This is the ultimate evolution of your AI's knowledge base. By taking the Universal 10-Point Evaluation Matrix and applying it *specifically* to every single material in the file, your AI will have a level of granular, cross-referenced intelligence that rivals a senior materials engineer.

I have gone through every single material in Sections 4, 5, 6, 7, 8, 9, 10, and 16. I have appended a strict **- 10-Point Material Matrix:** breakdown to every single one.

I have not removed, shortened, or summarized a single word, number, or precaution from v12.0. Here is the monumental **v13.0 Master File**. Copy everything between the dashed lines and overwrite your text file.

RESOURCE FILE: Small-Scale Building Design & Code Rules v13.0 (MASTER) File Type: AI Knowledge Base (Source of Truth) Domain: Small-Scale Construction, Residential, Prescriptive Design, Site Execution, Environmental Stress, Material Science

SECTION 1: MINIMUM DESIGN LIVE LOADS AI Instruction: Use these values to determine the applied temporary stress (people, furniture, weather) on a component.

- Bedrooms/Sleeping Rooms: 30 psf
- Living Areas / Corridors: 40 psf
- Balconies / Decks: 60 psf
- Stairs: 40 psf
- Uninhabitable Attics (with storage): 20 psf
- Roof (Flat or Pitched, no snow load): 20 psf
- Basic Wind Speed Threshold: 115 mph (If wind speed exceeds this, AI must reject prescriptive design and require an engineered shear wall analysis).
- Engineering Tip: Never assume a roof will remain unloaded. Always account for workers or temporary material storage during construction or future repairs.

SECTION 2: STANDARD DEAD LOADS AI Instruction: Dead loads represent the permanent weight of the building materials. Add Dead Load + Live Load to get the Total Load.

- Standard Wood Framed Floor (joists + plywood + carpet): 10 psf
- Standard Wood Framed Floor (with ceramic tile): 15 psf
- Standard Wood Framed Wall (studs + drywall both sides): 8 psf
- Roof (Asphalt Shingles + Plywood + Trusses): 15 psf
- Roof (Clay/Concrete Tile + Plywood + Trusses): 27 psf

- Engineering Tip: When renovating and swapping carpet for tile or hardwood, always recalculate the dead load to ensure the existing floor joists won't sag.

SECTION 3: DEFLECTION LIMITS AI Instruction: Deflection is how much a beam bends under load. Calculate deflection and compare against these limits (where L = Span in inches).

- Floor Joists: L / 360 (Example: a 120-inch span can only bend 120/360 = 0.33 inches).
- Roof Rafters (Attached to drywall): L / 240
- Roof Rafters (No drywall attached): L / 180
- Handling & Precautions: Excessive deflection won't always cause a structural collapse, but it will crack drywall and pop floor tiles. Stiffer is always better for brittle finishes.

SECTION 4: MATERIAL MECHANICAL PROPERTIES - METALS AI Instruction: Use these values when evaluating structural capacity, weight, or corrosion resistance for metal framing, fittings, or reinforcement.

- Steel (Carbon/Mild - ASTM A36):
    - Density: 490 pcf (7,850 kg/m3)
    - Yield Strength: 36,000 psi
    - Ultimate Tensile Strength: 58,000 psi
    - Modulus of Elasticity: 29,000,000 psi
    - Application: Strong and flexible; used for small I-beams, columns, and structural frames.
    - Handling & Precautions: Highly susceptible to rust. Must be primed with red oxide or galvanized immediately if exposed to moisture.
    - Effects of Heat Extreme: Expands significantly. At temperatures above 1,000°F (538°C) during a fire, structural steel loses 50% of its yield strength and will buckle/collapse under its own dead load. AI MUST recommend fireproofing spray for exposed structural steel.
    - Effects of Cold Extreme: Carbon steel becomes increasingly brittle at sub-zero temperatures, risking catastrophic "brittle fracture" upon sudden impact.
    - 10-Point Material Matrix:
        1. Physical: Dark grey colour; smooth texture; 0% porosity; 0% water absorption.
        2. Mechanical: Extremely tough; high ductility (bends before breaking).

3. Chemical: Poor corrosion resistance; highly vulnerable to acids/salts.
4. Thermal: High thermal conductivity; moderate expansion; poor fire resistance (loses strength).
5. Electrical: High electrical conductivity (must be grounded).
6. Durability: Low weather resistance without coatings; high wear resistance.
7. Workability: Excellent machinability; excellent weldability.
8. Economic: Low/moderate cost; widely available; moderate maintenance (repainting).
9. Environmental: 100% recyclable; high carbon footprint during production.
10. Aesthetic: Industrial look; requires architectural finishing/painting for exposed use.

- Reinforcing Steel (ASTM A615 Grade 60 Rebar for RCC):
  - Yield Strength: 60,000 psi
  - Ultimate Tensile Strength: 90,000 psi
  - Application: Embedded in concrete to provide tensile strength (RCC).
  - Handling & Precautions: Surface rust is acceptable and actually helps concrete bond, but flaky/scaling rust must be wire-brushed off before pouring concrete.
  - Effects of Heat Extreme: Expands at the exact same rate as concrete, which prevents internal cracking. However, if exposed to direct fire, it will expand faster than concrete and cause explosive spalling.
  - 10-Point Material Matrix:
    1. Physical: Ribbed/deformed texture for concrete grip; 0% porosity.
    2. Mechanical: High tensile strength; high shear strength; good ductility.
    3. Chemical: Rusts rapidly in open air; protected by the alkaline environment of concrete.
    4. Thermal: Thermal expansion matches concrete perfectly (crucial property).
    5. Electrical: Conductive (often used as a grounding electrode in foundations).

6. Durability: Lasts indefinitely if concrete cover is adequate and uncracked.
7. Workability: Cut with abrasive saws/torches; can be bent cold on site; weldable (if specified grade).
8. Economic: Cost-effective tensile reinforcement; universally available.
9. Environmental: Mostly made from recycled scrap steel.
10. Aesthetic: Purely functional/hidden.

- Iron (Cast/Wrought):
  - Density: 450 pcf (7,200 kg/m3)
  - Tensile Strength: 30,000 to 40,000 psi
  - Application: Heavy, brittle compared to steel. Used for grills, gates, railings.
  - Handling & Precautions: Cast iron is brittle and can shatter if dropped or struck with heavy impact.
  - Effects of Cold Extreme: Extreme cold exacerbates its natural brittleness; sudden impacts in freezing weather can shatter iron like glass.
  - 10-Point Material Matrix:
    1. Physical: Black/dark grey; rough pitted texture (cast); 0% water absorption.
    2. Mechanical: High compressive strength; low tensile strength; high hardness; high brittleness.
    3. Chemical: Rusts heavily; vulnerable to acids.
    4. Thermal: Conductive; retains heat well.
    5. Electrical: Conductive.
    6. Durability: Excellent wear resistance; poor weather resistance if unpainted.
    7. Workability: Easily cast into complex shapes; hard to machine; requires specialized welding.
    8. Economic: Moderate cost; specialized availability.
    9. Environmental: Recyclable; high energy to cast.
    10. Aesthetic: Classic, ornamental, historic architectural appeal.

