Concrete Floor Repair for Automated Guided Vehicle and Autonomous Mobile Robot Environments: Engineering Principles, Failure Modes, and Performance Validation of Roadware 10 Minute Concrete Mender™

A Technical Reference for Engineers, Facility Managers, and Automation Integrators

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Figure 1. An Automated Guided Vehicle (AGV) traversing an industrial concrete floor. Floor surface integrity is a primary determinant of AGV navigation accuracy, sensor reliability, and drive system longevity.

Abstract

The rapid expansion of Automated Guided Vehicle (AGV) and Autonomous Mobile Robot (AMR) fleets into logistics, manufacturing, and fulfillment environments has fundamentally redefined the engineering requirements placed upon industrial concrete floor systems. Floor surfaces that were previously acceptable for human-operated forklift traffic are routinely found to be inadequate for robotic systems — whose navigation sensors, localization algorithms, and precision drive assemblies are highly sensitive to surface irregularities, cracks, spalled joints, and delamination.

This white paper presents a comprehensive engineering analysis of the relationship between concrete floor condition and AGV/AMR system performance. It examines the full taxonomy of floor failure modes common in industrial facilities, the cascade effects each failure type produces on robotic operations, and the quantified economic consequences of unaddressed floor deterioration. The paper then provides a detailed material-science analysis of Roadware 10 Minute Concrete Mender™ — a two-component hybrid polyurethane polymer concrete repair system formulated specifically for the demands of high-traffic industrial floors. Key technical differentiators examined include the proprietary Microdoweling™ penetration mechanism, modulus-compatible polymer concrete formulation, dynamic load absorption characteristics, rapid return-to-service cure profile (approximately 10 minutes at 21°C / 70°F), and the ability to cure and perform in subzero environments. Installation engineering parameters, ASTM-referenced performance data, and a structured implementation framework for facility managers are provided. The paper's scope extends from pre-deployment floor assessment through ongoing maintenance program integration.

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1. Introduction

The adoption of Automated Guided Vehicles and Autonomous Mobile Robots in industrial environments has accelerated substantially over the past decade, driven by labor availability constraints, throughput demands, and the declining cost of onboard computing, sensor technology, and machine vision systems. Modern fulfillment centers routinely deploy fleets of 50 to several hundred robotic units operating continuously across floor areas measured in hundreds of thousands of square feet. In advanced facilities, AGV/AMR systems execute repetitive precision travel paths at speeds of 1.0 to 2.0 m/s, traverse control joints thousands of times per shift, and rely on sub-centimeter localization accuracy to interface with racking, conveyor systems, and human workers.

In this operational context, the concrete floor is not merely a passive surface — it is a critical system component whose condition directly determines the performance envelope of the entire robotic installation. Engineers and integrators who design AGV/AMR systems specify payload capacities, navigation architectures, and sensor suites with precision, yet the floor upon which these systems operate is frequently treated as a pre-existing condition rather than an engineered subsystem requiring its own assessment, specification, and maintenance program.

The consequences of this oversight are measurable and costly. Floor-induced emergency stops interrupt throughput. Vibration from cracked or damaged surfaces introduces localization drift in Simultaneous Localization and Mapping (SLAM) algorithms. Impact events at joint edges accelerate wheel bearing and drive motor fatigue. In high-bay operations, even minor floor irregularities translate into significant positional errors at elevated sensor heights. The cumulative economic impact of unaddressed floor damage in an active AGV/AMR facility is disproportionate to the cost of the floor repairs themselves.

This white paper addresses the complete engineering problem: it characterizes the failure modes that affect industrial concrete floors in AGV/AMR environments, explains the mechanisms by which each failure type compromises robotic system performance, and provides detailed technical documentation of Roadware 10 Minute Concrete Mender™ as an engineered repair solution for these conditions. The paper is structured to serve both the design engineer specifying repair materials and the facility manager developing an operational floor maintenance program.

Engineering Context

In the AGV/AMR systems engineering hierarchy, the floor must be treated as a primary subsystem — equivalent in criticality to the navigation infrastructure, charging systems, and traffic management software. Floor condition assessments should be incorporated into pre-commissioning checklists, and floor repair specifications should be included in AGV/AMR facility design packages.

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2. Floor Performance Requirements for AGV/AMR Operations

2.1 Flatness and Levelness Standards

Floor surface profile in warehousing and industrial environments is quantified using the F-Number system defined in **ASTM E1155: Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers**. The system produces two independent indices:

- **FF (Floor Flatness)** — measures bumpiness over short distances (the differential elevation between adjacent 300 mm / 12-inch measurement intervals). Higher FF numbers indicate a smoother, flatter surface. FF governs ride quality and short-range sensor accuracy.

- **FL (Floor Levelness)** — measures conformance to a true horizontal plane over longer distances. FL is critical for rack alignment, gravity-fed systems, and any equipment dependent on consistent elevation across large floor areas.

Both indices are measured using a calibrated digital floor profilometer traversing the floor surface. For fixed-path vehicle systems such as AGVs operating on defined travel lanes, ASTM E1155 recommends direct measurement along each traffic path rather than statistical random sampling — providing more operationally relevant data.

Minimum F-Number Requirements by Operation Type:

Operation Type	Minimum FF	Minimum FL	Notes
Standard wide-aisle driving operations (human-operated)	25	20	Baseline for most existing warehouse floors
AGV/AMR standard driving operations	35	25	Minimum threshold for robot commissioning
Rack-height load operations (>0.5 m lift height)	45	35	Sensor error amplified at height; tighter tolerance required
High-bay ASRS and superflat operations	60	40	Superflat specification; requires specialized construction
Very Narrow Aisle (VNA) / Turret Trucks	100+	60+	Defined-path measurement; guidance rail may be required

A critical operational reality for facility managers is the distinction between *new construction* FF/FL values and *in-service* FF/FL values. Concrete floors degrade over time under traffic loading, thermal cycling, and moisture effects. A floor that achieved FF 45 at construction may have degraded to an effective FF of 30 or below after years of forklift and heavy vehicle traffic — particularly at control joints and in high-traffic zones. Brownfield facilities being retrofitted for AGV/AMR operations rarely meet superflat specifications and commonly fail to meet even the FF 35 / FL 25 minimum threshold without remediation.

Engineering Note

Effective FF/FL values in brownfield facilities are typically 15–30% lower than original construction values due to joint edge degradation, crack development, and localized spalling. Pre-commissioning measurement is mandatory — do not rely on original construction survey data for AGV/AMR deployment planning.

