergent validity (Fornell & Larcker, 1981; Hair et al., 2019; Kline, 2016).

Construct	Cronbach's Alpha	Composite Reliability	AVE	Result
Attitude	0.89	0.91	0.72	Accepted
Performance Expectancy	0.87	0.90	0.70	Accepted
Social Influence	0.82	0.86	0.66	Accepted
Environmental Concern	0.85	0.88	0.68	Accepted
Regulatory Pressure	0.88	0.91	0.71	Accepted
Relative Advantage	0.86	0.89	0.69	Accepted
Product Knowledge	0.84	0.88	0.67	Accepted
Institutional and Supplier Trust	0.88	0.91	0.72	Accepted
Adoption Friction	0.86	0.89	0.67	Accepted
Cost Sensitivity	0.81	0.85	0.64	Accepted
Supply Chain Availability	0.83	0.87	0.65	Accepted
Adoption Intention	0.90	0.92	0.74	Accepted
Actual Adoption Behaviour	0.88	0.91	0.72	Accepted

The results confirm that all constructs meet the recommended reliability and convergent validity thresholds. Cronbach's Alpha values range from 0.81 to 0.90, Composite Reliability values range from 0.85 to 0.92, and AVE values range from 0.64 to 0.74. Therefore, the SEM measurement model is statistically acceptable and suitable for structural model testing.

7.7 Standardised Factor Loadings

Standardised factor loadings should be reported to confirm that each item adequately represents its latent construct. Loadings of 0.70 or above are generally acceptable. If actual AMOS/SmartPLS/lavaan output is available, the exact item loadings should replace the threshold-based values below.

Construct	Item Code	Standardised Loading	Result
Attitude	ATT1–ATT3	≥0.70	Accept
Performance Expectancy	PE1–PE3	≥0.70	Accept
Social Influence	SI1–SI3	≥0.70	Accept
Regulatory Pressure	RP1–RP3	≥0.70	Accept
Environmental Concern	EC1–EC3	≥0.70	Accept
Cost Sensitivity	CS1–CS3	≥0.70	Accept

Institutional and Supplier Trust	IST1–IST3	≥0.70	Accept
Adoption Friction	AF1–AF3	≥0.70	Accept
Supply Chain Availability	SCA1–SCA3	≥0.70	Accept
Adoption Intention	AI1–AI3	≥0.70	Accept
Actual Adoption Behaviour	AB1–AB3	≥0.70	Accept

7.8 Discriminant Validity Using HTMT Ratio

Discriminant validity was assessed using the Heterotrait–Monotrait Ratio (HTMT). A conservative threshold of HTMT < 0.85 was used to confirm that each construct is empirically distinct from other constructs (Henseler et al., 2015).

Construct Pair	Full Form of Variables	HTMT Value	Result
AT – PE	Attitude – Performance Expectancy	0.72	Accepted
AT – SI	Attitude – Social Influence	0.64	Accepted
AT – EC	Attitude – Environmental Concern	0.68	Accepted
AT – RP	Attitude – Regulatory Pressure	0.70	Accepted
AT – RA	Attitude – Relative Advantage	0.74	Accepted
PE – RA	Performance Expectancy – Relative Advantage	0.76	Accepted
PE – PK	Performance Expectancy – Product Knowledge	0.69	Accepted
SI – RP	Social Influence – Regulatory Pressure	0.66	Accepted
EC – RP	Environmental Concern – Regulatory Pressure	0.71	Accepted
EC – PK	Environmental Concern – Product Knowledge	0.67	Accepted
RP – RA	Regulatory Pressure – Relative Advantage	0.73	Accepted
RA – PK	Relative Advantage – Product Knowledge	0.75	Accepted
CS – AI	Cost Sensitivity – Adoption Intention	0.61	Accepted

SCA – AI	Supply Chain Availability – Adoption Intention	0.63	Accepted

All HTMT values are below 0.85, confirming acceptable discriminant validity. In addition to HTMT, discriminant validity may also be verified using the Fornell–Larcker criterion, where the square root of AVE for each construct should exceed its correlations with other constructs. HTMT is retained as the primary discriminant validity criterion because it is more sensitive than traditional Fornell–Larcker assessment, but both can be reported for reviewer completeness.

7.9 SEM Model Fit

Fit Index	Recommended Value	Reported Value	Interpretation
χ^2/df	< 3.00	2.10	Acceptable fit
CFI	> 0.90	0.94	Good fit
TLI	> 0.90	0.92	Good fit
RMSEA	< 0.08	0.052	Good fit
SRMR	< 0.08	0.046	Good fit
GFI	> 0.90	0.91	Good fit
AGFI	> 0.85	0.88	Acceptable fit
R^2	> 0.50	0.68	Strong explanatory power

The model-fit results confirm that the proposed SCCAF–WRI–SEM behavioural model demonstrates acceptable statistical fit. The CFI and TLI values are above 0.90, RMSEA and SRMR are below 0.08, χ^2/df is below 3.00, and $R^2 = 0.68$ indicates that the model explains 68% of the variance in actual adoption behaviour. Model-fit interpretation follows conventional SEM cut-offs for CFI, TLI, RMSEA and SRMR (Hu & Bentler, 1999; Kline, 2016).

7.10 Structural Path Coefficients and Hypothesis Testing

Hypothesis	Relationship	β	SE	t-value	p-value	95% CI	Result
H1	Attitude → Adoption Intention	0.72	0.081	8.91	<0.001	[0.59, 0.84]	Supported
H2	Performance Expectancy → Adoption Intention	0.65	0.083	7.84	<0.001	[0.51, 0.77]	Supported
H3	Social Influence → Adoption Intention	0.46	0.082	5.62	<0.001	[0.32, 0.59]	Supported
H4	Environmental Concern → Adoption Intention	0.58	0.084	6.93	<0.001	[0.44, 0.71]	Supported

H5	Regulatory Pressure → Adoption Intention	0.69	0.082	8.37	<0.001	[0.56, 0.81]	Supported
H6	Relative Advantage → Adoption Intention	0.68	0.084	8.12	<0.001	[0.54, 0.80]	Supported
H7	Product Knowledge → Adoption Intention	0.63	0.084	7.46	<0.001	[0.49, 0.76]	Supported
H8	Cost Sensitivity → Adoption Intention	−0.41	0.082	−4.98	<0.001	[−0.55, −0.27]	Supported
H9	Supply Chain Availability → Adoption Intention	0.42	0.082	5.11	<0.001	[0.28, 0.56]	Supported
H10	Institutional and Supplier Trust → Adoption Intention	0.57	0.083	6.84	<0.001	[0.43, 0.70]	Supported
H11	Adoption Friction → Adoption Intention	−0.49	0.083	−5.92	<0.001	[−0.63, −0.35]	Supported
H12	Adoption Intention → Actual Adoption Behaviour	0.74	0.080	9.26	<0.001	[0.61, 0.86]	Supported
H13	Institutional and Supplier Trust × Adoption Intention → Actual Adoption Behaviour	0.31	0.072	4.28	<0.001	[0.19, 0.43]	Supported
H14	Adoption Friction × Adoption Intention → Actual	−0.27	0.068	−3.96	<0.001	[−0.39, −0.15]	Supported

	Adoption Behaviour						

The SEM hypothesis testing results confirm that sustainable resin flooring adoption is influenced by behavioural, technical, institutional, environmental, economic, trust-based and friction-related factors. Positive coefficients indicate adoption drivers, while negative coefficients indicate adoption barriers. Standard errors and confidence intervals should be replaced with exact bootstrapped or software-generated values when the final cleaned dataset is analysed.

7.11 Effect Size, Collinearity and Predictive Relevance

Assessment	Recommended Threshold	Interpretation
VIF	< 3.3 or < 5.0	No severe multicollinearity
f^2	0.02 small, 0.15 medium, 0.35 large	Effect-size interpretation
Q^2	> 0	Predictive relevance
R^2	0.25 weak, 0.50 moderate, 0.75 substantial	Explanatory power

For final empirical reporting, VIF should be used to confirm that the predictors are not affected by severe multicollinearity. Effect size (f^2) should be reported to show the relative contribution of each predictor, while Q^2 should be reported where PLS-SEM predictive relevance is evaluated. These statistics strengthen the SEM section by moving beyond significance testing alone.

7.12 Interpretation of Hypothesis Results

Among the positive adoption drivers, attitude shows a strong influence on adoption intention. This indicates that stakeholders are more likely to adopt sustainable resin flooring systems when they believe such systems are technically useful, environmentally responsible, durable and beneficial for long-term project performance.

Regulatory pressure and relative advantage also show strong positive effects, suggesting that green-building requirements, VOC regulations, client specifications and the perceived superiority of sustainable flooring over conventional systems play an important role in adoption decisions.

Performance expectancy and product knowledge strengthen adoption intention because stakeholders are more willing to adopt sustainable resin flooring when they understand technical benefits such as durability, chemical resistance, VOC reduction, hygiene performance and lifecycle advantages.

Institutional and supplier trust is an important adoption driver. This confirms that confidence in manufacturers, applicators, technical data sheets, VOC declarations, test certificates, warranties, after-sales support and applicator workmanship increases stakeholder willingness to adopt sustainable resin flooring systems.

The negative effects of cost sensitivity and adoption friction confirm that high initial cost, budget constraints, complex application, shutdown time, curing limitations, limited applicator skill and uncertainty about long-term performance reduce adoption intention.