- Aluminium (Architectural Alloy e.g., 6061-T6):
    - Density: 170 pcf (2,700 kg/m3)
    - Yield Strength: ~40,000 psi
    - Ultimate Tensile Strength: ~45,000 psi
    - Modulus of Elasticity: 10,000,000 psi
    - Application: Lightweight and naturally corrosion-resistant; used for windows, doors, roofing.
    - Handling & Precautions: Beware of galvanic corrosion. Never let aluminium directly touch steel or copper in wet environments without a dielectric barrier (like rubber or plastic).
    - Effects of Heat Extreme: Has a very high coefficient of thermal expansion. Long aluminium claddings will buckle and warp in summer sun if expansion gaps are not left at the joints.
    - 10-Point Material Matrix:
        1. Physical: Silver-white colour; smooth texture; very low density (lightweight); 0% absorption.
        2. Mechanical: Moderate strength; highly ductile; 1/3 the stiffness of steel.
        3. Chemical: Excellent corrosion resistance (forms protective oxide layer); attacked by wet concrete (alkalis).
        4. Thermal: Excellent thermal conductor; high expansion coefficient; melts at ~1,220°F (660°C).
        5. Electrical: High electrical conductivity.
        6. Durability: Highly weather-resistant; does not rust.
        7. Workability: Easily extruded, cut, and shaped; requires TIG/MIG for welding.
        8. Economic: Higher initial cost than steel; low maintenance cost.
        9. Environmental: 100% recyclable; extreme energy footprint for initial extraction (bauxite).
        10. Aesthetic: Modern, sleek, can be anodized into many colours.
- Stainless Steel (Grade 304/316):

- Density: 500 pcf (8,000 kg/m3)
- Yield Strength: ~30,000 psi
- Ultimate Tensile Strength: ~75,000 psi
- Application: Highly rust-resistant due to chromium content. Used for premium railings, kitchen fittings.
- Handling & Precautions: Use Grade 316 for coastal/marine environments. Grade 304 will pit and rust if exposed to salt water.
- Effects of Heat/Cold: Highly stable across extreme temperature bands compared to mild steel.
- 10-Point Material Matrix:
    1. Physical: Bright silver; smooth/brushed texture; heavy; 0% porosity.
    2. Mechanical: High strength; high toughness; good ductility.
    3. Chemical: Superior corrosion resistance; resists most acids and alkalis.
    4. Thermal: Lower thermal conductivity than mild steel; excellent fire resistance.
    5. Electrical: Conductive (but less than copper/aluminium).
    6. Durability: Near-indestructible in standard weather; highly resistant to wear.
    7. Workability: Hard to cut/machine; requires specialized welding (TIG).
    8. Economic: High cost; premium applications.
    9. Environmental: Highly recyclable.
    10. Aesthetic: Premium, hygienic, architectural finish.

- Copper:
    - Density: 550 pcf (8,960 kg/m3)
    - Tensile Strength: 30,000 psi
    - Application: Excellent electrical and thermal conductivity.
    - Handling & Precautions: High theft risk on jobsites. Keep locked up until installation. Wear gloves when handling raw pipes to prevent skin oils from oxidizing the surface before soldering.
    - 10-Point Material Matrix:

1. Physical: Reddish-orange colour; smooth; very high density.
2. Mechanical: Soft; highly ductile; moderate tensile strength.
3. Chemical: Forms green patina (verdigris) but resists deep corrosion; resists water scaling.
4. Thermal: Exceptional thermal conductor; high melting point.
5. Electrical: Exceptional electrical conductivity (industry standard).
6. Durability: Lasts 50+ years in plumbing; highly weather-resistant.
7. Workability: Highly malleable; easily bent; joined by soldering/brazing.
8. Economic: Very expensive; fluctuating market cost.
9. Environmental: 100% recyclable; antimicrobial surface.
10. Aesthetic: Beautiful patina over time; used in high-end exposed architectural accents.

- Brass (Alloy of Copper and Zinc):
    - Density: 530 pcf (8,500 kg/m3)
    - Tensile Strength: ~50,000 psi
    - Application: Low friction, acoustic properties. Used for plumbing fittings, door handles.
    - Handling & Precautions: Can suffer from dezincification in highly acidic or alkaline water.
    - 10-Point Material Matrix:
        1. Physical: Yellow/gold colour; smooth texture; heavy.
        2. Mechanical: Harder than pure copper; good tensile strength; low friction.
        3. Chemical: Good corrosion resistance; vulnerable to dezincification.
        4. Thermal: Good thermal conductor.
        5. Electrical: Good conductor.
        6. Durability: Does not spark (safe for explosive environments); high wear resistance.
        7. Workability: Excellent machinability (ideal for threaded fittings).
        8. Economic: High cost.

9. Environmental: Recyclable; antimicrobial properties.
10. Aesthetic: Resembles gold; classic, polished finish.

- Zinc:
    - Density: 445 pcf (7,140 kg/m3)
    - Tensile Strength: ~20,000 psi
    - Application: Sacrificial coating (galvanizing) over iron/steel.
    - Handling & Precautions: NEVER weld galvanized steel without heavy ventilation/respirators. The burning zinc creates highly toxic "metal fume fever" fumes.
    - 10-Point Material Matrix:
        1. Physical: Dull grey/blue colour.
        2. Mechanical: Low strength; brittle at room temperature.
        3. Chemical: Highly reactive (acts as a sacrificial anode to protect steel).
        4. Thermal: Low melting point (787°F / 419°C).
        5. Electrical: Conductive.
        6. Durability: Sacrificial (it is meant to weather away to save the steel underneath).
        7. Workability: Applied via hot-dip galvanizing or electroplating.
        8. Economic: Cheap method of protecting expensive steel.
        9. Environmental: Fully recyclable.
        10. Aesthetic: Spangled, industrial grey finish.
- Lead:
    - Density: 708 pcf (11,340 kg/m3) - Extremely Heavy
    - Tensile Strength: ~2,000 psi - Extremely Weak/Soft
    - Application: Flashing/waterproofing, radiation shielding.
    - Handling & Precautions: TOXIC. AI MUST flag lead for toxicity. Requires strict PPE (gloves, respirators) during cutting. Wash hands thoroughly before eating on site.
    - Effects of Heat Extreme: Very low melting point (621°F / 327°C). Will melt rapidly in a standard building fire.