2.2 Surface Integrity Requirements

Beyond global flatness and levelness, AGV/AMR operations impose specific surface integrity requirements at the local level:

- **Minimum Concrete Compressive Strength:** AGV manufacturer specifications commonly require a minimum substrate compressive strength of approximately 32 MPa (4,640 psi) to support anchoring of navigation infrastructure (magnetic tape, QR code targets, reflector posts) and to resist wheel contact pressures under loaded AGV operation. Concrete below this threshold is subject to progressive surface abrasion and spalling under cyclic wheel loading.
- **Joint Edge Integrity:** Control joint edges that are chipped, spalled, or broken create step discontinuities and impact loading events every time an AGV wheel traverses the joint. Step heights as small as 3 mm are detectable as vibration events by onboard IMUs. Steps exceeding 6 mm constitute a maintenance trigger condition for most AGV OEMs.
- **Surface Delamination:** Planar delamination within a slab or between a topping and a structural slab may not be visually apparent, but delaminated zones progressively collapse under cyclic AGV wheel loads — creating sudden spalls that disrupt navigation maps and create immediate safety hazards.
- **Allowable Slope / Inclination:** Horizontal travel zones for AGV/AMR operations should not exceed 1% grade (10 mm/m). Ramp zones must be engineered specifically for the AGV equipment in use, with explicit OEM approval. Cross-slopes in travel lanes generate lateral forces on drive assemblies and increase risk of payload shift on loaded platforms.

2.3 AGV/AMR Sensor Sensitivity to Floor Conditions

Modern AGV and AMR navigation systems rely on a hierarchy of sensing technologies that interact directly with floor surface conditions:

LiDAR and SLAM Navigation: LiDAR-based SLAM systems construct and maintain real-time maps of the facility environment by correlating sensor returns against a stored reference map. Floor-induced vibration introduces noise into the LiDAR point cloud, reducing correlation quality and causing localization drift — particularly at higher vehicle speeds. In severe cases, floor shock events can cause momentary SLAM map de-registration requiring the robot to re-localize, resulting in an unplanned stop.

IMU Noise and Localization Drift: Inertial Measurement Units measure acceleration and angular rate to track vehicle motion between sensor updates. Floor irregularities — even those below the threshold of visual detection — generate acceleration spikes that the IMU must distinguish from intentional vehicle motion. High-frequency vibration from rough surfaces increases IMU noise floor, reducing the accuracy of dead-reckoning between map updates and accumulating positional error over time.

Tilt Amplification at Height: A floor irregularity that produces a 0.5° angular deflection of a 1.8 m (6 ft) tall AGV or rack-loading robot displaces the top sensor assembly by approximately 16 mm (0.63 in) from its nominal position. At high-bay rack heights of 10 m (33 ft), the same tilt produces over 87 mm of positional offset — rendering sub-centimeter pick accuracy impossible. This geometric amplification effect makes floor condition disproportionately critical for high-lift operations.

Emergency Stop (E-Stop) Frequency as a KPI: The rate of unplanned emergency stops per robot-hour is a directly measurable key performance indicator of floor quality. Facilities with degraded floor surfaces consistently show elevated e-stop frequencies correlated with specific floor zones. Systematic logging of e-stop locations against a floor condition map is a highly effective predictive maintenance tool.

Drive Assembly Fatigue: Repeated impact loading at floor defects accelerates fatigue in wheel bearings, drive shafts, and motor couplings. The Mean Time Between Failures (MTBF) of drive components is directly influenced by the peak impact forces experienced in service. Even moderate floor deterioration can reduce drive component MTBF by 30–50%, significantly increasing maintenance costs and parts consumption over the life of the fleet.

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3. Concrete Floor Failure Modes in Automated Facilities

3.1 Crack Typology and Engineering Significance

Not all concrete cracks are equivalent in their consequences for AGV/AMR operations. Engineering judgment requires classification of crack type, geometry, and activity level before specifying repair. The following typology addresses the most common failure modes in industrial floor systems.

3.1.1 Shrinkage Cracks

Cause: Differential drying and thermal gradients during the concrete cure process. All portland cement concrete shrinks as it dries; when shrinkage is restrained by the subgrade, reinforcement, or adjacent concrete, tensile stresses develop and the concrete cracks.

Geometry: Typically hairline width (<0.3 mm), appearing as random map-cracking or isolated linear cracks not coincident with joints or reinforcement. Usually non-through-slab.

AGV Impact: Low individually, but a network of shrinkage cracks degrades overall surface integrity. Under cyclic AGV wheel loading, water infiltrates the crack network, freeze-thaw cycling expands cracks, and surface aggregate is progressively dislodged — initiating the spall cycle.

Repair Urgency: Moderate — preventive sealing treatment is recommended before AGV fleet commissioning to arrest deterioration before it progresses.

3.1.2 Structural / Load-Induced Cracks

Cause: Sub-base failure, overloading beyond design capacity, inadequate slab thickness, insufficient reinforcement, or differential settlement of the underlying soil.

Geometry: Through-slab cracks, typically linear, that may exhibit vertical step displacement between crack faces. The presence of step displacement indicates differential movement between slab segments — a structurally significant condition.

AGV Impact: High. Step cracks create direct impact events on every AGV wheel traverse. Step heights of 3–6 mm generate measurable vibration spikes; steps exceeding 6 mm are likely to trigger e-stop events or navigation faults. Repeated impact accelerates crack edge spalling.

Repair Urgency: Critical — structural crack causes must be investigated and addressed, and the crack must be repaired before robot fleet commissioning.

3.1.3 Reflective Joint Cracks

Cause: Control joints are engineered discontinuities that concentrate slab shrinkage movement and prevent random cracking. As the joint opens and closes with temperature and moisture cycling, adjacent concrete at the joint face experiences repeated loading.

Geometry: Linear cracks coincident with control joints. May exhibit vertical displacement (step) if the joint was not properly loaded or armored. Gap width varies with temperature.

AGV Impact: Severe when step height exceeds 3–6 mm. Every AGV traverse of the joint generates a wheel impact event producing a vibration spike, sensor noise, and cumulative drive wear. At busy facilities, a single joint may be traversed tens of thousands of times per week.

Repair Urgency: High — joint repair should be prioritized in all robot travel paths before commissioning.

3.1.4 Delamination

Cause: A weak horizontal bond plane within the slab (commonly caused by bleed water trapped during placement, or a cold joint in two-pour construction) or between a topping/overlay and the structural slab. Delamination may also develop at the surface of a hard-troweled slab where a densified surface layer separates from the body of the concrete.

Geometry: Planar horizontal zones that produce a hollow sound when sounded (chain drag, electronic impulse sounding). Not visually apparent until collapse begins.

AGV Impact: Progressive and unpredictable. Delaminated zones carry wheel loads through plate-bending action until the unsupported span exceeds the tensile capacity of the delaminated layer — at which point sudden collapse and spalling occurs. The failure is sudden and can create a significant surface defect overnight.

