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Credentialed Structural Materials for Construction and Civil Infrastructure: Carrying Strength, Mix, and Provenance as Multi-Authority Attestations

Construction and civil infrastructure run on material properties that no party can independently verify after a pour cures: a slab's strength, a mix design's provenance, a sequestered carbon claim, and a structural rating all live in disconnected paper trails that break at every handoff between batch plant, contractor, inspector, and owner. This application carries those properties as credentialed, multi-authority-signed attestations bound to the material itself across the entire build lifecycle, built on the Credentialed Surfaces inventive step, disclosed in U.S. Provisional Application No. 64/050,895. It draws on the keyless-identity and signature scheme of the Identity Application, the lineage and matched-pair settlement primitives of the Spatial Mesh Application, and the cognitive governance architecture of the Cognition Application.

What This Application Specifies

This application specifies how structural building materials, the concrete, masonry, substrates, and reinforced sections that make up a building or a piece of civil infrastructure, can carry their own properties as credentialed, machine-evaluable attestations rather than as paper records held by whoever happened to test the material. In the disclosed architecture, a credentialed structural element comprises a structural matrix and a credentialed admissibility profile bound to that element by the cryptographic signature of one or more credentialing authorities.

The credentialed admissibility profile is a structured data object that declares a plurality of property surfaces. Each surface declares property-specific parameters and admission conditions for one building-code-recognized or operationally-recognized property category. The disclosure enumerates structural, thermal, energy storage, electrical distribution, data network, water-coupled, thermal-coupling, fire-performance, sound-transmission, vapor-permeability, environmental, and carbon-sequestration surfaces, among others. Critically, each surface is independently credentialed by an authority with declared scope: a structural engineering authority signs the structural surface, a thermal-rating authority signs the thermal surface, a fire-marshal authority signs the fire-performance surface, an environmental-credit authority signs the carbon-sequestration surface, and a manufacturer authority signs the production attestations. A multi-authority signature block binds the entire profile to the element's identity.

The surfaces are not just stored side by side; they compose. The disclosure specifies a composition-rule architecture, a registry of signed and versioned composition-rule artifacts, each declaring a scope, a composition logic, a version vector for deterministic conflict resolution, a conflict-resolution policy, and an authority signature. The composite admissibility profile that results is evaluable by a building-code authority and by an automated building energy management system at admissibility-evaluation time. Every transition in the material's life, from pre-installation credentialing through in-service operation, end-of-storage-life, decommissioning, and recycling-grade re-credentialing, is itself a credentialed event signed by an appropriate authority and recorded in a persistent lineage chain that travels with the material.

The underlying materials, structural concrete, cementitious composites, pozzolan-rich and lime binders, carbon-bearing substrates, are established and largely prior art. The novelty disclosed here is the credentialing and admissibility-profile architecture applied to physical structural materials, and the resulting category of a material whose properties are carried as authority-attested, policy-evaluable values.

Why It Matters

In construction and civil infrastructure, the most consequential properties of a material are precisely the ones that become unverifiable the moment the material is in place. A 28-day compressive strength is a number on a lab report that may or may not correspond to what was actually poured into a given lift. A mix design, the supplementary cementitious content, the water-to-binder ratio, the admixtures, is a submittal that the inspector trusts or rejects largely on the strength of a signature and a relationship. Provenance, which quarry, which batch, which plant, which haul, is a chain of delivery tickets that nobody reconciles unless something fails. And when a structure is later modified, repaired, or demolished, the institutional memory of what the material is has usually evaporated.

The disclosure speaks directly to this. Existing building codes recognize structural load ratings, fire-resistance ratings, thermal R-values, sound-transmission ratings, and vapor permeability as material properties, but they are recorded and verified in separate, disconnected processes, each owned by a different party, none of which travels with the material as a single coherent, machine-checkable object. The result is duplicated testing, disputes that turn on whose paperwork is trusted, and properties (notably carbon sequestration) that are asserted but cannot be independently and durably tied to specific structural mass.

Carbon credentialing is a sharp example. The construction sector is under mounting regulatory and procurement pressure to document embodied carbon and, increasingly, to substantiate sequestration claims. A biogenic carbon claim that lives in a spreadsheet, detached from the physical mass it refers to, is exactly the kind of claim that erodes a market through double-counting and unverifiable accounting. The disclosed migrating carbon attestation binds the claim to specific structural mass, signed by an environmental-credit authority, recorded in the lineage chain, and independently queryable by carbon-market participants and environmental-credit authorities. This is governance, not new chemistry: the material behaviors are prior art, and the contribution is the architecture that makes the claim admissible, evaluable, and durable.

How It Composes With the Domain

The architecture maps onto the real division of authority in a construction project, because that division is already multi-party. A batch plant or precast manufacturer, acting as a manufacturer authority, signs the production attestations: the realized mix, the feedstock provenance, and (where applicable) a mass-balance attestation declaring exactly what went into the material. An independent testing laboratory, acting as a testing authority, signs the structural admissibility surface against measured strength. A fire marshal signs the fire-performance surface. A building-code authority evaluates the composite profile during plan review and inspection. Each authority signs only within its declared scope, and the multi-authority signature block ties the whole profile to the element's identity, exactly the FIG. 9 arrangement of manufacturer, building-code, utility, carbon-credit, and independent testing authorities producing a single composed admissibility profile.