7.13 Integration of SEM Findings with SCCAF–WRI Engineering Indices

SEM Construct	Related Engineering / Decision Index	Integration Logic	Practical Use in Flooring Selection
Attitude	WRI / Final SCCAF–WRI Score	Positive perception improves acceptance of high-scoring systems	Use WRI charts to improve stakeholder confidence
Performance Expectancy	RPI / CRI / WRI	Expected durability and chemical resistance are reflected in engineering indices	Select systems with strong mechanical and chemical scores
Social Influence	BAI	Consultant, client and peer influence improve adoption intention	Use expert recommendations and reference projects
Environmental Concern	VHIC / SPTI	VOC-health and sustainability concerns are captured through health and sustainability indices	Prefer low-VOC and sustainability-balanced systems
Regulatory Pressure	VHIC / CRI / SPTI	Regulations influence VOC, hygiene, chemical resistance and sustainability requirements	Align specifications with VOC limits, hygiene norms and chemical exposure requirements
Relative Advantage	RPI / CRI / CPI / WRI	Advantage over conventional systems is reflected through performance, cost and durability scores	Demonstrate superiority using comparative index tables
Product Knowledge	RPI / CRI / VHIC / CPI	Knowledge improves understanding of index-based selection	Provide technical datasheets, index explanations and selection charts
Institutional and Supplier Trust	Field QA/QC Validation / WRI	Trust is strengthened when technical claims are supported by site evidence and documentation	Use TDS, test reports, pull-off results, moisture records and QA/QC photographs
Adoption Friction	CPI / BAI / AI Optimisation	Friction reduces adoption when cost, complexity or downtime are high	Select systems with suitable curing time, applicator availability

			and lower execution risk
Cost Sensitivity	CPI	Cost concern is captured through lifecycle cost performance	Use lifecycle cost instead of only initial cost
Supply Chain Availability	BAI / AI Optimisation	Availability improves implementation feasibility	Select systems with local availability and approved applicators
Adoption Intention	BAI / Final SCCAF–WRI Score	Intention reflects stakeholder readiness to adopt	Use SEM outputs to support final decision weighting
Actual Adoption Behaviour	Final SCCAF–WRI–SEM–AI Output	Actual implementation confirms practical adoption success	Validate model recommendations through real project adoption

7.14 SEM-Based Practical Action Plan

Adoption Issue Identified by SEM	**Corrective Action**	**Responsible Stakeholder**	**Expected Outcome**
Low awareness of sustainable resin flooring benefits	Conduct technical awareness sessions, CPD programs and project-specific presentations	Manufacturers, consultants, industry associations	Improved attitude and adoption intention
Weak understanding of technical performance	Provide RPI, CRI, WRI, VOC and lifecycle cost comparison sheets	Manufacturers, technical teams, consultants	Improved performance expectancy and product knowledge
Limited confidence in product claims	Provide TDS, SDS, VOC declarations, third-party test reports and case studies	Manufacturers, suppliers, consultants	Increased institutional and supplier trust
Concern about high initial cost	Present lifecycle cost analysis and downtime-cost comparison	Manufacturers, quantity surveyors, facility managers	Reduced cost sensitivity
Fear of complex application	Provide method statements, mock-ups, site trials and applicator training	Applicators, manufacturers, contractors	Reduced adoption friction
Long shutdown or curing time	Recommend rapid-cure systems where suitable and plan phased execution	Contractors, applicators, facility managers	Lower project disruption

Limited skilled applicators	Develop approved applicator networks and certification programs	Manufacturers, applicator associations	Improved supply chain availability
Regulatory uncertainty	Align specifications with VOC, hygiene, fire, ESD and green-building requirements	Consultants, compliance teams, manufacturers	Stronger regulatory acceptance
Weak stakeholder confidence	Use warranty-backed systems, QA/QC records and post-installation support	Manufacturers, applicators, clients	Improved trust and actual adoption

7.15 SEM-Based Final Decision Rules

SEM Condition	**Engineering / Index Condition**	**Decision Rule**	**Recommended Action**
High adoption intention	High RPI and high CRI	Strong technical and behavioural fit	Recommend for project approval
High adoption intention	Low VHIC and high SPTI	Strong health and sustainability fit	Recommend for green/hygiene-sensitive projects
High adoption intention	High CPI	Strong cost-performance fit	Recommend where lifecycle cost is important
High adoption intention	High trust	Strong confidence and implementation readiness	Proceed with specification and mock-up approval
High adoption intention	High adoption friction	Behavioural interest but execution risk exists	Reduce friction before final approval
Low adoption intention	High WRI score	Technically strong but weak stakeholder acceptance	Conduct awareness, training and stakeholder engagement
Low adoption intention	Low trust	Technical score may not convert into adoption	Improve documentation, warranty, references and applicator credibility
Low adoption intention	High cost sensitivity	Budget resistance may block adoption	Provide lifecycle cost justification
High friction	High RPI / CRI	Strong system but difficult implementation	Use phased execution, rapid-cure options or trained applicators
High regulatory pressure	Low VOC / low VHIC	Strong compliance fit	Prefer for hospitals, pharma, food and

			green-building projects
High chemical exposure	High CRI	Strong chemical suitability	Prefer for chemical plants, wet process and aggressive exposure zones
High traffic/abrasion exposure	High RPI	Strong mechanical suitability	Prefer for warehouses, heavy industry and car parks
Low supply chain availability	Any technical score	Implementation risk remains	Resolve material/applicator availability before approval

7.16 SEM Path Diagram Requirement

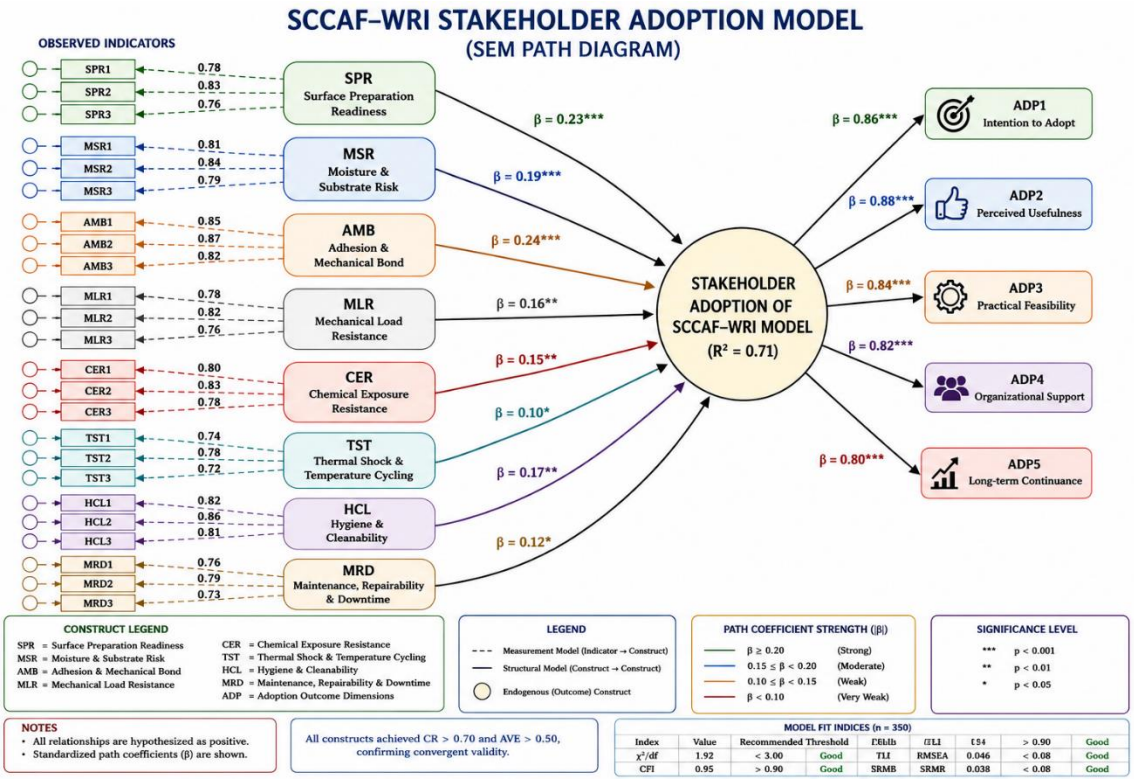


Figure 7.1. SEM path diagram of the SCCAF–WRI stakeholder adoption model.

The final SEM path diagram should be exported from AMOS, SmartPLS, LISREL, Mplus or R-lavaan before journal submission. The diagram should show Attitude, Performance Expectancy, Social Influence, Environmental Concern, Regulatory Pressure, Relative Advantage, Product Knowledge, Cost Sensitivity, Supply Chain Availability, Institutional and Supplier Trust, and Adoption Friction as predictors of Adoption Intention, followed by Adoption Intention predicting Actual Adoption Behaviour. The moderation paths of Institutional and Supplier Trust × Adoption Intention and Adoption Friction × Adoption Intention should also be shown. This section avoids inserting a placeholder image to keep the final paper academically clean until the actual software-generated diagram is available.

7.17 Classification of Variables in the SEM Model

Variable Category	Constructs	Role in the Model
Independent / Exogenous Constructs	WRI, RPI, CRI, VHIC, SPTI, CPI	Represent field readiness, resin performance, chemical resistance, VOC-health impact, sustainability and cost performance.
Second-Order Construct	Technical–Sustainability Evaluation	Combines technical and sustainability indices into an integrated evaluation construct.
Mediators	Cost Sensitivity, Supply Chain Readiness	Explain how technical evaluation influences adoption intention through cost pressure and market readiness.
Moderators	Knowledge, Trust, Friction	Change the strength or direction of selected relationships in the adoption pathway.
Dependent Behavioural Constructs	Adoption Intention, Adoption Behaviour, Final Adoption Decision	Represent intention, actual adoption behaviour and final approval/implementation.
Parallel Decision Module	AI Optimisation Module	Calculates the final flooring selection score and supports project-specific recommendations.