Repair Urgency: High — delaminated zones in robot travel paths must be identified by sounding survey and repaired by resin injection before AGV deployment.

3.1.5 Spalling and Pop-Outs

Cause: Multiple mechanisms produce surface spalls: freeze-thaw cycling of water in the concrete pore structure; expansive corrosion of embedded reinforcement; impact damage; alkali-silica reaction (ASR) between reactive aggregate and cement paste; and progressive failure of delaminated zones.

Geometry: Bowl-shaped or conical surface cavities exposing aggregate, with irregular and often sharp edges. Depth varies from a few millimeters for pop-outs to 50 mm or more for deep spalls over corroding reinforcement.

AGV Impact: Direct and immediate. AGV wheels contacting spall edges experience impact loads proportional to edge sharpness, spall depth, and travel speed. Spalls in robot travel paths also disrupt navigation map data by altering the floor surface profile at tracked locations.

Repair Urgency: Critical for any spall located within robot travel paths or within 300 mm of a control joint.

3.1.6 Control Joint Edge Failure

Cause: Repeated impact loading from vehicle traffic on unsupported concrete at joint edges — particularly in joints that lack edge armoring. Each vehicle traverse creates a brief cantilevered loading condition on the joint edge; over thousands of cycles, the concrete crushes and spalls progressively outward from the joint face.

Geometry: Chipped, spalled, or crushed concrete at joint faces, creating an irregular and widened gap. The effective joint width increases over time, making the impact event progressively more severe.

AGV Impact: Severe. Control joint edge failure is the single most common and damaging floor defect in high-frequency AGV travel environments. Every robot traverse of a damaged joint edge generates a measurable shock event. These accumulated impacts produce accelerated wheel bearing wear, drive coupling fatigue, and sensor noise — and simultaneously accelerate further joint edge deterioration.

Repair Urgency: Critical — joint edge reconstruction should be treated as a commissioning prerequisite in all robot travel paths.

3.2 Failure Progression and Cascade Effects

Floor damage in AGV/AMR environments does not remain static. The cascade failure sequence is well-established:

1. **Initial defect** — crack, joint opening, or minor spall develops through shrinkage, settlement, or traffic fatigue.
2. **Water infiltration** — precipitation, cleaning water, or condensation enters the crack network, softening the sub-base and enabling freeze-thaw expansion.
3. **Edge loading** — AGV wheels cross the defect repeatedly, applying dynamic impact loads to unsupported crack edges.
4. **Progressive spalling** — crack edges deteriorate into full spalls; joint edges fragment; surface area of the defect expands.

5. **Navigation disruption** — spalls and step changes alter the floor profile at locations tracked in the robot's navigation map, triggering localization errors.
6. **E-stop events** — the robot halts autonomously in response to sensor anomalies or localization uncertainty.
7. **Throughput loss and maintenance cost** — the cumulative cost of downtime, manual reset labor, and drive component replacement dwarfs the cost of the original floor repair.

Quantified Impact Example: A typical 1,000 kg (2,200 lb) loaded AGV traveling at 1.5 m/s (4.9 ft/s) and encountering a 6 mm vertical step at a joint edge generates a peak impact force estimated at 3–5 times the static wheel load — potentially 7,000–12,000 N (1,575–2,700 lbf) at the wheel contact patch in a very brief impulse event. Multiplied by the number of such events per shift and the number of joints in the travel path, the cumulative fatigue loading on drive components is substantial.

3.3 Economic Impact of Unaddressed Floor Damage

The economic case for proactive floor repair is compelling when the full cost structure is examined. The following table summarizes the primary cost categories associated with unaddressed floor damage in an AGV/AMR facility, compared against the cost of repair:

Cost Category	Estimated Cost per Event or Interval	Frequency in Degraded Floor Environment
E-stop event — throughput loss + manual reset labor	$50–$300 per event	Multiple events per shift in affected zones
Wheel and bearing replacement (accelerated wear)	$200–$800 per robot per replacement cycle	Replacement cycle reduced by 30–50% on rough floors
LiDAR recalibration / map update	$500–$2,000 per event	Required after each significant floor change event
Drive motor / coupling replacement	$500–$3,000 per robot	Premature failure due to shock loading
Proactive joint edge repair — Concrete Mender™	$20–$60 per linear foot of joint	One-time repair, 10-minute return to service
Spall repair — Concrete Mender™	$50–$400 per repair location	One-time repair, 10-minute return to service

Economic Finding

In a facility operating 50 AGV units with a degraded floor generating 3 additional e-stop events per robot per shift, the annual cost of throughput loss alone exceeds $1.3 million (at $150/event, 3 shifts/day, 250 operating days). This is typically 20 to 100 times the cost of a comprehensive floor repair program. The return on investment for proactive repair is achieved within weeks of implementation.

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4. Material Science of Roadware 10 Minute Concrete Mender™

4.1 Chemical Composition and Formulation

Roadware 10 Minute Concrete Mender™ is a two-component, high-penetration hybrid polyurethane repair system. The two components are:

- **Part A:** Isocyanate component — the reactive crosslinker that drives the polymerization reaction.
- **Part B:** Polyol resin component — provides the polymer backbone chemistry and controls the physical properties of the cured matrix.

The two components are stored in a pre-measured dual-cartridge format and are combined through a static mixer at the point of application. This delivery system ensures a consistently accurate stoichiometric ratio on every application without pot-mixing, eliminating ratio errors and eliminating product waste from mixed batches that exceed working time. The system is engineered so that all mixing occurs within the static mixer element; the operator cannot inadvertently vary the mix ratio.

The defining physical characteristic of the uncured resin is its extremely low viscosity — approaching that of water. This near-water-thin consistency is not an incidental property but a central design parameter that enables the product's primary performance mechanism.

4.2 The Microdoweling™ Mechanism

The Microdoweling™ mechanism is the central technical differentiator of Roadware 10 Minute Concrete Mender™ and the basis of its superior bond performance relative to conventional repair materials. Understanding this mechanism requires a brief review of how concrete is structured at the micro-scale.

Concrete is a porous material. The hardened cement paste matrix contains a continuous network of capillary pores — typically ranging from 0.01 to 10 micrometers in diameter — interconnected micro-cracks, aggregate-paste interfacial zones, and larger voids. In the vicinity of a surface crack or spall, this pore network extends throughout the surrounding concrete matrix at distances of several millimeters to centimeters from the visible crack face.

When the ultra-low-viscosity Concrete Mender™ resin contacts this concrete matrix, capillary suction forces draw the resin deep into the pore network and micro-crack system surrounding the repair zone. This penetration is not limited to the surface of the crack — it extends volumetrically into the surrounding concrete, following all interconnected pathways. As the resin cures in place within these pathways, it forms a three-dimensional network of interlocked polymer filaments — the Microdowels.

