

# Plastic and Concrete Construction Products: A Comparative Review of Material Performance, Cost, Sustainability, and Market Substitution Pathways

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**Abstract:** This review examines how plastic and concrete construction products compete, coexist, and increasingly hybridize under contemporary pressures of cost control, installation efficiency, service-life performance, and low-carbon transition. Reorganized from a broader bachelor thesis, the paper focuses on product categories in which substitution is already visible or commercially plausible, including drainage pipes, grass block pavers, modular road concepts, and recycled-plastic composite systems. The analysis is structured around five dimensions: intrinsic material characteristics, processing and installation routes, cost structure, application scenario, and sustainability performance. Plastics show clear advantages in low density, corrosion resistance, standardized factory processing, and reduced logistics burden, which supports their expansion in lightweight and modular applications. Concrete retains decisive strengths in compressive capacity, rigidity, fire resistance, and long-term reliability under heavy loading. The review argues that market change does not follow a simple replacement model. Instead, it proceeds through scenario-based substitution, selective coexistence, hybrid integration, and circular upgrading. For construction decision-makers, the central implication is that material choice should be based on service-fit and life-cycle value rather than on nominal material price alone.

**Keywords:** Plastic Products; Concrete Products; Construction Materials; Comparative Review; Life-Cycle Cost; Sustainability; Market Substitution

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## 1. Introduction

Material choice in construction has traditionally been guided by technical performance, local practice, and cost. However, growing attention to maintenance expenditure, carbon emissions, transport efficiency, and circular resource use has made the comparison between conventional and alternative materials more strategically important. Among the most visible material pairings in this transition are concrete and plastics. Both are deeply embedded in modern construction markets, but they compete, coexist, and increasingly hybridize in different ways and at different scales<sup>[1-3]</sup>.

Concrete remains one of the most widely used construction materials because of its compressive strength, rigidity, fire resistance, and suitability for structural and infrastructure systems<sup>[2,4,5]</sup>. Plastic products, by contrast, are valued for low density, corrosion resistance, design flexibility, and ease of mass manufacture. These characteristics have enabled plastics to expand rapidly in

pipings, insulation, modular components, pavers, and other non-structural or semi-structural applications<sup>[1,6,7]</sup>.

The source thesis contained extensive descriptive background on the history, classification, and processing of both materials, followed by product-by-product description. For journal submission, that structure is too broad and insufficiently analytical. The present paper therefore narrows the discussion to construction products in which substitution is already observable or commercially plausible. The central question is not whether plastics can replace concrete in general, but under what conditions plastic, concrete, or hybrid systems become the more rational market choice.

Accordingly, this review pursues three objectives. First, it compares the material logic of plastics and concrete from the perspectives of properties and processing routes. Second, it evaluates cost structure, application fit, and sustainability implications in representative product categories. Third, it proposes a concise framework of market substitution pathways that explains why some segments move toward plastic, others remain concrete-dominant, and others evolve toward hybrid or circular-material solutions.

## 2. Review Scope and Analytical Framework

This study is a narrative review rather than a systematic meta-analysis. The source base was substantially upgraded from the original bachelor thesis and now emphasizes peer-reviewed journal literature, life-cycle assessment studies, international policy reports, technical association publications, and documented infrastructure case materials relevant to plastic and concrete construction products<sup>[8-12]</sup>. The review retains selected product cases only when they clarify substitution, coexistence, hybridization, or circular-economy pathways within construction markets.

To increase analytical focus, the review does not attempt to compare the entire plastics and concrete industries. Instead, it treats the construction product as the unit of analysis and evaluates five decision-relevant dimensions: (1) intrinsic material characteristics, (2) manufacturing and installation logic, (3) cost structure across the product life cycle, (4) application scenario, and (5) sustainability implications. On this basis, a synthesis of market substitution pathways is proposed.