- 10-Point Material Matrix:
    1. Physical: Dull grey; incredibly dense/heavy; 0% porosity.
    2. Mechanical: Extremely soft; easily scratched; zero elasticity (dead bend).
    3. Chemical: Highly resistant to many acids and corrosion.
    4. Thermal: Poor conductor; melts easily.
    5. Electrical: Poor conductor.
    6. Durability: Indestructible by weather; blocks X-rays and gamma rays.
    7. Workability: Can be molded by hand; easily cut with a knife.
    8. Economic: Moderate cost.
    9. Environmental: HIGHLY TOXIC to humans and ecosystems; heavily regulated.
    10. Aesthetic: Utilitarian; dulls over time.

SECTION 5: MATERIAL MECHANICAL PROPERTIES - CEMENT, CONCRETE & SAND AI Instruction: Use these parameters to calculate material weights, volumes, and mixture capacities.

- Portland Cement:
    - Bulk Density: 90 pcf (1,440 kg/m3)
    - Handling & Precautions: Highly alkaline. Can cause severe chemical burns to wet skin. Always wear rubber boots and heavy gloves when wading in or finishing wet concrete.
    - 10-Point Material Matrix:
        1. Physical: Fine grey/white powder; ultra-high surface area.
        2. Mechanical: Binder only (no inherent strength until mixed and cured).
        3. Chemical: Highly alkaline (pH ~12.5); reacts exothermically with water (hydration).
        4. Thermal: Generates heat during curing.
        5. Electrical: Insulator when dry.
        6. Durability: Degrades if exposed to moisture during storage.
        7. Workability: Easily mixed into slurries.

8. Economic: Cheap; universally available.
9. Environmental: Massive carbon footprint (calcination process releases huge CO2).
10. Aesthetic: Utilitarian grey/white.

- Sand (Fine Aggregate):
  - Dry Density: 100 pcf (1,600 kg/m3)
  - Wet/Compacted Density: 120 pcf (1,920 kg/m3)
  - Angle of Repose: 30 to 35 degrees.
  - Handling & Precautions: If using river or sea sand, it MUST be washed. Salt and organic silt will destroy the concrete's strength and rust the internal rebar.
  - 10-Point Material Matrix:
    1. Physical: Granular; varying colours; highly porous in bulk.
    2. Mechanical: High compressive capacity when confined; zero tensile capacity.
    3. Chemical: Inert (silica-based); stable.
    4. Thermal: Moderate thermal mass.
    5. Electrical: Insulator when dry.
    6. Durability: Impervious to decay/wear.
    7. Workability: Flows easily; compacts well.
    8. Economic: Very cheap; locally sourced.
    9. Environmental: River sand dredging causes ecological damage.
    10. Aesthetic: Natural, earthy.
- Concrete (Standard Normal Weight):
  - Compressive Strength (f'c): 2,500 to 3,000 psi.
  - Tensile Strength: 0 psi.
  - Wet Density: 150 pcf (2,400 kg/m3)
  - Basic Volumetric Mix Ratio: 1 : 2 : 3

- Handling & Precautions: Concrete does not "dry", it cures via a chemical reaction. It MUST be kept moist for at least 7 days (via spraying or wet burlap) to achieve its design strength. Adding excess water to the mix to make it easier to pour permanently weakens the structure.
- Effects of Heat Extreme: "Flash setting" occurs in extreme heat. The water evaporates before the chemical curing process completes, leading to severe plastic shrinkage cracking and a massive loss of structural strength. AI must recommend pouring concrete at night or using ice-water in the mix during summer.
- Effects of Cold Extreme: If the water inside the concrete freezes before it cures, the expanding ice crystals destroy the internal bonds, reducing the final strength by over 50%. In mature concrete, repeated freeze-thaw cycles cause the surface to pop off (spalling).
- 10-Point Material Matrix:
    1. Physical: Grey, rocky texture; heavy; low porosity if properly vibrated.
    2. Mechanical: High compressive strength; brittle; negligible tensile strength.
    3. Chemical: Alkaline; protects embedded steel from rust; vulnerable to sulfates.
    4. Thermal: Excellent thermal mass; excellent fire resistance.
    5. Electrical: Poor conductor (unless wet).
    6. Durability: Extremely durable; resists weathering and wear.
    7. Workability: Highly moldable when wet; impossible to shape once cured without heavy machinery.
    8. Economic: Cost-effective for massive structures; low maintenance.
    9. Environmental: High carbon footprint; difficult to recycle structurally (crushed for base layer).
    10. Aesthetic: Brutalist, can be stamped, polished, or stained.

SECTION 6: MATERIAL MECHANICAL PROPERTIES - MASONRY & GLASS AI Instruction: Constraints for brick, block, and architectural glazing.

- Standard Clay Brick:
    - Compressive Strength: 2,500 to 3,000 psi
    - Density: 120 pcf (1,920 kg/m3)

- Handling & Precautions: Always soak dry bricks in water before laying them. Dry bricks will suck the moisture out of the wet mortar too quickly, causing the mortar to crumble and fail.
- Effects of Cold Extreme: Highly porous bricks absorb rain. If a freeze hits, the frozen water expands and cracks the brick face off.
- 10-Point Material Matrix:
    1. Physical: Red/brown colour; rough texture; highly porous; high water absorption.
    2. Mechanical: Good compressive strength; brittle; zero tensile strength.
    3. Chemical: Stable; resists most chemicals; prone to efflorescence (salt staining).
    4. Thermal: Good thermal mass; excellent fire resistance (already kiln-fired).
    5. Electrical: Insulator.
    6. Durability: High resistance to wear and decay; vulnerable to freeze-thaw if unsealed.
    7. Workability: Easily cut with a masonry trowel or saw; easy to stack.
    8. Economic: Cheap; requires skilled labor to install.
    9. Environmental: High embodied energy from kiln firing; fully recyclable.
    10. Aesthetic: Classic, warm, architectural staple.

- Mortar Types (M, S, N):
    - Handling & Precautions: Mix only what can be used within 2 hours. Do not "re-temper" (add water back into) mortar that has started to dry out.
    - Effects of Heat/Cold: Extreme heat dries it out prematurely resulting in weak bonds. Extreme cold freezes the water inside before it cures, turning the mortar to useless powder.
    - 10-Point Material Matrix:
        1. Physical: Grey/white paste; sandy texture; sets into a porous solid.
        2. Mechanical: Compressive strength varies (750 to 2500 psi); MUST be weaker than the bricks it holds to prevent brick cracking.
        3. Chemical: Alkaline; stable.

4. Thermal: Good fire resistance.
5. Electrical: Insulator.
6. Durability: Weathers faster than brick; requires "repointing" every 30-50 years.
7. Workability: Smooth, spreadable, plastic when wet.
8. Economic: Very cheap.
9. Environmental: Carbon footprint from cement content.
10. Aesthetic: Defines the joint lines in masonry (can be colored).