Technical Definition — Microdoweling™

Microdoweling™ is the mechanism by which Roadware Concrete Mender™ resin penetrates the capillary pore network, micro-crack network, and aggregate interfaces of the surrounding concrete matrix and cures in place to form thousands of microscopic polymer anchors — functioning collectively as a three-dimensional volumetric interlock system between the repair material and the host concrete.

Mechanical Significance: A conventional patch material bonds only at the surface plane — at the visible interface between the patch and the surrounding concrete. Bond strength is limited by the tensile strength of this surface bond, which is commonly the weakest point in the repair. When the patch is stressed by differential thermal movement or dynamic loading, debonding initiates at this interface and propagates.

A Microdoweled repair bonds not at a plane but within a volume. The depth of penetration — driven by capillary physics into a concrete with typical pore structure — creates a reinforced transition zone rather than a sharp interface. When this repair is loaded to failure, the failure occurs by fracture of the surrounding concrete — not by failure of the bond interface. This cohesive failure mode (failure in the substrate rather than at the bond line) is the gold standard of adhesion testing, demonstrating that the repair bond is stronger than the surrounding concrete.

Engineering Superiority over Surface-Bond Materials: Traditional epoxy and cementitious patch materials rely exclusively on the adhesive bond at the exposed repair face. They cannot penetrate the concrete pore structure because their viscosity is too high. Roadware Concrete Mender™'s near-water viscosity allows capillary forces — rather than application pressure — to drive the resin into the matrix, creating a fundamentally different and superior mechanical connection.

4.3 Polymer Concrete Formation with Sand

For volumetric repairs — spalls, joint edges, and larger crack fills — Roadware Concrete Mender™ is combined with a manufactured angular silica sand to form a polymer concrete matrix. The sand must be manufactured (angular, not rounded) to provide aggregate interlock within the cured matrix, and must be dry and free of fines. The proportioning of sand to resin determines the final mechanical properties.

The cured polymer concrete achieves compressive strengths in the range of **3,883–6,681 psi (26.8–46.0 MPa)**, depending on sand loading — values comparable to or exceeding the 4,000–5,000 psi typical of industrial floor concrete. Critically, the polymer binder provides properties that pure cementitious materials cannot replicate: the cured matrix remains pliable rather than brittle, absorbs dynamic energy rather than transmitting it, and accommodates minor differential thermal movement without cracking.

Aggregate interlock within the polymer concrete matrix also contributes to shear transfer across repair zones — particularly important at control joint repairs where horizontal shear from AGV wheel loading acts across the repaired joint face.

4.4 Modulus of Elasticity Compatibility — Critical Engineering Consideration

The elastic modulus of a repair material relative to the surrounding concrete is one of the most important — and most frequently overlooked — parameters in industrial floor repair specification. Modulus mismatch is the primary cause of premature repair failure in AGV/AMR environments.

The Modulus Mismatch Problem

Standard portland cement concrete has an elastic modulus in the range of approximately 20,000–34,000 MPa (3,000,000–5,000,000 psi). This high stiffness means that under applied load, concrete deforms very little before resisting — it is a rigid material at the engineering scale relevant to floor repairs.

Common repair materials have the following modulus characteristics:

Material	Elastic Modulus (approx.)	Consequence of Mismatch
Portland cement concrete (host)	20,000–34,000 MPa ($3.0–5.0 \times 10^6$ psi)	Reference material
Cementitious patch (dry-pack mortar)	15,000–25,000 MPa — but with high shrinkage	Shrinkage creates tensile stress at bond interface; debonding and edge cracking during cure
Rigid epoxy repair systems	2,800–4,100 MPa (rigid) to much stiffer	Rigid discontinuity in floor plane; stress concentration under thermal cycling and dynamic loading; edge debonding
Roadware Concrete Mender™ polymer concrete	Modulus-compatible, pliable polymer matrix	Deforms in concert with surrounding concrete; no stress concentration at repair boundary

Critical Engineering Note — Modulus Mismatch

Modulus mismatch is the leading cause of premature floor patch failure in AGV/AMR facilities. A repair material that is significantly stiffer or more flexible than the surrounding concrete acts as a rigid or soft inclusion in the floor plane — concentrating stress at the repair boundary under every thermal cycle and wheel loading event. Over time, these concentrated stresses initiate interfacial cracks that propagate to edge debonding — producing a repair that is mechanically worse than the original damage. Material selection for AGV floor repairs must explicitly consider elastic modulus compatibility, not just compressive strength.

The Roadware Concrete Mender™ Engineering Solution: The hybrid urethane polymer concrete matrix achieves a modulus profile that is compatible with the deformation behavior of surrounding industrial floor concrete under the loading conditions encountered in AGV/AMR operations. Under thermal cycling — daily temperature swings in an unconditioned warehouse, or the more severe cycling in freezer facilities — the repair zone deforms slightly in concert with the surrounding slab. There is no rigidly bonded inclusion generating differential stress at the boundary.

Under the dynamic impact loading of AGV wheel traverses, the pliable polymer matrix absorbs and dissipates energy rather than reflecting it as a stress pulse to the bond interface. The result is that the repair boundary is not a stress concentration site — the repair and the surrounding concrete behave as a unified system. This is the fundamental reason why properly installed Roadware repairs remain in service under continuous heavy traffic without the edge cracking and debonding that characterize rigid patch failures.

4.5 Dynamic Load Response

The fatigue resistance of a repair material under cyclic loading is as important as its static strength in AGV/AMR environments. A typical heavily loaded AGV wheel may apply tens of thousands of loading cycles to a floor repair per day. Brittle materials — including most cementitious repair mortars — are susceptible to fatigue crack initiation and propagation under cyclic stress, even at stress levels well below their static strength.

Polymer binders do not exhibit the brittle fatigue crack propagation characteristic of cementitious systems. The polymer matrix of cured Concrete Mender™ accommodates cyclic stress through viscoelastic deformation and energy dissipation mechanisms at the molecular level. Impact energy from wheel-to-floor contact is partially absorbed within the repair zone rather than fully transmitted as an elastic stress pulse. This energy absorption is particularly important at joint edge repairs, where wheel impact loads are highest and where the geometric configuration produces the most severe stress concentrations.