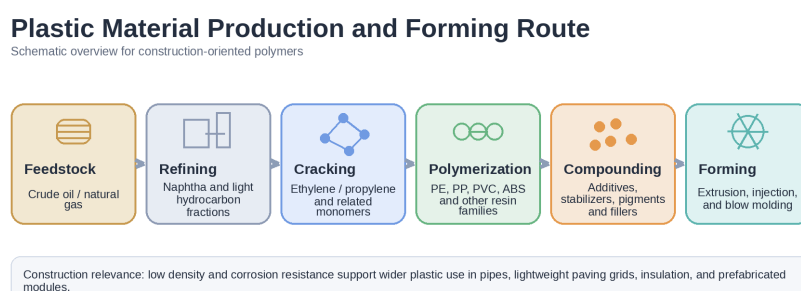
Because the cited sources use different accounting scopes, regions, and performance standards, the paper does not present a unified quantitative cost model. Cost is therefore discussed in qualitative or semi-quantitative terms, with emphasis on transport burden, installation complexity, maintenance demand, replacement risk, and system value rather than on a single nominal market price.

## 3. Comparative Review and Market Analysis

### 3.1 Material characteristics and processing routes

Plastics used in construction are mainly polymer-based thermoplastics such as polyethylene (PE), polyvinyl chloride (PVC), polypropylene (PP), and acrylonitrile-butadiene-styrene (ABS). Their common advantages include low density, corrosion resistance, electrical insulation, design adaptability, and ease of standardized factory production<sup>[6,7,13]</sup>. Extrusion, injection molding, and blow molding enable plastics to be formed into pipes, fittings, pavers, liners, and modular shells with comparatively low transport burden and consistent geometry<sup>[6,7]</sup>. As a result, plastic products often perform best where lightweight handling, chemical stability, and rapid installation are important. As shown in Figure 1, the plastic route is characterized by a refinery-to-polymer-to-forming chain in which product diversity emerges largely through downstream shaping processes.

Figure 1: Author-generated schematic of the plastic production chain from refinery feedstock to polymer pellets and downstream forming routes. Synthesized from<sup>[6,7]</sup>.

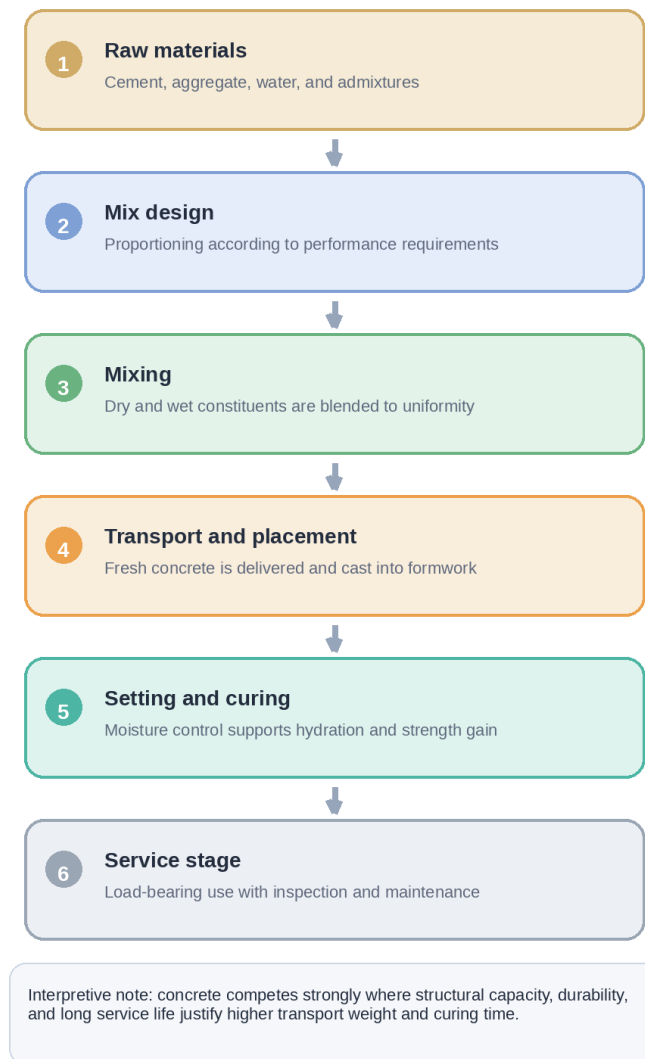


Concrete is a composite system composed primarily of cement, water, fine aggregate, coarse aggregate, and admixtures. Its commercial strength lies in rigidity, compressive capacity, fire resistance, and long-term service in load-bearing environments<sup>[2,4,5]</sup>. Concrete is especially well suited to structural members, rigid pipes, heavy-duty pavers, and large-section infrastructure components<sup>[2,4,5]</sup>. Unlike plastics, which typically enter the market as finished factory products, concrete can be cast in place or precast in large units, allowing wide dimensional flexibility but usually at higher transport weight and installation effort. By contrast, the concrete route shown in Figure 2 is organized around batching, mixing, placement, compaction, and curing, which ties performance more directly to site execution and structural service conditions.