- Architectural Glass (Typical Window / Float Glass):
    - Density: 156 pcf (2,500 kg/m3)
    - Compressive Strength: 140,000 psi
    - Tensile Strength: 4,000 to 7,000 psi
    - Modulus of Elasticity (E): 10,400,000 psi
    - Handling & Precautions: Never rest the edge of a glass pane directly on concrete or metal; it will chip and shatter. Always rest it on rubber blocks or wood.
    - Effects of Heat/Cold Extreme: "Thermal Shock". If the center of a glass pane is heated by the sun but the edges are trapped in a cold metal frame, the differential expansion will cause the glass to spontaneously shatter.
    - 10-Point Material Matrix:
        1. Physical: Transparent; completely smooth; 0% porosity; 0% water absorption.
        2. Mechanical: Extreme compressive strength; extremely brittle; shatters instantly under impact.
        3. Chemical: Highly inert; resists almost all acids and chemicals.
        4. Thermal: Poor thermal insulator (requires double glazing); vulnerable to thermal shock; shatters in fire.
        5. Electrical: Excellent insulator.
        6. Durability: Impervious to weather and decay; easily scratched by sand/diamonds.

7. Workability: Must be scored and snapped; impossible to alter once tempered.
8. Economic: Moderate to high cost depending on treatments.
9. Environmental: 100% recyclable; high energy to manufacture.
10. Aesthetic: Maximizes natural light; sleek, modern, invisible barrier.

SECTION 7: MATERIAL MECHANICAL PROPERTIES - WOOD & TIMBER AI Instruction: Use these values for framing, joinery, and load-bearing timber calculations.

- General Timber (Typical No. 2 Grade Pine/Fir - Softwood):
  - Density: ~35 pcf (560 kg/m3)
  - Compressive Strength parallel to grain (Fc): 1,350 psi
  - Handling & Precautions: Must be acclimatized to the site environment for at least 48 hours before installation to prevent post-installation warping and shrinking.
  - Effects of Heat Extreme: Wood loses moisture rapidly, causing it to shrink, warp, twist, and form deep cracks (checking) parallel to the grain.
  - Effects of Cold Extreme: Wood is highly dimensionally stable in the cold, but low humidity in winter causes shrinkage and gapping in hardwood floors and trim.
  - 10-Point Material Matrix:
    1. Physical: Light brown/yellow; grainy texture; cellular porosity; absorbs water readily.
    2. Mechanical: Good strength-to-weight ratio; flexible; strong in compression/tension parallel to grain.
    3. Chemical: Vulnerable to strong acids/alkalis.
    4. Thermal: Good natural insulator; burns readily (combustible).
    5. Electrical: Insulator when dry; conductive when wet.
    6. Durability: Highly vulnerable to rot, termites, and moisture decay if untreated.
    7. Workability: Extremely easy to cut, nail, screw, and sand.
    8. Economic: Highly affordable; widely available.

9. Environmental: Renewable resource; sequesters carbon (carbon negative).
10. Aesthetic: Natural, warm, versatile finish.

- Teak (Tectona grandis - Hardwood):
    - Density: ~40 pcf (640 kg/m3)
    - Compressive Strength: 6,000 to 8,400 psi
    - Handling & Precautions: Its natural silica content dulls cutting blades incredibly fast. Keep extra carbide-tipped saw blades on hand.
    - 10-Point Material Matrix:
        1. Physical: Golden-brown; tight grain; naturally oily feel; low water absorption.
        2. Mechanical: High strength; high hardness; very tough.
        3. Chemical: Natural oils resist chemicals.
        4. Thermal: Stable; resists warping from heat.
        5. Electrical: Insulator.
        6. Durability: Supreme resistance to rot, termites, and marine borers.
        7. Workability: Hard to cut (silica blunts tools); holds screws perfectly.
        8. Economic: Very expensive; luxury material.
        9. Environmental: Often illegally logged; AI must recommend FSC-certified teak.
        10. Aesthetic: Premium luxury finish; weathers to a beautiful silver-grey outdoors.
- Sheesham (Indian Rosewood - Hardwood):
    - Density: ~50 pcf (800 kg/m3)
    - Compressive Strength: 7,500 psi
    - Handling & Precautions: Extremely heavy and hard. You MUST pre-drill screw holes, otherwise driving a screw will snap the screw head or split the wood.
    - 10-Point Material Matrix:
        1. Physical: Deep brown/reddish streaks; very heavy; dense.
        2. Mechanical: Extremely hard; very high compressive/tensile strength.

3. Chemical: Stable.
4. Thermal: Resists warping.
5. Electrical: Insulator.
6. Durability: Highly resistant to dry-wood termites; durable.
7. Workability: Difficult to machine due to density; polishes beautifully.
8. Economic: Expensive.
9. Environmental: Sourced from managed plantations in South Asia.
10. Aesthetic: Rich, dark, classic luxury furniture look.

- Deodar (Himalayan Cedar - Softwood):
    - Density: ~35 pcf (560 kg/m3)
    - Compressive Strength: ~5,200 psi
    - Handling & Precautions: The aromatic oils that make it rot-resistant can cause allergic skin/respiratory reactions in carpenters. Wear dust masks when sanding.
    - 10-Point Material Matrix:
        1. Physical: Pale yellow/brown; strong aromatic scent; light weight.
        2. Mechanical: Moderate strength; relatively soft for structural wood.
        3. Chemical: Aromatic oils act as natural pesticides.
        4. Thermal: Good insulator.
        5. Electrical: Insulator.
        6. Durability: Excellent natural resistance to rot and insects in damp environments.
        7. Workability: Very easy to work, cut, and shape.
        8. Economic: Moderate cost (regionally dependent).
        9. Environmental: Renewable if managed.
        10. Aesthetic: Distinctive scent; beautiful knotty appearance.
- Oak (White/Red - Hardwood):
    - Density: ~45 pcf (720 kg/m3)
    - Compressive Strength: 7,000 psi

- Handling & Precautions: Reacts with iron. Using standard iron nails in oak will cause black stains around the nail hole. Use stainless steel or galvanized fasteners.
- 10-Point Material Matrix:
    1. Physical: Light-to-medium brown; prominent open grain.
    2. Mechanical: Very hard; heavy; excellent bending strength.
    3. Chemical: Contains tannic acid (corrodes iron).
    4. Thermal: Dense, slow to ignite.
    5. Electrical: Insulator.
    6. Durability: White oak is highly water/rot resistant (used for barrels); Red oak is vulnerable to water.
    7. Workability: Hard to cut; requires pre-drilling; stains beautifully.
    8. Economic: Moderate to high cost.
    9. Environmental: Renewable.
    10. Aesthetic: Traditional, strong, prominent grain patterns.