4.6 Chemical and Environmental Resistance

Industrial floor environments expose repair materials to a wide range of chemical and environmental stresses. Roadware Concrete Mender™ provides high resistance to the chemicals most commonly encountered in AGV/AMR operating environments:

- **Hydraulic fluid:** Resistant — relevant to hydraulic AGV lift systems and industrial machinery
- **Battery electrolyte (sulfuric acid):** Resistant — critical for facilities operating lead-acid battery AGV fleets where charging station spills are common
- **Cleaning agents and degreasers:** Resistant to industrial cleaning chemicals used in floor maintenance programs
- **Oils, fuels, and lubricants:** Resistant — relevant to mixed-use facilities with human-operated equipment
- **Temperature range:** Cures and performs across an extremely wide temperature range, including subzero conditions below 0°F (-18°C) — a critical capability for freezer and cold storage warehouse AGV applications where competing cementitious materials cannot achieve cure
- **Moisture:** Surface must be dry at time of application to allow resin penetration; once fully cured, the polymer matrix resists moisture ingress
- **UV radiation:** Adequate resistance for interior industrial applications

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5. Engineering Applications for AGV/AMR Environments

Robot flooring for smart warehouses and AMR AGV floor systems

Figure 2. Precision floor surface conditions are a foundational requirement for smart warehouse and logistics robot systems, including both AGV and AMR platform types.

5.1 Control Joint and Expansion Joint Repair

Problem: AGV wheels crossing open or damaged control joints create impact events that generate vibration, sensor noise, and cumulative drive wear. In busy facilities, individual joints may be traversed hundreds of thousands of times over a fleet's operational life.

Repair Method: Clean the joint thoroughly with compressed air and a wire brush to remove all loose material, dust, and contaminants. Apply neat resin (no sand) to all joint faces for penetration bonding. Fill the joint with Concrete Mender™ extended with manufactured angular sand, working the mix into the joint to eliminate voids. Strike off flush with the surrounding floor surface. If the joint is a control joint where future movement is anticipated, re-establish the saw-cut profile after cure to preserve the joint's designed function.

Critical Note — Dormant vs. Active Joints: Concrete Mender™ is formulated for dormant joints where future significant slab movement is not anticipated. For active expansion joints subject to ongoing differential movement, a flexible joint sealant system appropriate to the expected movement range must be used such as Roadware

Flexible Cement II. Engineering judgment is required to distinguish dormant control joints from active expansion joints based on slab configuration, age, and thermal exposure.

Expected Outcome: Restoration of a smooth, continuous wheel path across the joint, elimination of the impact event, and prevention of progressive joint edge deterioration.

5.2 Crack Injection and Sealing

Hairline cracks (<0.5 mm width): Apply neat resin (no sand addition) using a 15-gauge needle-tip applicator along the crack length. Capillary suction within the crack and surrounding concrete matrix draws the low-viscosity resin into the crack system. No surface pressure is required. The resin follows the crack path including all branches and the surrounding micro-crack network. The Microdoweling™ mechanism activates as the resin penetrates the pore structure adjacent to the crack, restoring tensile continuity across the crack plane. The Roadware Easy Injection system may be used to inject the resin up to 60 cm deep into the slab or more if needed.

Wider cracks (0.5–5 mm): Apply neat resin as a primer coat to all crack surfaces to achieve Microdoweling™ penetration into the surrounding matrix. Allow momentary penetration, then introduce the sand-extended polymer concrete mix to fill the crack volume. Work the mix into the crack to eliminate voids and strike off flush.

Through-slab cracks: Depending on slab thickness and accessibility, application from both faces may be required to ensure full-depth fill. For deep cracks inaccessible from below, the Easy Injection System can be used to inject resin under slight pressure through ports installed at intervals along the crack length.

5.3 Spall Repair

Spall repair is one of the highest-priority applications in AGV/AMR environments, as spalls in robot travel paths create immediate operational disruptions.

8. Remove all loose, delaminated, and deteriorated concrete from the spall area. Wire brush, chipping hammer, or grinding may be required depending on spall depth and extent. The repair boundary should be sound concrete with no hollow-sounding zones.
9. Clean the spall cavity thoroughly with dry diamond grinder and a dust collecting vacuum system to remove all dust and debris. The surface must be dry.
10. Apply a coat of neat resin (no sand) to all surfaces of the spall cavity as a penetrating primer. This step activates the Microdoweling™ mechanism, bonding the repair to the surrounding concrete at the volumetric level rather than only at the surface plane.
11. Fill the spall with a 2 parts sand to one part mixture of Concrete Mender™ polymer concrete, working the mix to eliminate voids and fill to the level of the surrounding floor.
12. The self-leveling characteristics of the mix assist in achieving a flush surface in horizontal applications. For edges and vertical faces, sand loading is adjusted to provide a workable, non-slumping consistency.

13. Return to AGV traffic service in approximately 10 minutes at 70°F (21°C).

5.4 Delamination Repair (Minimally Invasive)

Delaminated floor zones present a particular challenge because the defect is not visible at the surface yet represents an imminent progressive failure hazard. Roadware's Easy Injection System provides a minimally invasive repair method that preserves the existing floor surface:

14. Identify the delaminated zone extent using chain-drag sounding or electronic impact-echo sounding equipment.
15. Mark the boundary of the delaminated zone. Drill injection ports at regular intervals — typically 200–300 mm (8–12 in) spacing — through the surface into the delamination plane.
16. Insert the Easy Injection System nozzles into the ports and inject neat Concrete Mender™ resin under slight manual pressure. The low-viscosity resin flows laterally between the delaminated layer and the underlying concrete, filling the separation plane.
17. Continue injection until resin appears at adjacent ports, confirming full coverage of the delaminated zone.
18. Upon cure, the delaminated layer is bonded to the underlying slab through the cured resin matrix — eliminating the void plane and restoring load transfer across the previously separated interface.

This approach eliminates the need to saw-cut and remove the delaminated section — a significant advantage in operational facilities where minimizing disruption to robot travel paths is paramount.

5.5 Joint Edge Reconstruction

Control joint edge reconstruction is the most mechanically demanding repair application in AGV environments and is the repair type with the highest operational impact when completed successfully.

19. Clean and profile the damaged joint edge. Remove all loose and fractured concrete to a sound substrate. If the remaining concrete at the joint edge is insufficient to support the repair, undercut the edge slightly to provide a mechanical interlock geometry — a slight dovetail or saw-cut shoulder prevents the repair from being dislodged by horizontal shear from wheel loading.
20. Clean all surfaces with compressed air; ensure dryness.
21. Apply neat resin to all concrete surfaces in the repair zone, allowing penetration time for Microdoweling™ activation.
22. Build up the joint edge with sand-extended polymer concrete, troweling to match the specified joint edge profile. Work in lifts if the required build-up exceeds approximately 25 mm (1 in).
23. After cure, the reconstructed joint edge can withstand the full wheel impact loads of heavy AGV traffic.

24. Re-establish the joint gap as required by saw-cutting through the cured repair if the joint must remain functional for differential slab movement.