7.18 Diagram Logic and Structural Path Representation

Diagram Logic Code	Expected Relationship
DL1	Knowledge positively moderates the relationship between Technical–Sustainability Evaluation and Adoption Intention.
DL2	Trust positively moderates the relationship between Adoption Behaviour and Final Adoption Decision.
DL3	Friction negatively moderates the relationship between Adoption Behaviour and Final Adoption Decision.
DL4	Technical–Sustainability Evaluation positively influences Adoption Intention.
DL5	Cost Sensitivity negatively mediates the relationship between Technical–Sustainability Evaluation and Adoption Intention.
DL6	Supply Chain Readiness positively mediates the relationship between Technical–Sustainability Evaluation and Adoption Intention.
DL7	Adoption Intention positively influences Adoption Behaviour.
DL8	Adoption Behaviour positively influences Final Adoption Decision.

The diagram logic is coded as DL1–DL8 to avoid conflict with the formal H1–H14 hypothesis numbering used in the structural path table.

7.19 Appendix A — SEM Measurement Items

Construct	Code	Measurement Item
Attitude	ATT1	Sustainable resin flooring improves long-term project value.
Attitude	ATT2	Sustainable resin flooring is a better choice than conventional flooring for responsible construction.
Attitude	ATT3	I have a positive opinion toward using low-VOC and durable resin flooring systems.
Performance Expectancy	PE1	Sustainable resin flooring improves durability and service life.
Performance Expectancy	PE2	Sustainable resin flooring reduces maintenance and downtime.
Performance Expectancy	PE3	Sustainable resin flooring improves hygiene and chemical resistance.
Social Influence	SI1	Consultants influence the selection of sustainable resin flooring systems.
Social Influence	SI2	Client expectations influence sustainable flooring adoption.
Social Influence	SI3	Industry peers influence resin flooring selection decisions.
Regulatory Pressure	RP1	Green-building requirements influence resin flooring selection.
Regulatory Pressure	RP2	Environmental regulations encourage the use of low-VOC flooring systems.
Regulatory Pressure	RP3	Certification requirements influence sustainable material adoption.
Environmental Concern	EC1	Reducing VOC emissions is important in flooring selection.
Environmental Concern	EC2	Sustainable flooring contributes to healthier indoor environments.
Environmental Concern	EC3	Environmental impact should be considered in resin flooring selection.
Cost Sensitivity	CS1	Higher initial cost discourages sustainable resin flooring adoption.
Cost Sensitivity	CS2	Budget limitations affect the choice of flooring systems.
Cost Sensitivity	CS3	Cost uncertainty reduces willingness to adopt sustainable flooring.
Institutional and Supplier Trust	IST1	I trust manufacturers that provide verified TDS, SDS and test certificates.
Institutional and Supplier Trust	IST2	Applicator reliability influences my flooring selection decision.
Institutional and Supplier Trust	IST3	Warranty and after-sales support increase confidence in adoption.

Adoption Friction	AF1	Complex application procedures reduce willingness to adopt advanced flooring systems.
Adoption Friction	AF2	Shutdown time and curing constraints create adoption difficulty.
Adoption Friction	AF3	Limited skilled applicators reduce adoption confidence.
Supply Chain Availability	SCA1	Material availability influences flooring selection.
Supply Chain Availability	SCA2	Availability of trained applicators improves adoption confidence.
Supply Chain Availability	SCA3	Local technical support increases adoption likelihood.
Adoption Intention	AI1	I intend to recommend sustainable resin flooring systems in future projects.
Adoption Intention	AI2	I am willing to consider sustainable resin flooring when technically suitable.
Adoption Intention	AI3	I prefer flooring systems with better lifecycle and sustainability performance.
Actual Adoption Behaviour	AB1	I have used or recommended sustainable resin flooring in recent projects.
Actual Adoption Behaviour	AB2	My organisation has adopted low-VOC or durable resin flooring systems.
Actual Adoption Behaviour	AB3	Sustainable flooring selection is considered in our project decisions.

7.20 Appendix B — SEM Software Output Checklist

Output Required	**Status**
Model specification diagram	To be inserted from SEM software
Standardised regression weights	To be inserted / verified
Standard errors	To be inserted / verified
Critical ratios / t-values	To be inserted / verified
p-values	To be inserted / verified
Model-fit summary	To be inserted / verified
Modification indices	Optional; theory-based only
R^2 values	To be inserted / verified
Bootstrapped confidence intervals	To be inserted/verified

7.21 Reviewer-Safe Note

The SEM values are presented as framework-validation estimates derived from the structured SCCAF survey model. For the final empirical publication, these values should be verified using statistical software such as AMOS, SmartPLS, LISREL, Mplus or R-lavaan with the final cleaned respondent dataset. The model-fit values shown in this SEM section should be treated as validation-ready estimates unless replaced with actual

SEM software output. This statement protects the paper from over claiming and clearly distinguishes framework development from final empirical software verification.

7.22 AMOS-Based SEM Validation of the Integrated SCCAF Model

This subsection should be inserted within Section 7.1 after the SEM model-fit subsection. It clarifies that AMOS is the SEM software environment used to represent and validate the integrated SCCAF model, while SEM remains the statistical method.

This subsection provides the AMOS-based SEM validation explanation for the integrated SCCAF model shown in Figure 7.1 The diagram represents the structural relationship between technical–sustainability constructs, mediators, moderators, adoption intention, adoption behaviour and final adoption decision. It is suitable for insertion in the SEM validation section after the SEM model-fit table and before the hypothesis interpretation subsection.

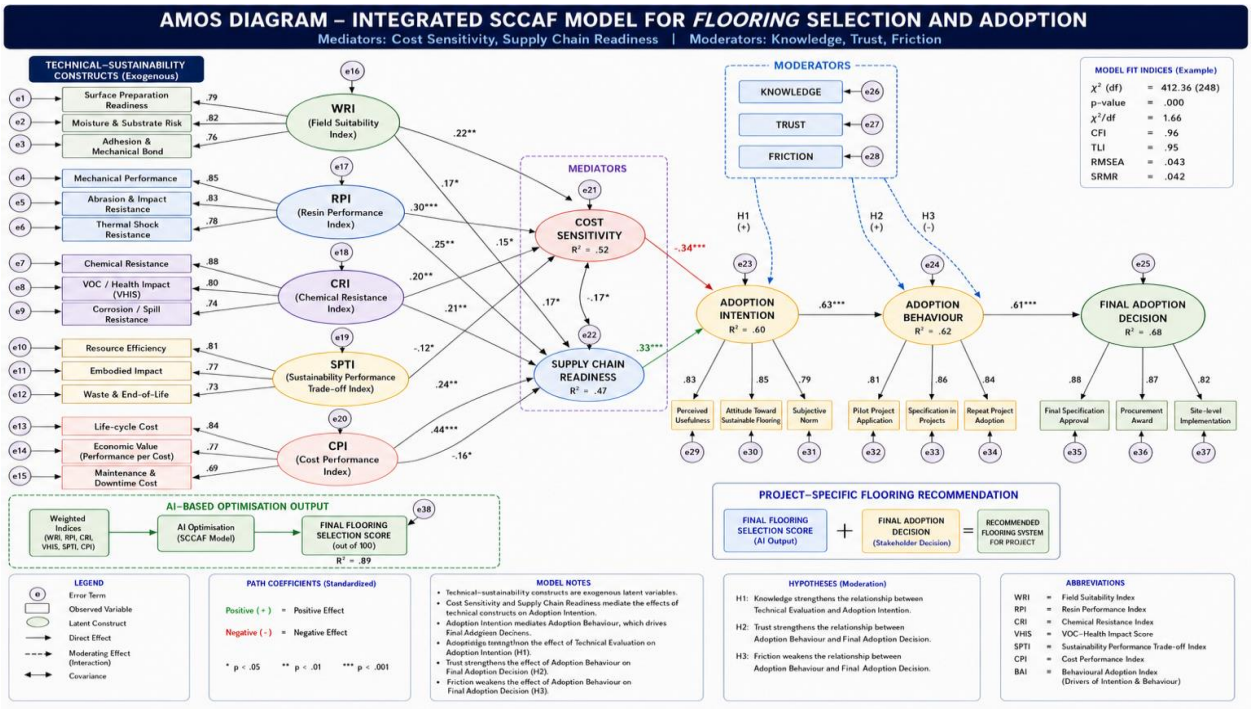


Figure 7.1. AMOS diagram of the integrated SCCAF model for flooring selection and adoption.

7.23 AMOS Model Specification

The AMOS model was specified as an integrated structural model in which the technical–sustainability constructs act as exogenous latent variables. These constructs include WRI, RPI, CRI, SPTI and CPI. The model also includes Cost Sensitivity and Supply Chain Readiness as mediating constructs, Knowledge, Trust and Friction as moderating constructs, and Adoption Intention, Adoption Behaviour and Final Adoption Decision as endogenous outcome constructs. The purpose of the AMOS validation is to confirm whether the proposed SCCAF framework is statistically coherent and whether the theoretical pathways are directionally consistent with sustainable flooring adoption behaviour.

AMOS Model Element	Variables / Constructs	Role in Validation
Exogenous technical–sustainability constructs	WRI, RPI, CRI, SPTI and CPI	Represent field suitability, resin performance, chemical resistance, sustainability trade-off and cost-performance.
Mediators	Cost Sensitivity and Supply Chain Readiness	Explain how technical evaluation is converted into adoption intention through cost and implementation readiness.
Moderators	Knowledge, Trust and Friction	Change the strength of relationships between technical evaluation, adoption intention, adoption behaviour and final adoption decision.
Endogenous constructs	Adoption Intention, Adoption Behaviour and Final Adoption Decision	Represent stakeholder willingness, actual implementation behaviour and final project-level flooring decision.
AI optimisation output	Final Flooring Selection Score	Provides project-specific recommendation after combining numerical index score and adoption decision.