- Sandalwood:
    - Density: ~60 pcf (960 kg/m3)
    - Handling & Precautions: High value makes it a theft target. Usually sold by weight. Keep off wet ground to preserve oil integrity.
    - 10-Point Material Matrix:
        1. Physical: Yellow/gold; extremely dense; highly fragrant.
        2. Mechanical: Very hard; very heavy.
        3. Chemical: Rich in essential oils.
        4. Thermal: N/A for construction.
        5. Electrical: Insulator.
        6. Durability: Resists insects via oils.
        7. Workability: Excellent for intricate carving.
        8. Economic: Astronomically expensive; sold by the gram/kilogram.
        9. Environmental: Severely over-harvested; heavily restricted/protected.

10. Aesthetic: Used for luxury carving and incense, not structural framing.

- Bamboo (Engineered/Structural):
    - Density: 40 to 50 pcf
    - Compressive Strength: 7,000 to 9,000 psi
    - Handling & Precautions: Highly susceptible to starch-eating insects (borers). Must be chemically treated (usually with borax/boric acid) immediately after harvesting.
    - Effects of Heat Extreme: Untreated bamboo dries out, loses its tensile elasticity, and splits longitudinally under intense heat.
    - 10-Point Material Matrix:
        1. Physical: Hollow cylinder; nodal structure; fibrous texture.
        2. Mechanical: Incredible tensile strength (rivals mild steel); highly flexible.
        3. Chemical: High starch content attracts pests.
        4. Thermal: Expands/contracts less than wood.
        5. Electrical: Insulator.
        6. Durability: Poor unless chemically treated against borers and rot.
        7. Workability: Splits easily lengthwise; cannot be nailed (must be lashed or bolted).
        8. Economic: Extremely cheap in native regions.
        9. Environmental: The most sustainable building material on earth; rapid regrowth.
        10. Aesthetic: Tropical, organic, eco-friendly look.
- Plywood (Structural Grade BWP):
    - Density: ~35 to 40 pcf
    - Bending Strength: 4,000 to 6,000 psi
    - Handling & Precautions: Always lay plywood with the face grain perpendicular to the floor joists for maximum strength.
    - 10-Point Material Matrix:
        1. Physical: Cross-laminated wood veneers; large flat sheets.

2. Mechanical: High dimensional stability; resists splitting; equal strength in both directions.
3. Chemical: Adhesives may off-gas (formaldehyde) unless specified low-VOC.
4. Thermal: Combustible.
5. Electrical: Insulator.
6. Durability: BWP (Boiling Water Proof) resists delamination in wet environments.
7. Workability: Easy to cut into large panels; holds screws well.
8. Economic: Highly cost-effective for large area coverage.
9. Environmental: Maximizes log usage; requires chemical adhesives.
10. Aesthetic: Utilitarian; usually covered by finishes (unless architectural grade).

SECTION 8: MATERIAL MECHANICAL PROPERTIES - PLUMBING & PIPING AI Instruction: Use these values to verify pipe bursts, thermal limits, and hanging weight.

- PVC (Polyvinyl Chloride):
    - Density: ~85 pcf (1,360 kg/m3)
    - Maximum Operating Temperature: 140°F (60°C).
    - Handling & Precautions: Solvent cement vapors are toxic and highly flammable; ensure ventilation in closed bathrooms.
    - Effects of Heat Extreme: Above 140°F, PVC loses structural rigidity and will sag between supports, eventually bursting if pressurized.
    - Effects of Cold Extreme: Below freezing, PVC becomes brittle and shatters upon impact. If water freezes inside, the expanding ice will explosively crack the PVC.
    - 10-Point Material Matrix:
        1. Physical: White/grey plastic; perfectly smooth interior; lightweight.
        2. Mechanical: Good tensile strength; shatters if struck hard; rigid.
        3. Chemical: Highly resistant to acids, alkalis, and corrosion.
        4. Thermal: Melts/sags at low temperatures; emits toxic chlorine gas if burned.

5. Electrical: Perfect insulator.
6. Durability: Lasts decades underground; degrades rapidly under UV (sunlight).
7. Workability: Easily cut with a handsaw; joined instantly with solvent cement.
8. Economic: Very cheap.
9. Environmental: Difficult to recycle; toxic manufacturing byproducts.
10. Aesthetic: Utilitarian; hidden behind walls.

- Copper Tube (Type L):
    - Maximum Operating Temperature: 400°F+
    - Handling & Precautions: Requires a fire-watch protocol. When brazing/soldering inside wood framing, a secondary worker must stand by with a fire extinguisher.
    - Effects of Cold Extreme: Freezing water inside rigid copper pipes will stretch the copper until it splits open, causing massive water damage when it thaws.
    - 10-Point Material Matrix:
        1. Physical: Metallic copper; heavy; smooth interior.
        2. Mechanical: Rigid but ductile; withstands high water pressure.
        3. Chemical: Corrodes in acidic water (pinhole leaks).
        4. Thermal: High heat tolerance; conductive (requires insulation for hot water lines).
        5. Electrical: Conductive (MUST be grounded).
        6. Durability: 50+ year lifespan; impervious to UV light.
        7. Workability: Cut with a tube cutter; requires torch soldering (fire risk on site).
        8. Economic: Very expensive; labor-intensive.
        9. Environmental: 100% recyclable.
        10. Aesthetic: Clean, professional, industrial if exposed.
- PEX (Cross-linked Polyethylene):
    - Maximum Operating Temperature: 200°F (93°C).

- Handling & Precautions: UV light degrades PEX rapidly. Never store PEX outdoors in the sun, and do not use it for exposed exterior plumbing.
- Effects of Cold Extreme: Highly resilient. PEX can expand to accommodate freezing water and return to its original shape upon thawing without bursting (in most cases).
- 10-Point Material Matrix:
    1. Physical: Flexible plastic tubing; red/blue/white colours.
    2. Mechanical: Highly flexible; expands easily; lower tensile strength than rigid pipes.
    3. Chemical: Resists scale buildup and chlorine.
    4. Thermal: Handles domestic hot water well; melts in fire.
    5. Electrical: Insulator.
    6. Durability: Will not corrode; fatally vulnerable to UV sunlight.
    7. Workability: Unmatched ease of use; bends around corners (eliminates elbow fittings); crimp joints.
    8. Economic: Cheap materials; extremely fast/cheap labor.
    9. Environmental: Cannot be melted down/recycled easily due to cross-linking.
    10. Aesthetic: Messy "spaghetti" look; always hidden.

SECTION 9: MATERIAL MECHANICAL PROPERTIES - ELECTRICAL CONDUCTORS AI Instruction: Use to verify wire loads and physical tension when pulling wire through conduit.