Figure 2: Author-generated schematic of the concrete production and construction sequence, from material proportioning and mixing to placement and curing. Synthesized from <sup>[2,4,5]</sup>.

## Concrete Production and Construction Workflow

Step-by-step route from raw materials to service stage



These differences in processing route help explain market boundaries. Plastic products are more likely to expand where the product is modular, repetitive, corrosion-sensitive, and installation-intensive. Concrete remains more competitive where high compressive demand, dimensional stability, abrasion resistance, or long-term heavy loading dominate product selection. The comparison therefore begins not only with material properties but also with the manufacturing logic embedded in each material system.

Table 1. Comparative profile of plastic and concrete construction products.

Dimension	Plastic products	Concrete products	Market implication
Density and handling	Low density; easy transport; simple manual handling in many cases	High self-weight; greater transport and lifting demand	Plastic gains advantage in installation-sensitive and distributed projects
Mechanical behavior	Good toughness and flexibility; lower stiffness and lower load-bearing capacity	High compressive strength and rigidity; suitable for heavy-duty service	Concrete remains preferred for structural and heavily loaded segments
Chemical and moisture resistance	Strong corrosion resistance in many service environments	Can deteriorate under aggressive chemical exposure if not properly designed	Plastic is attractive in sewage, drainage, and corrosive environments
Fire and thermal behavior	Generally weaker fire resistance and higher temperature sensitivity	Strong fire resistance and thermal mass	Concrete is favored where fire safety is a primary criterion
Manufacturing route	Extrusion/injection/blow molding support high-volume standardized production	Cast-in-place and precast routes support large-section products	Plastic fits modular mass products; concrete fits rigid large-scale systems
Maintenance and replacement	Often easier to replace and repair because of lower weight	Long service life in stable heavy-duty conditions but replacement can be labor-intensive	Life-cycle cost depends strongly on service environment and access conditions
Environmental issues	Recycling potential and recycled feedstock options, but waste leakage and end-of-life remain concerns	Durable and recyclable as aggregate, but cement production is carbon-intensive	Both materials require life-cycle assessment rather than single-indicator judgment

### 3.2 Cost structure and life-cycle implications

A meaningful material comparison in construction cannot rely on raw material price alone. Product competitiveness depends on a broader cost structure that includes manufacturing efficiency, transport, installation time, required equipment, maintenance frequency, service life, and replacement risk. In many lightweight product categories, plastics gain a clear economic advantage because low density reduces freight cost and simplifies storage, handling, and on-site assembly<sup>[9,14-16]</sup>. This is particularly evident in pipes and modular pavers, where transportation and labor can account for a substantial part of delivered cost<sup>[9,10,14,17]</sup>.

Concrete, however, should not be treated as universally more expensive. Its raw constituents are abundant, its production system is mature, and its durability under compression and abrasion gives it strong life-cycle value in heavy-duty applications<sup>[2-5]</sup>. For large-diameter drainage systems, high-load pavements, and structural settings, concrete frequently retains an advantage where dimensional stability and load-bearing reliability under demanding service conditions outweigh the initial burden of transport and installation<sup>[2,4,9]</sup>.

The cost comparison therefore leads to a scenario-dependent conclusion. Plastics are often cheaper in total installed cost when handling, labor, corrosion protection, and rapid construction matter more than extreme structural capacity. Concrete remains economically rational where the dominant cost risk comes from failure under load, abrasion, fire, or long-term deformation. In practice, market substitution usually occurs where plastics lower system cost without creating unacceptable performance trade-offs.