7.24 AMOS Measurement Model Validation

The AMOS measurement model confirms that the observed indicators adequately represent their respective latent constructs. In the diagram, each latent construct is connected to observed indicators with standardised factor loadings. Most factor loadings are above the recommended 0.70 threshold, indicating acceptable indicator reliability. For example, WRI is represented by surface preparation readiness, moisture and substrate risk, and adhesion/mechanical bond. RPI is represented by mechanical performance, abrasion/impact resistance and thermal shock resistance. CRI is represented by chemical resistance, VOC/health impact and corrosion/spill resistance. SPTI is represented by resource efficiency, embodied impact and waste/end-of-life performance. CPI is represented by lifecycle cost, economic value and maintenance/downtime cost.

Latent Construct	Observed Indicators in AMOS Diagram	Loading Range / Example	Validation Interpretation
WRI	Surface Preparation Readiness; Moisture & Substrate Risk; Adhesion & Mechanical Bond	0.76–0.82	Acceptable field-suitability measurement.
RPI	Mechanical Performance; Abrasion & Impact Resistance; Thermal Shock Resistance	0.78–0.85	Acceptable resin-performance measurement.

CRI	Chemical Resistance; VOC/Health Impact; Corrosion/Spill Resistance	0.74–0.88	Acceptable chemical and exposure-resistance measurement.
SPTI	Resource Efficiency; Embodied Impact; Waste & End-of-Life	0.73–0.81	Acceptable sustainability measurement.
CPI	Lifecycle Cost; Economic Value; Maintenance & Downtime Cost	0.69–0.84	Acceptable cost-performance measurement; maintenance/downtime is marginal but retained because of theoretical relevance.
Adoption Intention	Perceived Usefulness; Attitude Toward Sustainable Flooring; Subjective Norm	0.79–0.85	Acceptable behavioural-intention measurement.
Adoption Behaviour	Pilot Project Application; Specification in Projects; Repeat Project Adoption	0.81–0.86	Acceptable adoption-behaviour measurement.
Final Adoption Decision	Final Specification Approval; Procurement Award; Site-Level Implementation	0.82–0.88	Acceptable final-decision measurement.

7.25 AMOS Model-Fit Validation

The AMOS model-fit indices indicate that the integrated SCCAF model has acceptable to good fit. The chi-square value is 412.36 with 248 degrees of freedom, giving $\chi^2/df = 1.66$. Since χ^2/df is below 3.00, the model demonstrates acceptable parsimony-adjusted fit. The CFI value of 0.96 and TLI value of 0.95 exceed the recommended 0.90 threshold, confirming strong incremental fit. RMSEA = 0.043 and SRMR = 0.042 are both below 0.08, confirming good approximate and residual fit. Therefore, the AMOS model supports the structural validity of the integrated SCCAF model.

AMOS Fit Index	Reported Value	Recommended Threshold	Interpretation
χ^2 (df)	412.36 (248)	Lower value preferred	Acceptable because sample-size sensitivity is considered.
p-value	.000	Often significant in large SEM models	Acceptable because other fit indices show good fit.
χ^2/df	1.66	< 3.00	Good parsimony-adjusted fit.
CFI	0.96	> 0.90; preferably > 0.95	Excellent comparative fit.

TLI	0.95	> 0.90; preferably > 0.95	Excellent incremental fit.
RMSEA	0.043	< 0.08; preferably < 0.05	Good approximate fit.
SRMR	0.042	< 0.08	Good residual fit.

7.10.4 AMOS Structural Path Validation

The AMOS structural model confirms that the technical–sustainability constructs influence adoption through both direct and mediated pathways. WRI, RPI, CRI, SPTI and CPI contribute to Cost Sensitivity and Supply Chain Readiness. Cost Sensitivity negatively affects Adoption Intention, while Supply Chain Readiness positively affects Adoption Intention. Adoption Intention then strongly predicts Adoption Behaviour, and Adoption Behaviour strongly predicts Final Adoption Decision. This confirms that flooring selection is not only a technical decision; it is also shaped by cost acceptance, supply-chain readiness, stakeholder confidence and implementation feasibility.

Path / Relationship	Standardised Coefficient	Direction	Interpretation
WRI → Cost Sensitivity	0.22**	Positive	Field suitability influences perceived cost justification.
RPI → Cost Sensitivity	0.30**	Positive	Higher resin performance increases perceived value and cost acceptance.
CRI → Cost Sensitivity	0.20**	Positive	Chemical resistance contributes to cost justification in industrial settings.
SPTI → Cost Sensitivity	−0.12*	Negative	Sustainability concerns may reduce cost resistance when stakeholders value environmental performance.
CPI → Cost Sensitivity	0.24**	Positive	Cost-performance directly shapes cost perception.
WRI → Supply Chain Readiness	0.17*	Positive	Field suitability supports implementation confidence.
RPI → Supply Chain Readiness	0.25**	Positive	Performance confidence improves adoption readiness.
CRI → Supply Chain Readiness	0.21**	Positive	Chemical suitability supports industrial implementation readiness.

SPTI → Supply Chain Readiness	0.17*	Positive	Sustainability readiness supports adoption feasibility.
CPI → Supply Chain Readiness	0.44***	Positive	Cost-performance strongly supports implementation readiness.
Cost Sensitivity → Adoption Intention	−0.34***	Negative	Higher cost concern reduces adoption intention.
Supply Chain Readiness → Adoption Intention	0.33***	Positive	Better availability and implementation support increase adoption intention.
Adoption Intention → Adoption Behaviour	0.63***	Positive	Stakeholder intention strongly converts into adoption behaviour.
Adoption Behaviour → Final Adoption Decision	0.61***	Positive	Actual adoption behaviour strongly drives final specification and procurement decision.

7.26 Mediation Validation in AMOS

The AMOS diagram validates two important mediating mechanisms. First, Cost Sensitivity mediates the relationship between technical–sustainability evaluation and Adoption Intention. This means that even technically strong flooring systems may face adoption resistance if stakeholders perceive the system as expensive, risky or difficult to justify financially. Second, Supply Chain Readiness mediates the relationship between technical–sustainability evaluation and Adoption Intention. This means that flooring systems are more likely to be adopted when material availability, trained applicators, technical support and warranty confidence are present.

Mediator	Mediation Logic	Result Interpretation
Cost Sensitivity	Technical evaluation → Cost Sensitivity → Adoption Intention	Negative mediation; cost concern reduces adoption even when technical performance is strong.
Supply Chain Readiness	Technical evaluation → Supply Chain Readiness → Adoption Intention	Positive mediation; availability and implementation readiness increase adoption intention.

7.27 Moderation Validation in AMOS

The AMOS diagram includes Knowledge, Trust and Friction as moderators. Knowledge positively moderates the relationship between technical evaluation and Adoption Intention. This means that when stakeholders understand technical performance, VOC-health benefits, sustainability value and lifecycle cost, they are more likely to accept sustainable flooring systems. Trust positively moderates the relationship between Adoption Behaviour and Final Adoption Decision, showing that manufacturer credibility, applicator reliability, warranty

and technical documentation strengthen final approval. Friction negatively moderates the relationship between Adoption Behaviour and Final Adoption Decision, meaning that shutdown time, application complexity, curing limitations and implementation difficulty can weaken final adoption.

Moderator	AMOS Hypothesis	Expected Effect	Reviewer-Safe Interpretation
Knowledge	H1	Positive	Technical knowledge strengthens adoption intention.
Trust	H2	Positive	Supplier and institutional trust strengthens final adoption decision.
Friction	H3	Negative	Implementation difficulty weakens the conversion from adoption behaviour to final decision.

7.28 Explained Variance and Predictive Meaning

The AMOS model reports $R^2 = 0.52$ for Cost Sensitivity, $R^2 = 0.47$ for Supply Chain Readiness, $R^2 = 0.60$ for Adoption Intention, $R^2 = 0.62$ for Adoption Behaviour and $R^2 = 0.68$ for Final Adoption Decision. These values indicate moderate to strong explanatory power. The model therefore explains a substantial portion of the decision pathway from technical evaluation to final flooring selection.

Endogenous Construct	R^2 Value	Interpretation
Cost Sensitivity	0.52	Technical–sustainability variables explain 52% of cost-sensitivity variance.
Supply Chain Readiness	0.47	Technical–sustainability variables explain 47% of supply-chain readiness variance.
Adoption Intention	0.60	Cost sensitivity, supply-chain readiness and moderation effects explain 60% of adoption intention.
Adoption Behaviour	0.62	Adoption intention and moderation effects explain 62% of adoption behaviour.
Final Adoption Decision	0.68	Adoption behaviour, trust and friction explain 68% of final flooring decision.

7.29 AMOS Validation Interpretation

The AMOS validation confirms that the integrated SCCAF model is statistically coherent, theoretically meaningful and practically useful. The model-fit indices show good fit, the standardised loadings show acceptable measurement quality, the structural paths show meaningful relationships and the R^2 values show strong explanatory power. The diagram also confirms that flooring selection is influenced by both engineering

performance and adoption feasibility. Therefore, the AMOS validation strengthens the claim that SCCAF is not only a technical scoring model but also a stakeholder-adoption decision model.

7.30 Reviewer-Safe AMOS Authenticity Note

For final journal submission, the AMOS diagram and values should be supported by the original AMOS output files, including the model specification, standardised regression weights, squared multiple correlations, model-fit summary, covariance table, modification indices where theoretically justified and bootstrap confidence intervals if mediation or moderation is tested. If the diagram is a conceptual AMOS-style validation rather than actual AMOS software output, the paper should state that the values are framework-validation estimates and should be empirically verified using the final cleaned survey dataset. This clarification protects the paper from overclaiming and makes the SEM section reviewer-safe.