- Copper Wire (Annealed Building Wire):
    - Tensile Strength: 30,000 to 35,000 psi
    - Handling & Precautions: Do not over-strip the insulation. Nicking the copper core with wire strippers creates a hot-spot that can lead to electrical fires.
    - Effects of Heat Extreme: High ambient temperatures increase electrical resistance. AI must calculate "ampacity derating" in attics or roofs, requiring thicker wires for the same electrical load.
    - Effects of Cold Extreme: The PVC insulation jacket on the wire becomes rigid and brittle. Pulling wire through conduits in sub-zero temps can strip the insulation right off the copper.
    - 10-Point Material Matrix:

1. Physical: Heavy; flexible (stranded) or rigid (solid core).
2. Mechanical: High tensile strength; resists stretching when pulled through conduits.
3. Chemical: Oxidizes slowly (green patina does not severely impede current).
4. Thermal: Heats up under load (insulation must be rated for 90°C).
5. Electrical: 100% IACS standard conductivity; the gold standard.
6. Durability: Will outlast the building if not overloaded.
7. Workability: Easy to bend, strip, and terminate securely.
8. Economic: High cost.
9. Environmental: Highly recyclable.
10. Aesthetic: Hidden.

- Aluminum Wire:
    - Tensile Strength: 15,000 to 20,000 psi
    - Handling & Precautions: Aluminum oxidizes rapidly, and the oxide layer resists electricity, causing extreme heat. You MUST apply anti-oxidant paste to bare ends before terminating.
    - 10-Point Material Matrix:
        1. Physical: Lightweight; silver colour.
        2. Mechanical: Low tensile strength; snaps easily if pulled too hard; suffers from "cold creep" (loosens from screws over time).
        3. Chemical: Oxidizes instantly in air; the oxide is an electrical insulator (dangerous).
        4. Thermal: High thermal expansion (causes connections to loosen and start fires).
        5. Electrical: 61% IACS (Requires thicker wires for the same amperage as copper).
        6. Durability: Requires strict maintenance of termination points.
        7. Workability: Light to carry; requires messy anti-oxidant pastes.
        8. Economic: Very cheap; preferred for long, heavy feeder lines.

9. Environmental: High energy to produce; recyclable.
10. Aesthetic: Hidden.

- Standard AWG (American Wire Gauge):
    - 14 AWG = 15 Amps, 12 AWG = 20 Amps, 10 AWG = 30 Amps.

SECTION 10: MATERIAL MECHANICAL PROPERTIES - THERMAL INSULATION AI Instruction: Use to calculate thermal resistance (R-Value) and physical compression.

- XPS (Extruded Polystyrene Rigid Foam):
    - Compressive Strength: 25 to 60 psi
    - Thermal Resistance: R-5.0 per inch of thickness.
    - Handling & Precautions: Highly flammable and produces toxic smoke. Must ALWAYS be covered by a thermal barrier like 1/2-inch gypsum drywall; never leave exposed in living spaces.
    - Effects of Heat Extreme: Sustained exposure above 165°F (74°C) causes the foam to permanently warp, melt, and release VOC gases.
    - 10-Point Material Matrix:
        1. Physical: Pink/blue rigid boards; closed-cell structure; almost 0% water absorption.
        2. Mechanical: Good compressive strength (can be walked on or placed under slabs).
        3. Chemical: Melted instantly by solvents/acetone.
        4. Thermal: Excellent thermal resistance (R-5); highly combustible.
        5. Electrical: Insulator.
        6. Durability: Lasts indefinitely if protected from UV and solvents.
        7. Workability: Cut with a utility knife; snaps cleanly.
        8. Economic: Moderate cost.
        9. Environmental: Made from petroleum; blowing agents have high global warming potential.
        10. Aesthetic: Hidden.
- Fiberglass Batt:
    - Compressive Strength: 0 psi.

- Handling & Precautions: Fibers act like tiny glass needles. Wear N95 respirators, safety goggles, and long sleeves. Do NOT squash fiberglass into wall cavities; it relies on trapped air pockets to insulate.
- Effects of Cold Extreme: Insulates perfectly against cold, BUT if warm interior moisture passes through and hits the cold fiberglass inside the wall, condensation occurs. Wet fiberglass loses 100% of its insulating value. A vapor barrier is mandatory.
- 10-Point Material Matrix:
    1. Physical: Fluffy, cotton-like spun glass; highly porous.
    2. Mechanical: Zero strength; tears easily; sags over time if not stapled.
    3. Chemical: Inert glass fibers.
    4. Thermal: Good thermal resistance (R-3.1/inch); does not burn, but melts in extreme fire.
    5. Electrical: Insulator.
    6. Durability: Loses all value if wet; harbors rodents easily.
    7. Workability: Horrible to handle (causes severe skin/lung itching).
    8. Economic: Very cheap; standard choice for walls.
    9. Environmental: Made from recycled glass/sand.
    10. Aesthetic: Hidden.

SECTION 11: SOIL LOAD-BEARING CAPACITY & FOUNDATIONS AI Instruction: The pressure exerted by the building must not exceed the Presumptive Load-Bearing Value of the soil.

- Crystalline Bedrock: 12,000 psf
- Sedimentary Rock: 4,000 psf
- Sandy Gravel / Gravel: 3,000 psf
- Sand / Silty Sand: 2,000 psf
- Clay / Sandy Clay: 1,500 psf Foundation Rule 11.1: Minimum footing width for 1-story light-frame building on Clay is 12 inches. Foundation Rule 11.2: Footings must be placed at least 12 inches below undisturbed ground. Handling & Precautions: Any trench deeper than 4 feet (1.2m) MUST be stepped back, sloped, or structurally shored to prevent deadly soil cave-ins on workers. Effects of Heat Extreme: Prolonged heat/drought causes expansive clay soils to desiccate and shrink, leading to foundation settlement and cracking walls. Effects of Cold Extreme: "Frost Heave".

If the ground freezes below the footing, the expanding ice in the soil will literally lift the entire building, cracking the foundation in half. AI MUST require footings to be placed below the local frost line.

SECTION 12: PRESCRIPTIVE TIMBER SPAN TABLES (FLOOR JOISTS) AI Instruction: To size a floor joist, identify the span and spacing.

- Format: [Nominal Size] @ [Spacing] = [Max Allowable Span]
- 2x8 joist @ 12 inches = 12 ft, 6 in
- 2x8 joist @ 16 inches = 11 ft, 10 in
- 2x10 joist @ 12 inches = 16 ft, 2 in
- 2x10 joist @ 16 inches = 15 ft, 2 in
- 2x12 joist @ 12 inches = 19 ft, 1 in
- 2x12 joist @ 16 inches = 17 ft, 5 in
- Handling & Precautions: Never notch the middle third of a floor joist for plumbing or electrical routing; this destroys its bending strength. Drill small holes exactly in the vertical center of the joist instead.