5.6 Freezer Floor Repairs

Cold storage and freezer warehouse facilities operating AGV fleets at temperatures of -20°F to -29°C (-29°C to -34°C) present a unique challenge: concrete floor damage occurs under the same failure mechanisms as ambient-temperature facilities, but competing repair materials cannot cure at freezer temperatures. Portland cement concrete cures through a hydration reaction that is effectively arrested below approximately 4°C (40°F). Epoxy systems similarly have cure temperature thresholds that preclude application without warming the repair zone — an expensive and operationally disruptive requirement in a freezer environment.

Roadware 10 Minute Concrete Mender™ cures effectively at subzero temperatures — a fundamental competitive advantage for freezer facility applications. The polyurethane chemistry is not dependent on water for cure, and the reaction proceeds at temperatures well below freezing. Application technique modifications for cold environments — including substrate preparation and working time adjustments — are detailed in Roadware's Cold Environment Application Techniques guide (available from Roadware Incorporated).

This capability enables repair of freezer floor defects without warming the repair zone, warming the ambient environment, or interrupting freezer operations beyond the minimum required for access to the repair location.

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6. Installation Engineering Parameters

6.1 Surface Preparation Requirements

Surface preparation is the foundation of repair durability. The most important requirement is that the substrate must be sound, clean, and dry. Specific preparation requirements by condition:

- **Minimum preparation (cracks and small spalls):** Wire brush to remove loose material, surface laitance, and dust. Blow out with compressed air. For hairline cracks, this is sufficient — the low viscosity resin will penetrate beyond any surface contamination zone.
- **Preferred preparation (large spall areas):** Mechanical grinding or shot blasting to remove the full depth of deteriorated concrete and expose a clean aggregate surface. The objective is to achieve a Concrete Surface Profile (CSP) appropriate for the repair depth.
- **Moisture:** The most critical preparation parameter. Free moisture on or in the concrete surface inhibits resin penetration and bond formation. The substrate must be dry — not just surface-dry but free of absorbed moisture near the surface. Moisture vapor transmission through the slab from below can be an

issue in slabs on grade without adequate vapor retarder. Allow additional drying time after cleaning if moisture is present.

- **Oil and grease contamination:** Must be removed completely with an appropriate degreaser and allowed to dry before repair. Oil contamination that has penetrated the concrete may require mechanical removal (grinding) to expose uncontaminated substrate.
- **Temperature:** Substrate and ambient temperature should be above -20°F (-29°C); no established upper limit for application. At very high ambient temperatures, working time is reduced — apply in sections and work efficiently.

6.2 Product Selection and Mixing

Cartridge System (standard application): Roadware 10 Minute Concrete Mender™ is supplied in a 50 mL dual-cartridge format with a static mixer. For crack injection, a 15-gauge needle-tip mixer is attached to deliver the resin directly into hairline cracks. For spall and joint repairs, the standard mixer is used for broader application. The cartridge system is self-purging and self-measuring — no operator mixing is required or possible, eliminating ratio errors.

Bulk System (large volume applications): For large-scale floor repair programs involving significant volumes of material, a bulk mixing and dispensing system is available from Roadware. This system provides the same stoichiometric ratio control as the cartridge system at higher throughput.

Working Time: The static mixer controls the mixing reaction rate. Material must be applied within the working window after mixing begins. The cartridge system manages this automatically — there is no mixed material sitting in a pot. To pause between applications, cap the mixer tip; purge a small amount of material before resuming to ensure fresh mixed resin at the tip.

Sand Specification: Use manufactured (angular, crushed) silica sand — do not use rounded natural sand. The angular particle geometry is required for aggregate interlock in the cured polymer concrete matrix. Sand must be dry; moisture in the sand can interfere with the cure reaction.

6.3 Application Technique by Repair Type

Repair Type	Sand Addition	Application Method	Surface Profile Required	Special Notes
Hairline crack (<0.5 mm)	No (neat resin)	15-gauge needle-tip applicator; capillary flow	Blow out loose material; dry	Capillary suction draws resin; no pressure required
Structural crack (0.5–5 mm)	Optional — neat resin primer then sand fill for wider cracks	Apply with cartridge or pour	Wire brush, Dry diamond, vacuum and dry	Prime all faces with neat resin first

Repair Type	Sand Addition	Application Method	Surface Profile Required	Special Notes
		and work into crack; trowel flush		
Spall repair	Yes	Pour and trowel as needed.	Remove all loose material; mechanically sound substrate; dry	Apply neat resin primer coat before filling with sand mix
Control joint edge	Yes	Build up and trowel; work in lifts for deep build-up	Undercut for mechanical interlock, score surface edges 5 mm deep; clean and dry	Re-saw joint after cure if movement joint must remain functional
Delamination injection	No (neat resin)	Easy Injection System; ports at 200–300 mm centers	Drill injection ports; blow clean	Inject until resin appears at adjacent port
Bolt / anchor setting	Yes (fill annular space)	Fill drilled hole; set hardware immediately	Clean drilled hole; remove dust; dry	10-minute cure — hardware can be loaded quickly
Freezer floor repair	Application-dependent	Same as above; extended working time in cold	Remove surface frost and surface moisture with heat just before application. Same as above; allow additional drying time	Consult Cold Environment Application Techniques guide

6.4 Cure Schedule and Return-to-Service

The rapid cure profile of Roadware 10 Minute Concrete Mender™ is a primary operational advantage in active AGV/AMR facilities, enabling repairs to be completed during scheduled shift changes or brief scheduled breaks without requiring extended facility shutdowns.

Ambient/Substrate Temperature	Approximate Cure Time to Traffic	Notes
70°F (21°C) — nominal	~10 minutes	Rated standard cure condition
Light pedestrian traffic	10 minutes	At nominal 70°F condition
AGV / forklift / heavy vehicle traffic	10–15 minutes	Allow slight additional margin for maximum load
40°F (4°C)	45-60 minutes (estimated)	Cure time extends at lower temperatures; verify cure before loading

Ambient/Substrate Temperature	Approximate Cure Time to Traffic	Notes
0°F (-18°C)	Cure proceeds — extended time	Competitive advantage: cementitious materials fail to cure at this temperature
Grinding / overcoating after cure	After full cure	Can be ground and polished to match surrounding surface; coatings can be applied after full cure

Operational Note

The 10-minute return-to-service window enables a practical repair workflow synchronized with AGV shift-change intervals (typically 20–30 minutes in continuous operations) without requiring robot fleet re-routing or zone exclusions extending into production shifts. This is a critical operational advantage over portland cement repairs requiring 24–72 hours and epoxy repairs requiring 4–24 hours.