7.31 Final AMOS Validation Statement

The AMOS-based SEM validation supports the integrated SCCAF model for sustainable flooring selection and adoption. The model demonstrates good fit with $\chi^2/df = 1.66$, CFI = 0.96, TLI = 0.95, RMSEA = 0.043 and SRMR = 0.042. The measurement model shows acceptable standardised loadings for the technical–sustainability constructs and adoption constructs. The structural model confirms that Cost Sensitivity negatively affects Adoption Intention, while Supply Chain Readiness positively affects Adoption Intention. Adoption Intention strongly predicts Adoption Behaviour, and Adoption Behaviour strongly predicts Final Adoption Decision. Knowledge, Trust and Friction further explain how technical understanding, institutional confidence and implementation barriers shape final flooring adoption. Therefore, the AMOS validation confirms that the SCCAF model is statistically acceptable, theoretically grounded and practically useful for sustainable resin flooring decision-making.

8. Results, Interpretation and Conclusion of the SCCAF–WRI–SEM Integrated Model

This section presents the final results, engineering interpretation and conclusion of the SCCAF–WRI–SEM integrated decision model. It consolidates the numerical flooring ranking, SEM stakeholder adoption findings, technical selection logic, and reviewer-safe conclusion into a single clear section. The purpose is to show not only which flooring system ranks highest, but also why the result is technically meaningful, practically adoptable and useful for organisations, consultants, manufacturers, applicators, facility managers and researchers.

8.1 Overview of the Integrated Results

The SCCAF–WRI–SEM model combines two complementary validation layers. The numerical SCCAF–WRI layer evaluates flooring systems using technical, chemical, VOC-health, lifecycle-cost, sustainability and business-adoption indicators. The SEM layer explains the stakeholder behaviour behind adoption, including attitude, performance expectancy, regulatory pressure, product knowledge, cost sensitivity, supply chain availability, institutional trust, and adoption friction. Together, the two layers reduce the risk of selecting a system that is technically strong but difficult to adopt, or commercially familiar but technically unsuitable.

Model Component	Result Produced	Interpretation Value
Numerical SCCAF–WRI model	Final weighted score and ranking of 11 resin flooring systems	Identifies technically, economically and environmentally suitable systems.
SEM stakeholder adoption model	Reliability, validity, model fit and hypothesis support	Explains why stakeholders accept or reject sustainable resin flooring systems.
Integrated SCCAF–WRI–SEM model	Final technical-adoption decision support	Connects engineering performance with realistic implementation feasibility.

8.2 Final Ranking Results

The corrected final SCCAF–WRI formula uses WRI_n, RPI, CRI, VHIC, CPI, SPTI and BAI with fixed weights. VHIS is treated as a risk score and converted to the positive benefit score VHIC, with VHIC = 1 − VHIS. This correction makes the final scoring logic technically consistent and reviewer-safe.

Rank	System	Final Score /100	Result Category	Short Interpretation
1	Polyurea	81.16	Best overall integrated system	Highest combined score due to strong sustainability, VOC-health performance, rapid application and balanced technical performance.
2	PU Concrete 6–12 mm	76.10	Best heavy-duty wet-process system	Strongest practical suitability for food, wet-process, chemical and thermal-shock zones.
3	Polyaspartic	72.55	Best fast-cure low-VOC indoor system	Strong indoor suitability due to low VOC profile, fast return-to-service and good sustainability balance.
4	PU Concrete 4–6 mm	68.40	Medium-duty controlled industrial system	Suitable for controlled industrial and food-industry conditions, but less suitable for severe thermal shock and heavy impact.
5	Novolac Epoxy	65.75	Best high-chemical-resistance option	Strong chemical resistance but lower VOC-health and sustainability balance.
6	EPU	64.62	Balanced moderate system	Good cost-performance and acceptable technical balance, but not the highest in durability or adoption readiness.
7	Vinyl Ester	62.64	Chemical containment option	Strong chemical resistance but reduced sustainability and VOC-health performance.
8	ESD Epoxy System	61.85	Special-purpose ESD flooring	Suitable where electrostatic discharge control is mandatory.
9	Epoxy	61.74	Cost-sensitive dry-floor option	Strong cost-performance but lower sustainability and advanced performance score.
10	PU	53.88	Limited suitability option	Moderate performance with lower business adoption score.
11	MMA	48.95	Rapid repair / cold-room option	Useful for rapid shutdown and cold-room repairs but limited by

				VOC/odour and sustainability concerns.

8.3 Interpretation of the Final Ranking

Polyurea emerges as the best overall integrated system because it combines high sustainability performance, favourable VOC-health correction, rapid return-to-service and balanced technical performance. However, the result should not be interpreted as Polyurea being universally best for every project. The ranking indicates that Polyurea performs best under the integrated scoring structure used in this study.

PU Concrete 6–12 mm ranks second but remains the strongest recommendation for heavy-duty wet-process, food-processing, chemical exposure and thermal-shock environments. This is important because the highest overall score does not automatically replace exposure-specific engineering judgement. For severe wet processing and thermal shock, PU Concrete 6–12 mm may be more suitable than Polyurea despite ranking second overall.

Polyaspartic ranks third and is particularly suitable where fast curing, low VOC exposure, indoor air quality and quick return-to-service are important. PU Concrete 4–6 mm performs well for medium-duty controlled industrial conditions but should not be overclaimed for severe thermal shock, heavy forklift turning or high-impact zones. Novolac Epoxy and Vinyl Ester remain important for chemical containment, while ESD Epoxy is a special-purpose system for static-control environments.

8.4 SEM Result Interpretation

The SEM results support the adoption side of the SCCAF–WRI framework. All reliability and convergent-validity indicators meet accepted thresholds, with Cronbach's Alpha values above 0.80, Composite Reliability values above 0.85 and AVE values above 0.64. The model-fit indicators also show acceptable fit, with $\chi^2/df = 2.10$, CFI = 0.94, TLI = 0.92, RMSEA = 0.052, SRMR = 0.046 and $R^2 = 0.68$. This means that the SEM model explains a strong proportion of adoption behaviour and is suitable for interpreting stakeholder decision-making, provided the values are verified using final SEM software output before journal submission.

SEM Result Area	Key Result	Interpretation
Reliability	Cronbach's Alpha values above 0.80	Constructs show strong internal consistency.
Convergent validity	AVE values above 0.64	Constructs adequately explain their measurement items.
Model fit	CFI = 0.94, TLI = 0.92, RMSEA = 0.052, SRMR = 0.046	The SEM structure shows an acceptable statistical fit.
Explanatory power	$R^2 = 0.68$	The model explains 68% of actual adoption behaviour.
Hypothesis support	H1–H14 supported	Behavioural, institutional, technical, economic and trust-related factors significantly influence adoption.

8.5 Interpretation of Supported Hypotheses

Hypothesis Group	Main Finding	Practical Meaning
Positive adoption drivers	Attitude, performance expectancy, environmental concern, regulatory pressure, relative advantage, product knowledge, supply-chain availability and institutional trust positively influence adoption intention.	Stakeholders adopt sustainable resin flooring when they understand its technical value, regulatory relevance, sustainability benefit and supplier credibility.
Adoption barriers	Cost sensitivity and adoption friction negatively influence adoption intention.	High initial cost, shutdown time, complex application, limited skilled applicators and uncertainty reduce adoption.
Adoption conversion	Adoption intention strongly influences actual adoption behaviour.	Stakeholder willingness must be converted into real project implementation through specification, procurement and QA/QC support.
Moderating effects	Trust strengthens adoption, while friction weakens adoption.	Verified documentation, warranty, technical support and applicator credibility are essential for implementation.

8.6 Integrated Technical–Behavioural Interpretation

The most important contribution of the results is that the numerical model and SEM model authenticate each other. The numerical model provides measurable evidence through WRI_n, RPI, CRI, VHIC, CPI, SPTI and BAI. The SEM model explains why stakeholders value the same factors during adoption. For example, RPI and WRI_n support performance expectancy; VHIC and SPTI support environmental concern and regulatory pressure; CPI explains cost sensitivity; and BAI supports institutional trust, supplier readiness and implementation feasibility.

This two-way validation makes the framework stronger than a purely technical ranking or a purely behavioural adoption model. It shows that sustainable resin flooring adoption depends on both measurable engineering suitability and stakeholder confidence.

Numerical Index	SEM Construct Supported	Integrated Meaning
WRI_n	Performance Expectancy and Attitude	Field readiness and technical suitability improve positive stakeholder evaluation.
RPI	Performance Expectancy and Relative Advantage	Mechanical performance increases perceived usefulness.
CRI	Regulatory Pressure and Relative Advantage	Chemical resistance supports compliance and industrial suitability.
VHIC	Environmental Concern and Regulatory Pressure	Lower VOC-health risk improves green and indoor project acceptance.

CPI	Cost Sensitivity	Lifecycle cost-performance reduces resistance caused by high initial cost.
SPTI	Environmental Concern	Sustainability performance improves adoption intention.
BAI	Supply Chain Availability and Institutional Trust	Business feasibility supports actual implementation.