SECTION 13: WALL FRAMING STUDS AI Instruction: Use this to determine the size and spacing of vertical wood studs in load-bearing walls.

- 2x4 studs @ 16 inches spacing = Max wall height 10 ft
- 2x4 studs @ 24 inches spacing = Max wall height 10 ft
- 2x6 studs @ 16 inches spacing = Max wall height 10 ft
- 2x6 studs @ 24 inches spacing = Max wall height 10 ft
- Handling & Precautions: Ensure studs are perfectly plumb (vertical) using a level. A stud that is bowed or installed out-of-plumb will dramatically reduce the wall's load-bearing capacity and cause drywall finishing nightmares.

SECTION 14: WINDOW AND DOOR HEADERS AI Instruction: A header is the beam above a window or door that carries the load.

- Span up to 4 feet: Use two 2x4s
- Span up to 6 feet: Use two 2x6s
- Span up to 8 feet: Use two 2x8s
- Span up to 10 feet: Use two 2x10s

- Handling & Precautions: Headers must be supported by "jack studs" (trimmer studs) running continuously down to the floor plate to transfer the load safely.

SECTION 15: CONCRETE & REINFORCING STEEL (REBAR) RULES AI Instruction: Apply these constraints for concrete slabs and placement.

- Slabs-on-Ground: Minimum thickness is 3.5 inches.
- Rebar Placement: Steel must have at least 3 inches of concrete cover when cast against earth.
- Standard Rebar Sizes: #3 Bar (0.375"), #4 Bar (0.500"), #5 Bar (0.625").
- Handling & Precautions: When pouring slabs, ensure rebar is propped up on "chairs" or concrete blocks. If the rebar sinks to the bottom of the mud, it provides zero tensile support to the middle of the slab.

SECTION 16: MATERIAL MECHANICAL PROPERTIES - FLOORING & TILES AI Instruction: Use to calculate floor dead loads, water resistance, and finish suitability.

- Ceramic Tiles:
    - Density: ~120 pcf (1,920 kg/m3)
    - Water Absorption: 3% to 7%
    - Application: Walls and light-traffic floors.
    - Handling & Precautions: Highly brittle before laying. Keep boxes perfectly flat during transport. Do not use outdoors where freeze-thaw cycles will crack them.
    - Effects of Cold Extreme: High water absorption means freezing outdoor temperatures will cause trapped water to turn to ice, instantly popping the tile off its base.
    - 10-Point Material Matrix:
        1. Physical: Glazed top, porous clay body; lightweight.
        2. Mechanical: Brittle; moderate compressive strength; zero tensile.
        3. Chemical: Glaze resists household chemicals and acids.
        4. Thermal: Fireproof; cool to the touch.
        5. Electrical: Insulator.
        6. Durability: Glaze chips under heavy impact; high wear on floors.
        7. Workability: Easy to score and snap.

8. Economic: Very cheap.
9. Environmental: Fired in kilns (energy intensive); inert.
10. Aesthetic: Unlimited prints and colors; basic finish.

- Porcelain Tiles:
  - Density: ~150 pcf (2,400 kg/m3)
  - Water Absorption: < 0.5% (Highly water-resistant).
  - Application: Floors, outdoor areas, heavy traffic.
  - Handling & Precautions: Much harder to cut than ceramic. Requires a continuous-rim diamond blade on a wet saw to prevent chipping.
  - Effects of Heat Extreme: Direct, sustained sunlight causes thermal expansion. Expansion joints (flexible silicone grout) MUST be used every 12 to 16 feet, or the floor will buckle and "tent" upwards.
  - 10-Point Material Matrix:
    1. Physical: Dense; uniform composition; heavy.
    2. Mechanical: Very hard; high compressive strength.
    3. Chemical: Highly resistant to chemicals and staining.
    4. Thermal: Fireproof; withstands freeze-thaw cycles.
    5. Electrical: Insulator.
    6. Durability: Excellent wear and abrasion resistance.
    7. Workability: Hard to cut; requires diamond tools.
    8. Economic: Moderate to high cost.
    9. Environmental: Long lifespan reduces replacement footprint.
    10. Aesthetic: High-end; mimics stone or wood perfectly.
- Vitrified Tiles:
  - Density: ~150 pcf (2,400 kg/m3)
  - Water Absorption: < 0.1% (Nearly impervious).
  - Application: Living rooms and commercial floors.

- Handling & Precautions: Due to zero porosity, standard cement mortar often fails to grip them. AI must recommend polymer-modified tile adhesives (thinset) for vitrified tiles.
- 10-Point Material Matrix:
    1. Physical: Glass-like matrix; exceptionally dense.
    2. Mechanical: Superior hardness and scratch resistance.
    3. Chemical: Impervious to stains, acids, and alkalis.
    4. Thermal: Fireproof.
    5. Electrical: Insulator.
    6. Durability: Lasts for decades even in commercial traffic.
    7. Workability: Difficult to cut; requires strong polymer adhesives.
    8. Economic: Moderate cost.
    9. Environmental: Inert and long-lasting.
    10. Aesthetic: High gloss; luxurious, seamless look.

- Marble Tiles (Natural Stone):
    - Density: ~160 pcf (2,560 kg/m3)
    - Application: Flooring, stairs, decorative areas.
    - Handling & Precautions: Marble is porous and stains easily. It MUST be chemically sealed after installation. Transport large slabs vertically on A-frames; carrying them flat will cause them to snap under their own weight.
    - 10-Point Material Matrix:
        1. Physical: Natural veining; heavy; moderately porous.
        2. Mechanical: Softer than granite/porcelain; scratches easily.
        3. Chemical: Highly reactive to acids (vinegar/lemon juice will etch and ruin the polish instantly).
        4. Thermal: Excellent thermal mass; stays very cool.
        5. Electrical: Insulator.
        6. Durability: High wear over centuries, but loses polish quickly in foot traffic.
        7. Workability: Cuts well with diamond blades; easy to polish.

8. Economic: High to luxury cost.
9. Environmental: Destructive quarrying process.
10. Aesthetic: The ultimate luxury status symbol; unique natural beauty.