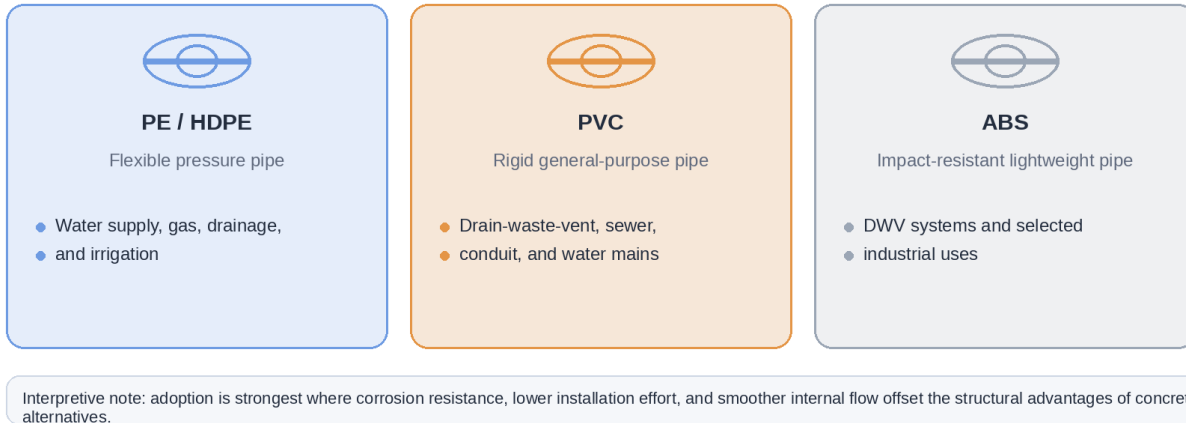
### 3.3 Application scenarios and functional fit

Drainage pipes provide one of the clearest examples of differentiated substitution. Plastic pipe systems are widely used because of their low weight, corrosion resistance, smooth internal surfaces, and ease of installation<sup>[9,14-16]</sup>. They are especially competitive in building drainage, stormwater conveyance, and buried pipelines where joint handling and transport efficiency are important. Concrete pipe, by contrast, remains relevant in some large-diameter and high-load gravity applications, where rigidity and external load performance are central selection criteria<sup>[9,14]</sup>. This pattern suggests not blanket replacement, but segmentation within the same product category. Figure 3 illustrates the diversity of plastic pipe families that support this shift, especially in buried and corrosion-sensitive drainage uses.

Figure 3: Author-generated comparison schematic of representative plastic pipe families used in construction applications, including PE/HDPE, PVC, and ABS. Synthesized from [9,14-16].

## Representative Plastic Pipe Families in Construction

Pipe materials differ in flexibility, rigidity, and target application

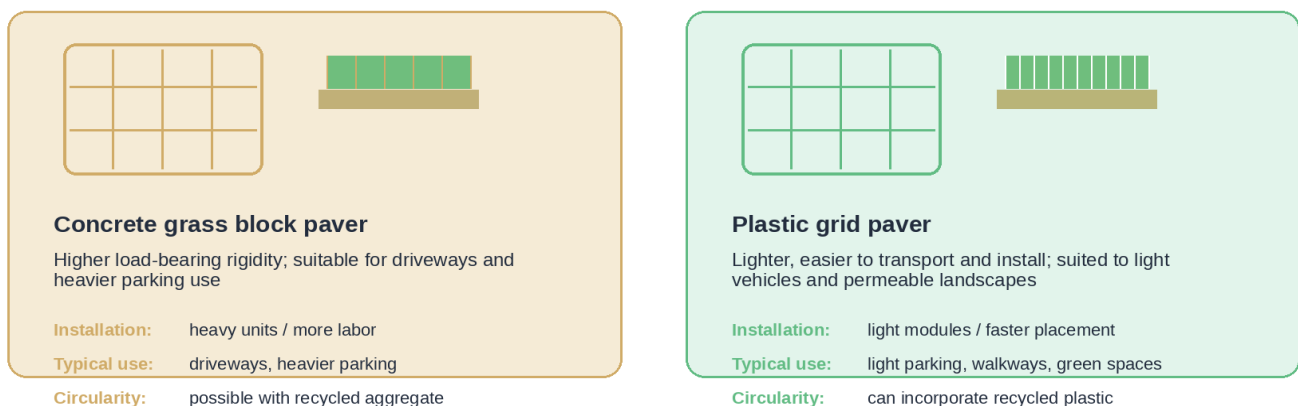


Grass block pavers show a similar but more visibly market-oriented division. Plastic grass pavers are generally favored in light-vehicle parking, pedestrian areas, and stormwater-sensitive landscapes because their lower weight and modular grid configuration can simplify transport and installation [10,17-19]. Concrete grass pavers, by contrast, are more suitable where higher load resistance and surface robustness are required [10,18,19]. As a result, the market tends to allocate plastic pavers to lighter and more environmentally themed applications, while concrete pavers retain a stronger position in high-load or high-wear surfaces. This contrast is visualized in Figure 4, where the heavier, rigid concrete format differs clearly from the lightweight grid-type plastic system.