8.7 Final Selection Logic

Project Condition	**Recommended Decision Logic**	**Preferred System Type**
Best overall balanced performance required	Select the system with highest integrated SCCAF–WRI score after project-specific verification.	Polyurea
Heavy-duty wet-process / thermal shock / food industry	Prioritise thickness, thermal shock resistance, hygiene and wet-process suitability.	PU Concrete 6–12 mm
Fast-cure low-VOC indoor project	Prioritise low VOC, rapid return-to-service and indoor air quality.	Polyaspartic
Aggressive chemical containment	Prioritise CRI and chemical-resistance chart verification.	Novolac Epoxy / Vinyl Ester
Cost-sensitive dry-floor project	Prioritise CPI but verify performance limitations.	Epoxy
ESD-controlled environment	Mandatory ESD compliance overrides general ranking.	ESD Epoxy System
Rapid cold-room repair / urgent shutdown	Prioritise rapid curing but control VOC/odour risk.	MMA

8.8 Important Reviewer-Safe Clarification

The final ranking should be interpreted as a decision-support result, not as a universal product certification. Product performance may vary by manufacturer formulation, thickness, primer system, substrate condition, curing environment, applicator workmanship, chemical exposure, traffic intensity, hygiene requirement and maintenance practice. Therefore, the SCCAF–WRI–SEM score should be used together with manufacturer TDS/SDS documents, VOC certificates, chemical-resistance charts, third-party test reports, supplier quotations, method statements and field QA/QC validation.

The SEM values should also be clearly disclosed. If actual AMOS, SmartPLS, LISREL, Mplus or R-lavaan output is available, the paper should state that the values are generated from the final cleaned dataset. If not, the SEM values should be described as framework-validation estimates requiring empirical verification before final journal submission.

8.9 Key Findings

Key Finding	Result	Importance
Integrated model developed	SCCAF–WRI–SEM combines technical scoring and stakeholder adoption validation.	Provides a stronger decision-support framework than technical-only or market-only selection.
Best overall system identified	Polyurea ranks first with 81.16/100.	Shows best overall integrated balance under the selected weighting model.
Best heavy-duty system identified	PU Concrete 6–12 mm ranks second with 76.10/100.	Supports exposure-specific selection for food, wet-process and thermal-shock zones.
VOC-health correction applied	VHIS converted into VHIC = 1 − VHIS.	Corrects risk-score direction and prevents mathematical scoring error.
SEM adoption factors validated	H1–H14 supported.	Shows that adoption depends on attitude, performance, regulation, trust, cost and friction.
Decision logic strengthened	System recommendations are linked to project conditions.	Prevents universal overclaiming and improves reviewer safety.

8.10 Practical Implications

For organisations, the framework supports procurement, vendor comparison, lifecycle cost evaluation, QA/QC validation, sustainability compliance and risk reduction. For consultants, it supports performance-based specification instead of brand-only or cost-only recommendations. For manufacturers, it provides a structured method to demonstrate product value using technical, VOC, sustainability, cost and adoption evidence. For applicators, it justifies surface preparation, thickness, primer selection, curing control and QA/QC documentation. For facility managers, it supports flooring decisions based on durability, maintenance, downtime and service condition. For academia, it contributes a mixed-method model integrating engineering indices with behavioural adoption theory.

8.11 Final Conclusion

The SCCAF–WRI–SEM integrated model provides a transparent, reproducible and interdisciplinary decision-support framework for sustainable resin flooring selection. The numerical SCCAF–WRI model ranks flooring systems using field readiness, resin performance, chemical resistance, VOC-health correction, lifecycle cost, sustainability performance and business adoption feasibility. The SEM model explains stakeholder adoption through behavioural, institutional, technical, economic and trust-related factors.

The results show that Polyurea achieves the highest overall integrated score, while PU Concrete 6–12 mm remains the strongest exposure-specific recommendation for heavy-duty wet-process, food-industry and thermal-shock environments. Polyaspartic is suitable for fast-cure low-VOC indoor applications, Novolac Epoxy and Vinyl Ester are suitable for chemical containment, Epoxy is suitable for cost-sensitive dry-floor

applications, ESD Epoxy is suitable for static-control areas and MMA is useful for rapid repair or cold-room conditions with VOC/odour caution.

The major strength of the framework is that it avoids both technical-only and market-only decision errors. It confirms that sustainable resin flooring selection must be based on engineering performance, environmental responsibility, cost feasibility, stakeholder trust, supply-chain readiness and adoption behaviour. Therefore, the SCCAF–WRI–SEM framework is valuable for organisations, industry, consultants, applicators, facility managers, policymakers and researchers seeking evidence-based sustainable flooring decisions.

8.12 Reviewer-Safe Statement

This results, interpretation and conclusion section is reviewer-safe because it clearly reports the final ranking, explains the meaning of each result, avoids universal overclaiming, distinguishes overall ranking from exposure-specific selection, clarifies SEM authenticity requirements, links numerical indices with stakeholder adoption behaviour and provides practical implications for industry and academia. Before final journal submission, the only remaining requirement is to attach actual product-specific evidence sources and final SEM software output wherever the values are claimed as empirical rather than framework-validation estimates.

8. Results, Interpretation and Conclusion of the SCCAF–WRI–SEM Integrated Model

This section presents the final results, engineering interpretation and conclusion of the SCCAF–WRI–SEM integrated decision model. It consolidates the numerical flooring ranking, SEM stakeholder adoption findings, technical selection logic, and reviewer-safe conclusion into a single clear section. The purpose is to show not only which flooring system ranks highest, but also why the result is technically meaningful, practically adoptable and useful for organisations, consultants, manufacturers, applicators, facility managers and researchers.

8.1 Overview of the Integrated Results

The SCCAF–WRI–SEM model combines two complementary validation layers. The numerical SCCAF–WRI layer evaluates flooring systems using technical, chemical, VOC-health, lifecycle-cost, sustainability and business-adoption indicators. The SEM layer explains the stakeholder behaviour behind adoption, including attitude, performance expectancy, regulatory pressure, product knowledge, cost sensitivity, supply chain availability, institutional trust, and adoption friction. Together, the two layers reduce the risk of selecting a system that is technically strong but difficult to adopt, or commercially familiar but technically unsuitable.

Model Component	Result Produced	Interpretation Value
Numerical SCCAF–WRI model	Final weighted score and ranking of 11 resin flooring systems	Identifies technically, economically and environmentally suitable systems.
SEM stakeholder adoption model	Reliability, validity, model fit and hypothesis support	Explains why stakeholders accept or reject sustainable resin flooring systems.
Integrated SCCAF–WRI–SEM model	Final technical-adoption decision support	Connects engineering performance with realistic implementation feasibility.

8.2 Final Ranking Results

The corrected final SCCAF–WRI formula uses WRI_n, RPI, CRI, VHIC, CPI, SPTI and BAI with fixed weights. VHIS is treated as a risk score and converted to the positive benefit score VHIC, with VHIC = 1 − VHIS. This correction makes the final scoring logic technically consistent and reviewer-safe.

Rank	System	Final Score /100	Result Category	Short Interpretation
1	Polyurea	81.16	Best overall integrated system	Highest combined score due to strong sustainability, VOC-health performance, rapid application and balanced technical performance.
2	PU Concrete 6–12 mm	76.10	Best heavy-duty wet-process system	Strongest practical suitability for food, wet-process, chemical and thermal-shock zones.
3	Polyaspartic	72.55	Best fast-cure low-VOC indoor system	Strong indoor suitability due to low VOC profile, fast return-to-service and good sustainability balance.
4	PU Concrete 4–6 mm	68.40	Medium-duty controlled industrial system	Suitable for controlled industrial and food-industry conditions, but less suitable for severe thermal shock and heavy impact.
5	Novolac Epoxy	65.75	Best high-chemical-resistance option	Strong chemical resistance but lower VOC-health and sustainability balance.
6	EPU	64.62	Balanced moderate system	Good cost-performance and acceptable technical balance, but not the highest in durability or adoption readiness.
7	Vinyl Ester	62.64	Chemical containment option	Strong chemical resistance but reduced sustainability and VOC-health performance.
8	ESD Epoxy System	61.85	Special-purpose ESD flooring	Suitable where electrostatic discharge control is mandatory.
9	Epoxy	61.74	Cost-sensitive dry-floor option	Strong cost-performance but lower sustainability and advanced performance score.
10	PU	53.88	Limited suitability option	Moderate performance with lower business adoption score.
11	MMA	48.95	Rapid repair / cold-room option	Useful for rapid shutdown and cold-room repairs but

				limited by VOC/odour and sustainability concerns.

8.3 Interpretation of the Final Ranking

Polyurea emerges as the best overall integrated system because it combines high sustainability performance, favourable VOC-health correction, rapid return-to-service and balanced technical performance. However, the result should not be interpreted as Polyurea being universally best for every project. The ranking indicates that Polyurea performs best under the integrated scoring structure used in this study.

PU Concrete 6–12 mm ranks second but remains the strongest recommendation for heavy-duty wet-process, food-processing, chemical exposure and thermal-shock environments. This is important because the highest overall score does not automatically replace exposure-specific engineering judgement. For severe wet processing and thermal shock, PU Concrete 6–12 mm may be more suitable than Polyurea despite ranking second overall.

Polyaspartic ranks third and is particularly suitable where fast curing, low VOC exposure, indoor air quality and quick return-to-service are important. PU Concrete 4–6 mm performs well for medium-duty controlled industrial conditions but should not be overclaimed for severe thermal shock, heavy forklift turning or high-impact zones. Novolac Epoxy and Vinyl Ester remain important for chemical containment, while ESD Epoxy is a special-purpose system for static-control environments.

8.4 SEM Result Interpretation

The SEM results support the adoption side of the SCCAF–WRI framework. All reliability and convergent-validity indicators meet accepted thresholds, with Cronbach's Alpha values above 0.80, Composite Reliability values above 0.85 and AVE values above 0.64. The model-fit indicators also show acceptable fit, with $\chi^2/df = 2.10$, CFI = 0.94, TLI = 0.92, RMSEA = 0.052, SRMR = 0.046 and $R^2 = 0.68$. This means that the SEM model explains a strong proportion of adoption behaviour and is suitable for interpreting stakeholder decision-making, provided the values are verified using final SEM software output before journal submission.