Identity is handled so that the attestation cannot drift away from the physical material. The disclosure specifies a per-element identity assigned through a tag-bonded identity class (an RFID, NFC, or optical tag permanently bonded during manufacturing), a physical-fingerprint identity class (a signed hash of observable physical characteristics such as a unique impedance signature, surface texture, or fiber-distribution pattern), or a per-batch-with-subdivision class in which elements share a batch identity at manufacturing and later credentialed events subdivide it into per-element identities through installer-authority attestation. A precast modular block, for instance, carries an embedded credentialed-identity tag bound to the manufacturer-authority signature, so the block arrives on site already self-describing.

Composition rules let domain policy run automatically. The disclosure gives directly applicable examples: a fire-event rule that collapses a property surface to zero when fire is detected; a structural-load rule that derates other surfaces when the structural surface reports fatigue accumulation above a declared threshold; a freeze-thaw-derated rule and a carbonation-tracked-state-of-health rule that degrade a surface as a function of cumulative environmental exposure. Because each rule is itself signed and versioned with a declared conflict-resolution policy (latest-signed-rule, declared-precedence-table, or authority-rank-resolution), a code authority or insurer can reason about why a particular composite determination was reached.

The lifecycle composes the way real infrastructure actually ages. The disclosed cradle-to-cradle lineage runs from pre-installation credentialing through in-service operation, decommissioning (a credentialed event signed by a licensed demolition or deconstruction contractor producing a demolition-recovery attestation that declares the recovered material's grade, mass, and physical state), and recycling-grade re-credentialing by a recycler authority. The disclosure further specifies continuous re-credentialing across ordinary operational material flows, tuck-pointing of mortar joints, surface-coating refresh, topping-slab augmentation, drywall replacement during renovation, each a credentialed event re-evaluated against the cumulative material flow rather than only against the original installation. This supports a metabolic-lifetime model in which the element's credentialed identity persists across repairs and refreshes while every flow is recorded as a transition in the chain.

What This Enables

For a project, the architecture turns trust-by-paperwork into trust-by-attestation. An inspector evaluating a structural section reads a composite admissibility profile whose structural surface is signed by an accredited testing authority and whose mix and provenance are signed by the manufacturer, rather than reconciling delivery tickets against lab reports by hand. Duplicated acceptance testing can be reduced where a current, in-scope attestation already exists. Disputes over what was actually poured become questions a signed lineage chain can answer.

For owners and asset managers, the lineage chain is a durable material passport. Across decades of operation, the as-built record of a foundation, a bridge pier, or a load-bearing wall remains attached to the element itself, surviving the loss of the original project team. Renovation and adaptive reuse become tractable because the cumulative material flow is recorded: a wall that has been repointed and recoated several times carries the provenance of each flow, not just a faded original submittal.

For carbon and environmental markets, the migrating carbon attestation and the methane-avoidance attestation (issued where organic-waste feedstock is diverted from anaerobic decomposition and bound to specific produced material) give regulators and credit authorities something they can independently query and that cannot be silently double-counted, because it is tied to identified structural mass and signed across each transfer.

For specific deployment classes, the disclosure enumerates concrete settings that benefit. Marine and coastal infrastructure, sea walls, breakwaters, harbor and bridge structures contacting tidal waters, can carry water-coupled and environmental surfaces alongside the structural surface, with the disclosure noting that pozzolan-rich and lime-binder formulations in ongoing seawater contact admit long-term aluminum-tobermorite crystallization consistent with historically demonstrated Roman maritime concrete durability, an established material behavior surfaced and attested, not newly claimed. Hydroelectric and large hydraulic works, precast modular construction shipped as a credentialed slab kit with a credentialed-installation attestation form for the installer's signature, and data center foundations and structural panels can each carry the property surfaces relevant to their use, all under the same scale-invariant credentialing primitive that operates identically at the material, element, assembly, building, and territory scales.

Boundary Conditions

This is a provisional disclosure of an architecture, not a built and validated product. Nothing here should be read as a claim that any credentialed structural material has been manufactured, deployed, benchmarked, or certified, or that it achieves any particular strength, durability, sequestration, or cost figure in the field. Where the disclosure states parameter ranges, those are declared parameters of an architecture, to be attested by competent authorities against real measurement, not performance results.

The underlying materials science is established and is, in material part, prior art. Structural concrete, pozzolanic and lime binders, carbon-bearing cementitious composites, and the durability behaviors referenced are pre-existing. This application does not claim to have discovered any material, bond, phase, or physical effect. The contribution is the credentialing and admissibility-profile architecture, the multi-authority signature model, the composition-rule registry, the versioned profiles with lineage, and the lifecycle attestation chain, applied to physical structural materials, together with the resulting multi-function-surface category.