Figure 4: Author-generated comparative schematic of concrete grass block pavers and plastic grid pavers, emphasizing differences in installation logic, load-bearing behavior, and typical use conditions. Synthesized from [10,17-19].

## Concrete vs. Plastic Grass Block Paver Systems

Conceptual comparison of structure, installation logic, and use intensity



Road applications illustrate an even more important point: innovation often proceeds through hybridization rather than one-to-one replacement. The PlasticRoad concept uses prefabricated modular plastic structures to integrate drainage, cable management, and lightweight installation, thereby expanding the functional value of pavement systems [12]. At the same time, plastic-modified asphalt and related road-material strategies use waste plastic as an additive or modifier rather than as a full replacement for mineral materials [11,21-26]. Similarly, recycled plastic particles introduced into concrete can improve selected properties or support lightweight and circular-design objectives, even though such mixes still face performance limitations and require careful interface engineering [8,27-29]. The modular system logic of PlasticRoad is shown in Figure 5.

Figure 5: Author-generated schematic section of the PlasticRoad modular concept, highlighting the hollow cavity, modular shell, and utility/drainage functions. Synthesized from [12].

### PlasticRoad Modular Structure

Schematic section of a hollow, climate-adaptive pavement element

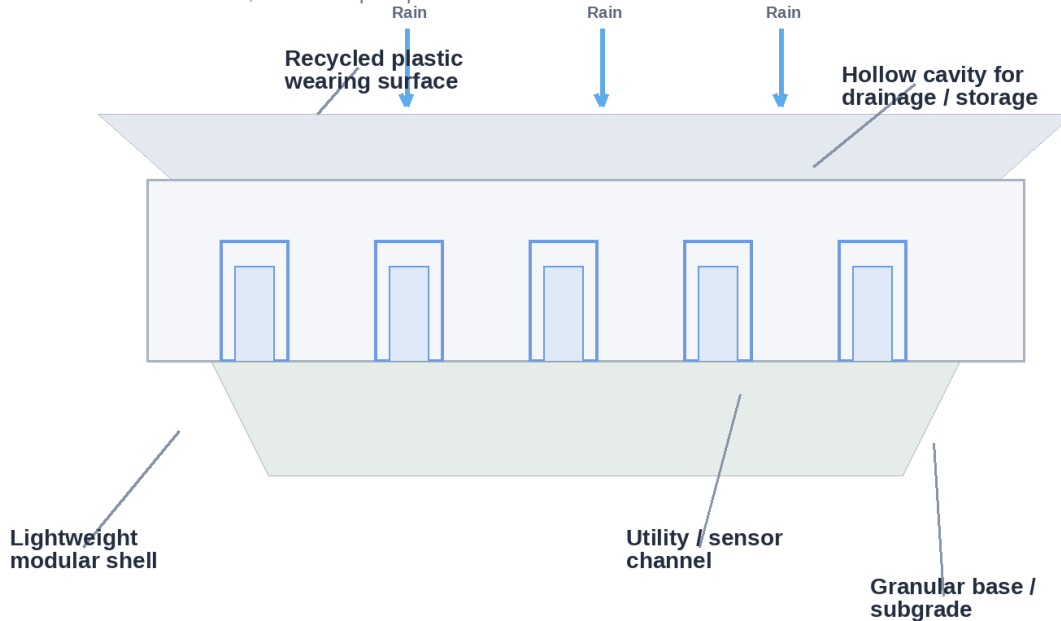


Table 2. Scenario-based comparison of representative construction products.