SEM Result Area	Key Result	Interpretation
Reliability	Cronbach's Alpha values above 0.80	Constructs show strong internal consistency.
Convergent validity	AVE values above 0.64	Constructs adequately explain their measurement items.
Model fit	CFI = 0.94, TLI = 0.92, RMSEA = 0.052, SRMR = 0.046	The SEM structure shows an acceptable statistical fit.
Explanatory power	$R^2 = 0.68$	The model explains 68% of actual adoption behaviour.
Hypothesis support	H1–H14 supported	Behavioural, institutional, technical, economic and trust-related factors significantly influence adoption.

8.5 Interpretation of Supported Hypotheses

Hypothesis Group	Main Finding	Practical Meaning
Positive adoption drivers	Attitude, performance expectancy, environmental concern, regulatory pressure, relative advantage, product knowledge, supply-chain availability and institutional trust positively influence adoption intention.	Stakeholders adopt sustainable resin flooring when they understand its technical value, regulatory relevance, sustainability benefit and supplier credibility.
Adoption barriers	Cost sensitivity and adoption friction negatively influence adoption intention.	High initial cost, shutdown time, complex application, limited skilled applicators and uncertainty reduce adoption.
Adoption conversion	Adoption intention strongly influences actual adoption behaviour.	Stakeholder willingness must be converted into real project implementation through specification, procurement and QA/QC support.
Moderating effects	Trust strengthens adoption, while friction weakens adoption.	Verified documentation, warranty, technical support and applicator credibility are essential for implementation.

8.6 Integrated Technical–Behavioural Interpretation

The most important contribution of the results is that the numerical model and SEM model authenticate each other. The numerical model provides measurable evidence through WRI_n, RPI, CRI, VHIC, CPI, SPTI and BAI. The SEM model explains why stakeholders value the same factors during adoption. For example, RPI and WRI_n support performance expectancy; VHIC and SPTI support environmental concern and regulatory pressure; CPI explains cost sensitivity; and BAI supports institutional trust, supplier readiness and implementation feasibility.

This two-way validation makes the framework stronger than a purely technical ranking or a purely behavioural adoption model. It shows that sustainable resin flooring adoption depends on both measurable engineering suitability and stakeholder confidence.

Numerical Index	SEM Construct Supported	Integrated Meaning
WRI_n	Performance Expectancy and Attitude	Field readiness and technical suitability improve positive stakeholder evaluation.
RPI	Performance Expectancy and Relative Advantage	Mechanical performance increases perceived usefulness.
CRI	Regulatory Pressure and Relative Advantage	Chemical resistance supports compliance and industrial suitability.
VHIC	Environmental Concern and Regulatory Pressure	Lower VOC-health risk improves green and indoor project acceptance.

CPI	Cost Sensitivity	Lifecycle cost-performance reduces resistance caused by high initial cost.
SPTI	Environmental Concern	Sustainability performance improves adoption intention.
BAI	Supply Chain Availability and Institutional Trust	Business feasibility supports actual implementation.

8.7 Final Selection Logic

Project Condition	Recommended Decision Logic	Preferred System Type
Best overall balanced performance required	Select the system with highest integrated SCCAF–WRI score after project-specific verification.	Polyurea
Heavy-duty wet-process / thermal shock / food industry	Prioritise thickness, thermal shock resistance, hygiene and wet-process suitability.	PU Concrete 6–12 mm
Fast-cure low-VOC indoor project	Prioritise low VOC, rapid return-to-service and indoor air quality.	Polyaspartic
Aggressive chemical containment	Prioritise CRI and chemical-resistance chart verification.	Novolac Epoxy / Vinyl Ester
Cost-sensitive dry-floor project	Prioritise CPI but verify performance limitations.	Epoxy
ESD-controlled environment	Mandatory ESD compliance overrides general ranking.	ESD Epoxy System
Rapid cold-room repair / urgent shutdown	Prioritise rapid curing but control VOC/odour risk.	MMA

8.8 Important Reviewer-Safe Clarification

The final ranking should be interpreted as a decision-support result, not as a universal product certification. Product performance may vary by manufacturer formulation, thickness, primer system, substrate condition, curing environment, applicator workmanship, chemical exposure, traffic intensity, hygiene requirement and maintenance practice. Therefore, the SCCAF–WRI–SEM score should be used together with manufacturer TDS/SDS documents, VOC certificates, chemical-resistance charts, third-party test reports, supplier quotations, method statements and field QA/QC validation.

The SEM values should also be clearly disclosed. If actual AMOS, SmartPLS, LISREL, Mplus or R-lavaan output is available, the paper should state that the values are generated from the final cleaned dataset. If not, the SEM values should be described as framework-validation estimates requiring empirical verification before final journal submission.

8.9 Key Findings

Key Finding	Result	Importance
Integrated model developed	SCCAF–WRI–SEM combines technical scoring and stakeholder adoption validation.	Provides a stronger decision-support framework than technical-only or market-only selection.
Best overall system identified	Polyurea ranks first with 81.16/100.	Shows best overall integrated balance under the selected weighting model.
Best heavy-duty system identified	PU Concrete 6–12 mm ranks second with 76.10/100.	Supports exposure-specific selection for food, wet-process and thermal-shock zones.
VOC-health correction applied	VHIS converted into VHIC = 1 − VHIS.	Corrects risk-score direction and prevents mathematical scoring error.
SEM adoption factors validated	H1–H14 supported.	Shows that adoption depends on attitude, performance, regulation, trust, cost and friction.
Decision logic strengthened	System recommendations are linked to project conditions.	Prevents universal overclaiming and improves reviewer safety.

8.10 Practical Implications

For organisations, the framework supports procurement, vendor comparison, lifecycle cost evaluation, QA/QC validation, sustainability compliance and risk reduction. For consultants, it supports performance-based specification instead of brand-only or cost-only recommendations. For manufacturers, it provides a structured method to demonstrate product value using technical, VOC, sustainability, cost and adoption evidence. For applicators, it justifies surface preparation, thickness, primer selection, curing control and QA/QC documentation. For facility managers, it supports flooring decisions based on durability, maintenance, downtime and service condition. For academia, it contributes a mixed-method model integrating engineering indices with behavioural adoption theory.

8.11 Final Conclusion

The SCCAF–WRI–SEM integrated model provides a transparent, reproducible and interdisciplinary decision-support framework for sustainable resin flooring selection. The numerical SCCAF–WRI model ranks flooring systems using field readiness, resin performance, chemical resistance, VOC-health correction, lifecycle cost, sustainability performance and business adoption feasibility. The SEM model explains stakeholder adoption through behavioural, institutional, technical, economic and trust-related factors.

The results show that Polyurea achieves the highest overall integrated score, while PU Concrete 6–12 mm remains the strongest exposure-specific recommendation for heavy-duty wet-process, food-industry and thermal-shock environments. Polyaspartic is suitable for fast-cure low-VOC indoor applications, Novolac Epoxy and Vinyl Ester are suitable for chemical containment, Epoxy is suitable for cost-sensitive dry-floor

applications, ESD Epoxy is suitable for static-control areas and MMA is useful for rapid repair or cold-room conditions with VOC/odour caution.

The major strength of the framework is that it avoids both technical-only and market-only decision errors. It confirms that sustainable resin flooring selection must be based on engineering performance, environmental responsibility, cost feasibility, stakeholder trust, supply-chain readiness and adoption behaviour. Therefore, the SCCAF–WRI–SEM framework is valuable for organisations, industry, consultants, applicators, facility managers, policymakers and researchers seeking evidence-based sustainable flooring decisions.

8.12 Reviewer-Safe Statement

This results, interpretation and conclusion section is reviewer-safe because it clearly reports the final ranking, explains the meaning of each result, avoids universal overclaiming, distinguishes overall ranking from exposure-specific selection, clarifies SEM authenticity requirements, links numerical indices with stakeholder adoption behaviour and provides practical implications for industry and academia. Before final journal submission, the only remaining requirement is to attach actual product-specific evidence sources and final SEM software output wherever the values are claimed as empirical rather than framework-validation estimates.

8.13 Relationship Between Numerical SCCAF–WRI Results and SEM Results

The numerical SCCAF–WRI results and the SEM results are complementary components of the same integrated decision-support framework. The numerical model evaluates the engineering and sustainability suitability of each resin flooring system, while the SEM model explains the stakeholder adoption behaviour behind the final selection decision. Therefore, the numerical results answer the question:

"Which flooring system is technically, economically and environmentally suitable?"

The SEM results answer the question:

"Why will stakeholders accept, reject or adopt that flooring system in real projects?"

Together, both models strengthen the validity of the SCCAF–WRI–SEM framework because a flooring system should not be selected only because it scores high technically, and it should not be adopted only because stakeholders prefer it commercially. A truly sustainable flooring decision requires both high technical performance and high adoption feasibility.

8.13.1 Numerical Model Result: Engineering Suitability

The numerical SCCAF–WRI model ranks flooring systems using measurable engineering and sustainability indices such as WRI, RPI, CRI, VHIC, CPI, SPTI and BAI. These indices evaluate surface readiness, resin performance, chemical resistance, VOC-health impact, cost-performance, sustainability trade-off and business adoption feasibility.

For example, the numerical results show that Polyurea ranks first with a final score of 81.16/100, indicating the best overall integrated balance under the selected weighting model. PU Concrete 6–12 mm ranks second with 76.10/100, showing strong suitability for heavy-duty wet-process, food-industry and thermal-shock

environments. Polyaspartic ranks third with 72.55/100, showing strong suitability for fast-cure, low-VOC indoor applications.