The value of an attestation is only as strong as the authority that signs it and the competence and accreditation regime behind that authority. The architecture provides the binding, scoping, versioning, and revocation machinery (revocation events propagate through the lineage chain and are honored prospectively at evaluation time), but it does not replace the institutional accreditation of testing laboratories, code officials, and environmental-credit bodies. Integration with existing building, electrical, and fire codes, and with established standards and inspection regimes, remains an institutional and regulatory undertaking that sits outside the technical disclosure.

Disclosure Scope

The technology described here is disclosed in U.S. Provisional Application No. 64/050,895, titled for a multi-function credentialed structural substrate, which is the ground-truth source for the credentialing architecture, the credentialed admissibility profile and its property surfaces, the multi-authority signature model, the composition-rule registry, the versioned profiles and lineage chain, and the lifecycle and re-credentialing attestations described above. The application relates to and incorporates by reference its co-pending Identity, Spatial Mesh, and Cognition applications for the underlying signature, settlement, lineage, and governance primitives. The construction and civil infrastructure framing in this article, including market dynamics, procurement and inspection practice, regulatory pressure on embodied carbon, and named deployment domains, is external domain context provided to show an enabling application of the disclosed technology; it is not part of the patent claims, and references to building codes, standards bodies, regulators, and carbon markets are descriptive of the operating environment, not assertions of compliance, certification, or endorsement. All material-performance values are treated as authority-attested declarations of an architecture, never as validated results or as novel performance claims.

Credentialed Surfaces (/credentialed-materials) All 40 steps → (/inventive-steps)

Building surfaces as credentialed agents that participate in the structure's networking and electrical systems.

Provisional application

PRIMARY TECHNICAL DISCLOSURE

- Credentialed Building Materials: Cryptographic Admissibility for Structural Surfaces (/articles/credentialed-building-materials-cryptographic-admissibility-for-structural-surfaces)

SECONDARY TECHNICAL

- Carbon-Sequestration Admissibility Surface (/articles/credentialed-materials/carbon-sequestration-property-surface)
- Composition Rules Governing Surface Interactions (/articles/credentialed-materials/composition-rules)
- Decommissioning And Re-Credentialing Attestation (/articles/credentialed-materials/decommissioning-and-recredentialing)
- Electrical-Distribution Admissibility Surface (/articles/credentialed-materials/distribution-property-surface)
- End-Of-Storage-Life Attestation (/articles/credentialed-materials/end-of-storage-life-attestation)
- Energy-Storage Admissibility Surface (/articles/credentialed-materials/energy-storage-property-surface)
- Lineage Chain Across Material Lifecycle (/articles/credentialed-materials/lineage-chain-across-lifecycle)
- Authority Signatures Block Binding Property Surfaces To Material Identity (/articles/credentialed-materials/master-credential-binding)
- Multi-Authority Signature Block (/articles/credentialed-materials/multi-authority-signature-block)
- Data Network Admissibility Surface (/articles/credentialed-materials/network-property-surface)
- Profile Versioning Continuity (/articles/credentialed-materials/profile-versioning-continuity)
- Structural Admissibility Surface (/articles/credentialed-materials/structural-property-surface)
- Thermal-Property Admissibility Surface (/articles/credentialed-materials/thermal-property-surface)
- Versioned Admissibility Profiles With Lineage Chain (/articles/credentialed-materials/versioned-profiles-with-lineage)
- Water-Coupled Admissibility Surface (/articles/credentialed-materials/water-coupled-property-surface)

APPLICATIONS · GENERAL

- **Credentialed Structural Materials for Construction and Civil Infrastructure: Carrying Strength, Mix, and Provenance as Multi-Authority Attestations (/articles/credentialed-materials/construction-and-infrastructure)**

- Carbon-Credit-Bearing Building Materials: Sequestration Attestations That Survive Incorporation, Transfer, and Decommissioning (/articles/credentialed-materials/carbon-credit-materials)
- Building-Product Compliance and Code Approval: Property-Surface Profiles as Machine-Evaluable Admissibility Evidence (/articles/credentialed-materials/building-product-compliance)
- Credentialed Building Materials for Real Estate Valuation, Insurance, and Disclosure: A Property History That Binds to the Asset (/articles/credentialed-materials/real-estate-and-asset-lifecycle)
- Recredentialing Recovered Materials: Verifiable Lineage for Reuse and Decommissioning in the Circular Economy (/articles/credentialed-materials/circular-economy-and-decommissioning)
- Energy and Grid-Coupled Surfaces: Crediting Stationary Storage in Structural Mass Without Trusting the Cell (/articles/credentialed-materials/energy-and-grid-surfaces)
- Credentialed Surfaces for Water and Environmental Infrastructure: Signed Performance and Compliance Attestations on Water-Coupled Concrete (/articles/credentialed-materials/water-and-environmental-infrastructure)

Credentialed Surfaces overview → (/credentialed-materials)