Product segment	Plastic-dominant conditions	Concrete-dominant conditions	Likely market pattern
Drainage pipes	Corrosion-sensitive environments; small to medium diameter; speed of installation; low handling burden	Large diameter; high external loads; rigid gravity systems; severe structural demand	Segmented coexistence with increasing plastic share in many non-structural applications
Grass block pavers	Light vehicles; pedestrian areas; high infiltration demand; low-cost modular layouts	Repeated heavy loading; higher abrasion; stronger surface stability requirement	Parallel use depending on traffic level and landscape function
Road modules	Need for modularity, integrated drainage, or utility corridors	Conventional heavy-duty pavement with proven long-term performance	Emerging niche for plastic systems; conventional dominance remains
Plastic-modified concrete/asphalt	Waste valorization; targeted performance improvement; circular branding	Where no performance or supply-chain advantage is demonstrated	Hybrid growth pathway rather than direct substitution

### 3.4 Sustainability trade-offs

Sustainability is one of the main reasons that the plastic–concrete comparison can no longer be reduced to traditional engineering criteria. Plastics contribute to lightweight logistics, corrosion resistance, and long service life in many non-structural applications<sup>[6,7,9,16]</sup>. Their production can also incorporate recycled feedstocks, and products such as recycled plastic pavers, as well as modular pavement systems such as PlasticRoad, demonstrate how waste plastics can be redirected into longer-lived construction uses<sup>[1,11,12,30,31]</sup>. However, these benefits are accompanied by persistent concerns over fossil-derived raw materials, end-of-life management, low recycling rates in some regions, and environmental leakage, including microplastic generation<sup>[1,13,30–32]</sup>.

Concrete, on the other hand, benefits from long service life and broad technical familiarity, but its sustainability burden is strongly affected by cement production, which is associated with substantial carbon emissions and resource demand<sup>[2–5,33,34]</sup>. The extraction and transport of aggregates also impose environmental costs. These drawbacks have stimulated growing

interest in recycled aggregate concrete, permeable concrete, and the incorporation of recycled plastic particles into cementitious systems<sup>[8,10,17–19,27–29]</sup>. Such approaches do not eliminate the environmental burden of concrete, but they help shift the material system toward resource recovery and functional efficiency.

The practical implication is that sustainability should be evaluated on a life-cycle basis rather than through isolated indicators. A lighter plastic product may reduce transport and installation impacts but still perform poorly if disposal is unmanaged. A concrete product may have a high embodied carbon burden but remain environmentally competitive if it delivers long service life in a high-load application with low replacement frequency. For both materials, the most promising path lies in circular design, improved recovery systems, and closer matching between material properties and actual service demand.

### 3.5 Market substitution pathways

The evidence reviewed above suggests that market change occurs through several distinct pathways rather than through a single replacement logic. The first pathway is direct substitution. This occurs when plastic products satisfy the required function at lower total cost and with fewer service risks, as in many low- to medium-load drainage and modular landscape applications<sup>[9,10,14–17]</sup>. Direct substitution is most likely when weight, corrosion resistance, and installation speed are more important than high compressive capacity.

The second pathway is selective coexistence. In this pattern, plastic and concrete remain in the same product family but serve different performance bands. Drainage pipes and grass block pavers are typical examples: plastics expand in lighter-duty, easier-to-install, and sustainability-oriented segments, while concrete retains the heavy-duty and high-rigidity market<sup>[9,10,14–19]</sup>. Here, substitution does not eliminate the incumbent material; instead, it redistributes market share according to service conditions.

The third pathway is hybrid integration. PlasticRoad systems, plastic-modified asphalt, and concrete containing recycled plastic particles show that innovation increasingly comes from combining the advantages of both material families<sup>[8,11,12,21–29]</sup>. Hybridization is particularly relevant in markets shaped by circular-economy policy, where the commercial value of a product includes not only mechanical performance but also waste reduction, modularity, and environmental branding. Figure 6 shows how this concept has been translated into pilot installation.

Figure 6. Author-generated project summary schematic of the PlasticRoad pilot implementation in the Netherlands, based on publicly reported pilot information and the source synthesis. Synthesized from<sup>[12]</sup>.

## PlasticRoad Pilot Implementation in the Netherlands

Illustrative project summary derived from publicly reported pilot information



The fourth pathway is circular upgrading. In this case, plastic waste or recycled concrete is not simply treated as disposal material but as a feedstock for new products, such as recycled plastic pavers, recycled aggregate paving systems, plastic-modified asphalt, and cementitious materials containing recycled polymer particles<sup>[8,11,21–29]</sup>. From a management perspective, this pathway is important because it links material selection with supply-chain design, municipal waste systems, and sustainability reporting<sup>[11,30,31]</sup>. It also broadens the competitive basis of construction products beyond price alone. A related pathway is shown in Figure 7, which summarizes the conversion of post-consumer plastic into road-material feedstock.