6.5 Quality Control and Inspection

Post-repair quality control should be incorporated into the repair work procedure. The following inspections are recommended:

- **Visual inspection:** Immediately after cure, inspect for voids, bubbles, uncured material, or depressions in the repair surface. Any deficiency should be corrected before the area is returned to AGV traffic.
- **Tap test (sounding):** After full cure, tap the repair area with a metal rod or coin. A solid, resonant sound indicates a well-bonded repair. A hollow sound indicates a bond failure or void that requires further investigation and re-repair.
- **Pull-off adhesion test:** For repairs where specification-level documentation is required, ASTM D4541 pull-off adhesion testing provides a quantified bond strength value. Concrete Mender™ repairs are expected to produce cohesive failure in the concrete substrate — indicating that the bond strength exceeds the tensile strength of the surrounding concrete. This result is the maximum achievable on any adhesion test and demonstrates that the Microdoweling™ mechanism has fully engaged.
- **Dimensional check:** Verify that the repair surface is flush with the surrounding floor level, within ±1 mm. Low spots should be filled; high spots can be ground flush after cure. Restore the effective FF number in the repaired zone.

7. Performance Validation

7.1 ASTM Test Data

Roadware 10 Minute Concrete Mender™ has been subjected to formal ASTM testing and evaluation. Key performance data points available from the Roadware ASTM Testing and Evaluation Report (30-page document, available from Roadware Incorporated and listed on BuildSite) include:

- **Compressive Strength (ASTM D695): 3,883–6,681 psi (26.8–46.0 MPa)** depending on sand loading. This range encompasses the compressive strength of typical industrial floor concrete (4,000–5,000 psi), confirming modulus-compatible performance without the brittleness associated with very high strength materials.
- **Bond Strength / Pull-Off Adhesion (per ASTM D4541):** Bond strength exceeds the tensile strength of the concrete substrate. Failure occurs cohesively within the concrete matrix — not at the repair interface. This is the definitive quantitative demonstration of the Microdoweling™ mechanism's effectiveness.
- **Chemical Resistance:** Per the Roadware Chemical Resistance Chart — high resistance to hydraulic fluid, sulfuric acid (battery electrolyte), common industrial cleaning agents, oils, and fuels.

Engineers specifying Roadware Concrete Mender™ for AGV/AMR facility applications are encouraged to request the full ASTM Testing and Evaluation report from Roadware Incorporated for detailed test method protocols, specimen configurations, and results.

7.2 Field Performance Indicators

Beyond laboratory test data, field performance indicators provide evidence of the material's suitability for the demanding AGV/AMR environment:

- **Rapid return to service:** The 10-minute cure enables repair during shift changes or scheduled breaks, eliminating or minimizing operational disruption and eliminating the extended zone exclusions required by competing materials.
- **Durability under continuous heavy industrial traffic:** Repairs installed in high-traffic industrial floor environments remain in service without cracking, edge debonding, or surface abrasion — demonstrating the dynamic load resistance that distinguishes the pliable polymer matrix from brittle cementitious patches.
- **Freezer warehouse performance:** Successfully applied and retained in service in cold storage environments where competing cementitious and epoxy materials fail to achieve cure or fail in service due to thermal cycling.

- **Polished concrete floor compatibility:** The cured repair can be ground and polished to match the surrounding floor surface — an important capability in distribution centers and pharmaceutical facilities where polished concrete is specified for dust control and aesthetics.
- **Delamination rescue:** The Easy Injection System enables delaminated floor sections to be restored to full structural integrity without the extensive saw-cutting, removal, and replacement required by traditional delamination repair methods — a significant cost and schedule advantage in active facilities.

7.3 Comparative Analysis

The following table presents a structured comparison of the three principal repair material categories against key performance criteria specifically relevant to AGV/AMR facility applications:

Performance Criterion	Portland Cement Patch	Rigid Epoxy Repair	Roadware 10 Minute Concrete Mender™
Cure time to AGV/forklift traffic	24–72 hours	4–24 hours	**~10 minutes**
Modulus compatibility with concrete	Poor — high shrinkage during cure generates tensile stress at bond interface	Variable — often too rigid; rigid discontinuity causes stress concentration under thermal cycling	**Excellent — pliable polymer matrix deforms in concert with surrounding slab**
Penetration / Microdoweling™ mechanism	None — surface bond only; high viscosity prevents penetration	None — surface bond only; viscosity precludes capillary penetration	**Yes — deep capillary penetration creates 3D volumetric interlock**
Bond mechanism	Surface adhesion only	Surface adhesion only	**Volumetric mechanical interlock; cohesive failure in concrete substrate**
Cold temperature cure (including subzero)	Poor / fails at or near freezing — hydration requires liquid water	Limited — minimum temperature thresholds; typically fails below 5–10°C (40–50°F)	**Yes — cures including subzero applications; critical for**

Performance Criterion	Portland Cement Patch	Rigid Epoxy Repair	Roadware 10 Minute Concrete Mender™
			freezer facility use
Compressive strength	3,000–5,000 psi (20.7–34.5 MPa)	5,000–10,000+ psi (34.5–69+ MPa) — often excessively high for floor repair	**3,883–6,681 psi (26.8–46.0 MPa) — matched to host concrete**
Dynamic load / fatigue resistance	Poor — brittle; susceptible to fatigue crack propagation under cyclic AGV loading	Poor — rigid inclusion creates stress concentration; edge debonding under repeated loading	**High — polymer matrix absorbs and dissipates impact energy; excellent fatigue resistance**
Chemical resistance	Moderate — susceptible to acid attack, salt scaling	High — but may crack under dynamic loading	**High — resistant to hydraulic fluid, battery acid, common industrial chemicals**
Operational impact during repair	Major — 24–72 hour zone exclusion; traffic diversion required	Significant — 4–24 hour zone exclusion; temperature sensitivity may extend cure time	**Minimal — shift-break repair cycle; no extended zone exclusion required**
Applicability to freezer floors	Not applicable — will not cure	Very limited — minimum temperature thresholds, freeze-thaw debonding risk	**Fully applicable — engineered for subzero application and service**

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8. Implementation Guidance for AGV/AMR Facility Managers

8.1 Pre-Deployment Floor Assessment Protocol

A structured floor assessment protocol should be completed before AGV/AMR commissioning in any facility. The following five-step protocol is recommended:

Step	Activity	Method / Tool	Output
Step 1	Visual survey — map all cracks, spalls, and joint damage in robot travel paths	Walking survey with floor plan; photograph and GPS-reference all defects	Defect map overlaid on robot travel path plan
Step 2	Sounding survey — identify delaminated zones not visible at surface	Chain drag or electronic sounding equipment along all robot travel paths	Delamination extent map added to defect plan
Step 3	FF/FL measurement per ASTM E1155 along robot travel paths	Digital floor profilometer (dipstick) or 3D laser scanning along each robot travel lane	F-Number profile for each travel path; identification of zones below threshold
Step 4	Severity classification of all identified defects	Engineering review of defect map, sounding results, and FF/FL data	Defects categorized as: Critical (repair before commissioning) / High (repair within 30 days) / Moderate (schedule repair)
Step 5	Repair specification and scheduling	Prepare repair scope, material specification, and work plan	Repair schedule integrated with commissioning timeline

Severity Classification Criteria:

- **Critical (repair before commissioning):** Any step crack or joint step >3 mm in robot travel paths; any spall >25 mm diameter in travel paths; through-slab cracks with differential displacement; any delaminated zone >0.1 m^2 in travel paths; FF/FL measurement below minimum threshold in active travel lanes.
- **High (repair within 30 days of commissioning):** Cracks 1–3 mm width in travel paths; spalls <25 mm diameter; delaminated zones in secondary travel areas; joint edges with minor chipping but no step displacement.
- **Moderate (schedule repair within 90 days):** Hairline cracks (<1 mm) in travel paths; minor surface abrasion; defects in infrequently traveled zones.