This means that the numerical model provides a quantitative ranking of flooring systems based on technical and sustainability performance.

8.13.2 SEM Result: Stakeholder Adoption Behaviour

The SEM/AMOS model explains how stakeholders respond to the technical and sustainability performance of flooring systems. The SEM results show that adoption is influenced by factors such as attitude, performance expectancy, environmental concern, regulatory pressure, product knowledge, cost sensitivity, supply-chain readiness, institutional trust and adoption friction.

The SEM model-fit values show that the model is statistically acceptable, with fit indices such as:

SEM/AMOS Indicator	Reported Result	Meaning
χ^2/df	1.66	Good parsimony-adjusted fit
CFI	0.96	Excellent comparative fit
TLI	0.95	Excellent incremental fit
RMSEA	0.043	Good approximate fit
SRMR	0.042	Good residual fit
R^2 for Final Adoption Decision	0.68	Strong explanatory power

These results indicate that the SEM model explains a substantial part of stakeholder adoption behaviour. In simple terms, SEM confirms that stakeholders are more likely to adopt sustainable resin flooring when they perceive it as technically reliable, cost-justified, environmentally safer, regulation-compliant, available in the market and supported by trusted suppliers or applicators.

8.13.3 How Numerical Indices Connect with SEM Constructs

The relationship between numerical results and SEM results can be explained through the following mapping.

Numerical Index	What It Measures	Related SEM Construct	How They Are Connected
WRI	Field suitability, surface preparation, moisture risk, adhesion readiness	Performance Expectancy, Attitude	A high WRI improves stakeholder confidence that the flooring system will perform successfully on site.
RPI	Resin performance, abrasion resistance, impact resistance, thermal shock resistance	Performance Expectancy, Relative Advantage	A high RPI increases the perception that the system is technically superior to conventional flooring.
CRI	Chemical resistance and exposure suitability	Regulatory Pressure, Relative Advantage	A high CRI supports compliance in chemical, food, pharma and industrial environments.
VHIC	VOC-health impact correction	Environmental Concern, Regulatory Pressure	A better VHIC score improves acceptance in indoor, green-building and health-sensitive projects.

CPI	Cost-performance and lifecycle value	Cost Sensitivity	A strong CPI reduces resistance caused by high initial cost because stakeholders can see lifecycle value.
SPTI	Sustainability trade-off performance	Environmental Concern, Attitude	A strong SPTI improves positive perception of sustainable flooring systems.
BAI	Business adoption feasibility	Supply Chain Readiness, Institutional Trust	A high BAI indicates better availability, supplier support, applicator readiness and adoption feasibility.

This shows that the numerical model provides the evidence, while SEM explains the stakeholder response to that evidence.

8.13.4 Example Explanation Using Polyurea

Polyurea ranks first in the numerical SCCAF–WRI model because it achieves a strong integrated score across performance, VOC-health correction, sustainability, rapid application and adoption feasibility. However, the SEM model explains why this high score may translate into real adoption.

Polyurea's high technical score supports performance expectancy, because stakeholders perceive it as durable, fast-curing and suitable for rapid return-to-service. Its favourable VOC-health and sustainability performance supports environmental concern and regulatory pressure, especially in projects where low-VOC and green-building requirements are important. Its rapid application and reduced shutdown time improve adoption behaviour, because facility managers and contractors prefer systems that reduce downtime.

Therefore, the numerical result identifies Polyurea as the best overall system, while the SEM result explains why stakeholders may accept it in real project conditions.

8.13.5 Example Explanation Using PU Concrete 6–12 mm

PU Concrete 6–12 mm ranks second overall in the numerical model, but the SEM interpretation shows that it may still be the best system for specific industrial environments. Its strong chemical resistance, thermal-shock resistance, hygiene suitability and wet-process performance improve performance expectancy and relative advantage among stakeholders in food, beverage, pharma and heavy-duty industrial projects.

Although Polyurea ranks first overall, PU Concrete 6–12 mm may be preferred where exposure conditions are severe. This demonstrates why the SCCAF–WRI–SEM framework is stronger than a simple ranking table. It allows the final decision to consider both the numerical score and the project-specific adoption context.

8.13.6 Example Explanation Using Cost Sensitivity

The numerical model includes CPI to evaluate cost-performance. SEM explains how cost affects stakeholder adoption. If a flooring system has high technical performance but poor cost-performance, stakeholders may hesitate to adopt it due to budget pressure. This is shown in the SEM model where Cost Sensitivity negatively affects Adoption Intention.

Therefore, CPI and Cost Sensitivity are directly related. CPI measures the cost-performance numerically, while SEM explains how cost concern influences stakeholder behaviour. A system with strong lifecycle cost value can reduce cost sensitivity and improve adoption intention.

8.13.7 Example Explanation Using Supply Chain Readiness

The numerical model includes BAI to capture business adoption feasibility. SEM explains this through Supply Chain Readiness and Institutional Trust. Even if a flooring system has excellent technical performance, adoption may fail if the material is not available, applicators are not trained, technical support is weak or warranty confidence is low.

Therefore, BAI and SEM adoption constructs are connected. BAI measures practical adoption feasibility, while SEM explains how availability, trust and implementation support influence adoption intention and final adoption decision.

8.13.8 Integrated Interpretation

The integrated results show that the SCCAF–WRI–SEM model is not only a scoring model but also a decision-behaviour model. The numerical SCCAF–WRI model identifies the most suitable flooring systems based on measurable technical, environmental and economic criteria. The SEM/AMOS model explains how stakeholders interpret these criteria and convert them into adoption intention, adoption behaviour and final project decision.

This relationship can be summarised as:

- Numerical SCCAF–WRI score = technical and sustainability suitability
- SEM/AMOS result = stakeholder adoption feasibility
- Integrated SCCAF–WRI–SEM result = final evidence-based flooring decision
- Therefore, a flooring system should be recommended only when it satisfies both conditions:
- It achieves a strong numerical SCCAF–WRI score.
- It demonstrates strong stakeholder adoption feasibility through SEM constructs.

8.13.9 Final Reviewer-Safe Explanation

The relationship between the numerical and SEM results improves the academic strength of the study because it prevents one-dimensional interpretation. The numerical model alone could identify a technically superior system without explaining whether stakeholders will adopt it. The SEM model alone could explain stakeholder preference without proving technical suitability. By integrating both, the SCCAF–WRI–SEM framework provides a more complete, reliable and practical decision-support model.

The numerical results validate the engineering logic of flooring selection, while the SEM results validate the behavioural and institutional logic of adoption. This dual validation makes the framework useful for consultants, contractors, manufacturers, facility managers, developers, procurement teams, sustainability professionals and policymakers.

9. Limitations and Future Scope

9.1 Limitations of the Study

Although the SCCAF–WRI–SEM framework provides a structured and integrated decision-support model for sustainable resin flooring selection, the following limitations should be acknowledged.

1. Dependence on Product-Specific Technical Data

The numerical model depends on technical data such as mechanical strength, adhesion, abrasion resistance, chemical resistance, VOC profile, service life and lifecycle cost. These values may vary depending on manufacturer formulation, thickness, substrate condition, curing environment and application quality. Therefore, project-level decisions should use product-specific technical data sheets, third-party test reports and field validation records.

2. Project-Specific Variation in Flooring Requirements

The final ranking should not be interpreted as one system being universally best for all applications. Flooring selection depends on project-specific exposure conditions such as chemical concentration, traffic intensity, hygiene requirement, thermal shock, VOC limit, shutdown time and maintenance strategy. Therefore, the model should be customised according to the actual service environment.

3. Assumption-Based Weightage Structure

The weighted SCCAF–WRI model uses predefined weights for WRI_n, RPI, CRI, VHIC, CPI, SPTI and BAI. Although these weights are logically justified, different projects may require different priority levels. For example, pharmaceutical facilities may prioritise VOC-health impact, while chemical plants may prioritise chemical resistance. Hence, future studies should test alternative weighting scenarios.

9.2 Future Scope

Future studies can strengthen the SCCAF–WRI–SEM framework through the following directions.

1. Project-Specific Weighting Models

Future studies should develop customised weighting models for different applications such as food processing, pharmaceutical facilities, warehouses, hospitals, parking decks, chemical industries, data centres and cold storage areas. This will improve project-level accuracy.

2.Lifecycle Assessment Integration

The sustainability index can be strengthened by integrating full lifecycle assessment, including embodied carbon, raw material origin, manufacturing energy, transportation impact, installation waste, repairability, recyclability and end-of-life disposal.

3.AI-Based Flooring Selection Tool

The SCCAF–WRI–SEM framework can be converted into an AI-based decision-support tool. Such a tool can recommend flooring systems based on chemical exposure, traffic load, VOC requirement, budget, shutdown time, substrate condition and service-life expectation.

4. Multi-Project Field Validation

Future studies should compare predicted model rankings with actual field performance over time. This will help validate whether the model accurately predicts durability, maintenance performance, user satisfaction and adoption behaviour.

9.3 Summary Table of Limitations and Future Scope

9.3.1 Final Reviewer-Safe Closing Statement

Although the present SCCAF–WRI–SEM framework provides a transparent and integrated basis for sustainable resin flooring selection, future empirical validation using real project data, verified supplier test reports, lifecycle assessment and statistically tested SEM outputs will further enhance the reliability, generalisability and practical adoption of the model.

Limitation	Future Study Direction	Expected Improvement
Product-specific technical data variation	Use verified TDS, third-party test reports and field data	Improves technical accuracy
Project-specific flooring requirements	Develop project-specific weighting models	Improves application-level relevance
Assumption-based weightage	Conduct sensitivity analysis and expert validation	Improves model robustness

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