Figure 7. Author-generated process schematic for incorporating recycled plastic into road materials, from waste collection

and sorting to blending and paving. Synthesized from <sup>[11,20-26]</sup>.

## Recycled Plastic Road Material Process Chain

Conceptual route for incorporating waste plastic into asphalt-based systems



Taken together, these pathways show that the future competition between plastics and concrete will be determined less by abstract claims of superiority and more by the alignment among product function, life-cycle cost, environmental regulation, and circular-material infrastructure. The most realistic market outlook is therefore a differentiated one: direct replacement in some segments, stable coexistence in others, and hybrid expansion where regulatory and commercial incentives reward multifunctionality and recycled content.

### 3.6 Implications for material selection and market strategy

For developers, contractors, and public procurement agencies, the decisive question is not which material is universally superior, but which product configuration delivers the best fit under specific service conditions. Plastic products tend to create value where logistics, corrosion exposure, modular installation, and distributed maintenance dominate total system cost<sup>[9,10,14-17]</sup>. Concrete remains preferable where stiffness, fire performance, mass, and long-term confidence under heavy loading carry greater economic weight<sup>[2,4,5,9]</sup>. In practice, this means that substitution decisions should be made at the product level and supported by life-cycle costing rather than by headline material price alone<sup>[9,10,14,15,17]</sup>.

A second implication concerns innovation strategy. Firms are more likely to succeed through hybrid and circular propositions than through blanket claims that plastic can replace concrete or vice versa. Products that combine recycled feedstocks, drainage functionality, modular construction, or maintenance savings align more closely with current infrastructure and sustainability pressures. For policy-makers, the enabling conditions are standards, waste-sorting infrastructure, and reporting frameworks that allow recycled-content products to compete on credible performance terms<sup>[8,11,12,20-29]</sup>.

Table 3. Proposed market substitution pathways for plastic and concrete products in construction.

Pathway	Description	Representative examples	Key decision variables
Direct substitution	Plastic replaces concrete where required performance can be met with lower system cost	Lightweight drainage pipes; plastic landscape pavers	Weight, corrosion resistance, labor intensity, installation speed
Selective coexistence	Both materials remain in use but occupy different performance bands	Plastic vs. concrete grass pavers; pipe size and load segmentation	Traffic load, stiffness demand, abrasion, service environment
Hybrid integration	Products combine plastic and mineral systems or use plastic as a modifier	Plastic-modified roads; concrete with recycled plastic particles	Performance gain, compatibility, supply-chain availability, standards
Circular upgrading	Waste streams become input materials for new products	Recycled plastic pavers; recycled aggregate permeable grass bricks	Waste collection system, policy incentives, environmental reporting

## 4. Conclusions and Implications

This review develops a focused comparative account of plastic and concrete construction products by centering the analysis on cost structure, application fit, sustainability, and market substitution pathways. The comparison shows that the two materials are not interchangeable in a general sense; rather, each is commercially strongest under a specific set of service conditions<sup>[2,9-11]</sup>.

Plastics are most competitive in product categories that reward low density, corrosion resistance, modular production, and rapid installation<sup>[6,7,9,13,16]</sup>. Concrete remains dominant where rigidity, mass, fire resistance, and high compressive reliability are central to performance<sup>[2,4,5]</sup>.

The review also indicates that the most promising future direction lies in hybrid and circular solutions. Plastic-modified road materials, recycled plastic pavers, and concrete systems that incorporate recycled plastics or recycled aggregates extend the comparison beyond simple material rivalry and toward integrated resource management<sup>[8,11,21-29]</sup>. For researchers and industry decision-makers, the key implication is that material selection should be based on service-fit and total system value rather than on nominal unit price alone<sup>[9,10,14,15,17]</sup>.

Future work would benefit from standardized life-cycle cost data, region-specific carbon accounting, and more long-term field evidence for emerging products such as modular plastic road systems and recycled-plastic concrete. Such evidence would strengthen the evaluation of substitution not only as a technical decision, but also as a strategic response to environmental policy and changing construction-market demand.

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No

## Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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