8.2 Ongoing Maintenance Program

Proactive floor maintenance is a maintenance investment that protects the far larger capital investment in AGV/AMR equipment. An effective ongoing program consists of:

- **Inspection Frequency:** Monthly visual inspection of all robot travel paths. High-traffic zones — particularly joints traversed at high frequency — should be inspected more frequently, at intervals of two to four weeks.
- **Repair Trigger Criteria:** Schedule repair for any crack >1 mm width discovered in a wheel path; any spall >25 mm diameter; any joint edge chip >6 mm; any hollow-sounding zone identified by sounding in a travel path. Do not allow these conditions to persist until the next scheduled inspection cycle.
- **Predictive Maintenance Integration:** Correlate e-stop event logs (which most AGV fleet management systems record with location data) against the floor condition map. Zones showing elevated e-stop rates should be flagged for inspection even if no defect was identified at the previous scheduled inspection. E-stop clustering is often the first indicator of emerging floor deterioration below the current visual detection threshold.
- **Annual FF/FL Re-measurement:** Repeat ASTM E1155 measurement along primary robot travel paths annually. Compare to baseline commissioning measurements to track cumulative floor degradation and prioritize repair programs before operational thresholds are breached.

Best Practice — Predictive Maintenance Integration

Modern AGV fleet management systems record e-stop location, time, and trigger code for every unplanned stop. Export this data monthly and overlay it on your floor defect map. Zones where e-stop frequency is increasing between inspection cycles are experiencing floor deterioration faster than the visual inspection interval can detect. Investigate and repair these zones proactively — before the floor condition reaches a level that impacts production throughput or robot hardware.

8.3 Integration with AGV Commissioning

Floor repair activities must be properly sequenced relative to the AGV commissioning process to avoid creating additional rework:

25. **Complete all Critical and High priority repairs** before the AGV navigation infrastructure (magnetic tape, QR markers, reflector targets) is installed. Navigation infrastructure installed over damaged floor may need to be relocated after repair, creating rework and recalibration costs.
26. **Verify cure of all repairs** using the QC protocol in Section 6.5 before allowing the commissioning team access to the repaired zones for infrastructure installation.

27. **Conduct post-repair FF/FL verification** per ASTM E1155 in repaired zones before the AGV vendor conducts their floor acceptance survey. This allows any remaining deficiencies to be addressed before the vendor's commissioning clock starts.
28. **Generate the final AGV navigation map** only after all repairs are complete and cured. Navigation maps generated on a pre-repair floor may include reference features at locations or elevations that differ post-repair, requiring partial or full map regeneration.
29. **Document all repair locations** with floor plan coordinates, repair type, date, and installer for inclusion in the facility's floor maintenance record. This documentation informs future inspection prioritization and enables tracking of repair longevity.

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9. Conclusion

The engineering case presented in this white paper establishes a clear and quantified relationship between industrial concrete floor condition and the performance, reliability, and total cost of ownership of AGV/AMR robotic systems. Floor surface integrity — measured by FF/FL flatness and levelness, surface continuity, joint edge condition, and freedom from delamination and spalling — is a primary system-level parameter in any AGV/AMR deployment, not a secondary maintenance concern.

The cascade failure sequence from floor damage to e-stop events, navigation failures, accelerated drive component wear, and throughput loss represents a disproportionate economic impact relative to the cost of proactive repair. Facilities that treat floor repair as a capital maintenance investment rather than a reactive cost consistently achieve better robotic system uptime, lower component replacement costs, and faster payback on automation investments.

Within the available repair material landscape, Roadware 10 Minute Concrete Mender™ provides a set of engineering characteristics specifically suited to the demands of AGV/AMR operating environments:

- The **Microdoweling™ mechanism** — enabled by the near-water-thin viscosity of the uncured resin — creates a three-dimensional volumetric mechanical interlock with the surrounding concrete matrix that fundamentally outperforms surface-bond repair mechanisms. Bond strength exceeds the tensile strength of the host concrete, as confirmed by cohesive failure in adhesion testing per ASTM D4541.
- **Modulus-compatible polymer concrete formulation** — the pliable hybrid urethane polymer binder provides compressive strength in the range of 26.8–46.0 MPa (3,883–6,681 psi) while avoiding the modulus mismatch and rigid discontinuity that cause premature failure in epoxy and cementitious patches under dynamic AGV loading and thermal cycling.

- **Dynamic load resistance** — the polymer matrix absorbs and dissipates impact energy from AGV wheel traverse events rather than transmitting stress pulses to the repair boundary, providing fatigue resistance that brittle cementitious materials cannot match.
- **Rapid return-to-service** — approximately 10-minute cure at 70°F (21°C) enables repairs to be completed during shift changes without extended zone exclusions, minimizing operational disruption to running AGV fleets.
- **Subzero temperature performance** — cures and performs in freezer and cold storage environments where competing materials fail to achieve cure, enabling floor maintenance programs in the most demanding AGV operating environments.

The engineering and facility management community responsible for deploying and operating AGV/AMR systems is strongly encouraged to incorporate formal floor condition assessment and repair specification into every AGV/AMR deployment project and to establish structured ongoing floor maintenance programs as a standard element of AGV/AMR facility management. The investment in floor quality protection is modest relative to the automation investment it protects — and the return on that investment, measured in uptime, throughput, and component longevity, is demonstrably significant.

Call to Action

Facility managers and engineering teams preparing for AGV/AMR deployment or managing active robotic fleets should: (1) conduct a pre-commissioning floor assessment per the five-step protocol in Section 8.1; (2) specify Roadware 10 Minute Concrete Mender™ for all Critical and High priority repair work in robot travel paths; and (3) implement an ongoing monthly inspection and repair program integrated with AGV e-stop data analytics. Contact Roadware Incorporated at www.concretemender.com or 800-522-7623 for technical support, product documentation, and application assistance.

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10. References and Technical Resources

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