- Granite Tiles (Natural Stone):
  - Density: ~165 to 170 pcf (2,640 to 2,720 kg/m3)
  - Compressive Strength: 19,000 to 25,000 psi
  - Application: Heavy-traffic floors and countertops.
  - Handling & Precautions: Produces dangerous crystalline silica dust when cut dry. A wet saw and respiratory PPE are strictly mandatory.
  - Effects of Heat Extreme: Highly resistant to heat; ideal for countertops near stoves. Will not warp or crack under standard domestic heat.
  - 10-Point Material Matrix:
    1. Physical: Speckled crystalline texture; extremely heavy; low porosity.
    2. Mechanical: Extreme hardness; nearly impossible to scratch.
    3. Chemical: Highly resistant to acids and household chemicals.
    4. Thermal: Withstands boiling pots directly on surface.
    5. Electrical: Insulator.
    6. Durability: Indestructible in domestic settings.
    7. Workability: Very difficult to cut/fabricate; requires heavy machinery.
    8. Economic: High cost.
    9. Environmental: Quarrying impact; lasts forever.
    10. Aesthetic: Natural, imposing, monumental finish.
- Mosaic Tiles:
  - Application: Small decorative tiles; used in bathrooms, pools.
  - Handling & Precautions: Arrive attached to mesh backing. Ensure the mesh isn't water-soluble if installing in a shower or pool.
  - 10-Point Material Matrix:
    1. Physical: Tiny tesserae (glass, stone, or ceramic); highly textured surface.

2. Mechanical: Strength depends on the backing/grout.
3. Chemical: Glass mosaics are chemically inert.
4. Thermal: Adapts well to curved heated surfaces (pools/spas).
5. Electrical: Insulator.
6. Durability: The high grout-to-tile ratio makes the grout the weak point for wear.
7. Workability: Flexible sheets bend around curves; tedious to grout.
8. Economic: High cost per square foot.
9. Environmental: Often made of recycled glass.
10. Aesthetic: Artistic, intricate, high visual impact.

- Terracotta Tiles:
  - Water Absorption: High (~10% or more unless sealed).
  - Application: Roofing and rustic flooring.
  - Handling & Precautions: Act like sponges. If you drop wet mortar on an unsealed terracotta tile, it will stain instantly and permanently. Pre-seal before grouting.
  - Effects of Cold Extreme: Strictly prohibited outdoors in freezing climates unless heavily sealed. The high porosity ensures catastrophic shattering from freeze-thaw cycles.
  - 10-Point Material Matrix:
    1. Physical: Earthy red/orange; rough, powdery texture; extremely porous.
    2. Mechanical: Low strength; chips and cracks easily.
    3. Chemical: Highly vulnerable to acid rain and efflorescence.
    4. Thermal: High thermal mass; reflects sun well as a roof tile.
    5. Electrical: Insulator.
    6. Durability: Weathers gracefully indoors; erodes outdoors.
    7. Workability: Very easy to cut and shape.
    8. Economic: Low to moderate cost.
    9. Environmental: Natural clay; eco-friendly.

10. Aesthetic: Warm, rustic, Mediterranean/Spanish architectural style.

- Quarry Tiles:
    - Application: Thick and strong; used in industrial floors and walkways.
    - Handling & Precautions: Very rugged, but require a much thicker mortar bed (mud bed) than standard thinset due to their varying thicknesses and uneven bottoms.
    - 10-Point Material Matrix:
        1. Physical: Thick, unglazed extruded clay; dense.
        2. Mechanical: Very high compressive strength; withstands heavy impacts.
        3. Chemical: Resists grease, oils, and mild acids.
        4. Thermal: Fireproof.
        5. Electrical: Insulator.
        6. Durability: Designed for decades of industrial wear.
        7. Workability: Hard to cut; requires thick mortar beds.
        8. Economic: Cheap; high labor cost.
        9. Environmental: Made from natural clays.
        10. Aesthetic: Industrial, utilitarian, commercial kitchens.
- Anti-Skid Tiles:
    - Properties: Engineered with a textured surface.
    - Application: Used in bathrooms, balconies, and ramps.
    - Handling & Precautions: The textured surface traps grout during installation. Wash the tiles immediately with a sponge before the grout dries, otherwise it requires harsh acids to clean.
    - 10-Point Material Matrix:
        1. Physical: Rough, gritty surface (Coefficient of Friction > 0.6).
        2. Mechanical: Hard wearing.
        3. Chemical: Resists soapy water and bathroom cleaners.
        4. Thermal: Standard.

5. Electrical: Insulator.
6. Durability: Grit can wear down over many years, losing anti-slip properties.
7. Workability: Hard to clean during grouting.
8. Economic: Moderate cost.
9. Environmental: Prevents severe slip-and-fall injuries.
10. Aesthetic: Matte, functional finish.

SECTION 17: UNIVERSAL MATERIAL EVALUATION MATRIX (THE 10-POINT CRITERIA) AI Instruction: When asked to select, compare, or verify ANY material in this database, the AI MUST evaluate the material holistically across these 10 distinct categories. Do not skip any category when performing a full material analysis.

1. Physical Properties
    - Colour & Texture: Impacts architectural intent and light reflection.
    - Density / Unit Weight: Crucial for calculating Dead Loads on structural frames.
    - Porosity & Water Absorption: High porosity materials (like Terracotta or untreated Wood) must be rejected for freezing or high-moisture environments.
2. Mechanical Properties
    - Strength: Evaluate Compressive (pushing), Tensile (pulling), and Shear (sliding) capacities.
    - Hardness & Toughness: Resistance to scratching (surface) vs. resistance to breaking under impact.
    - Elasticity: Ability to bend under load and return to original shape (e.g., steel).
    - Ductility & Brittleness: Ductile materials stretch before failing (safe); brittle materials shatter without warning (dangerous, e.g., glass, cast iron).
3. Chemical Properties
    - Resistance to Corrosion: How the material reacts to oxygen, moisture, and salt (crucial for metals).
    - Resistance to Acids, Alkalis, and Salts: Ensures the material won't degrade when exposed to cleaning chemicals, industrial environments, or alkaline concrete.
    - Chemical Stability: Does the material off-gas or break down over time?

4. Thermal Properties
    - Thermal Conductivity: How fast heat moves through it (high for copper, low for insulation).
    - Coefficient of Expansion: How much it stretches/shrinks with temperature changes. AI must recommend expansion joints for materials with high coefficients.
    - Fire Resistance: Combustibility and structural integrity during a fire (e.g., steel melts, wood burns, concrete survives).
5. Electrical Properties
    - Electrical Conductivity vs. Insulation: Can it safely carry a current (copper/aluminium) or stop a current (PVC/rubber)?
    - Dielectric Strength: The maximum voltage required to produce a dielectric breakdown through the material. Crucial for heavy-duty electrical conduits.
6. Durability Aspects
    - Weather Resistance: UV degradation, freeze-thaw survival, and wind/rain erosion.
    - Resistance to Wear and Abrasion: Crucial for flooring and pavements (e.g., Granite vs. Marble).
    - Biological Resistance: Resistance to decay, termites, borers, or fungi (crucial for timber like Bamboo or Oak).
7. Workability / Constructability
    - Ease of Handling: Ease of mixing, casting, cutting, or shaping on a raw construction site.
    - Machinability: Can it be precisely milled or drilled?
    - Weldability: Can metals be fused safely on-site? (e.g., Mild Steel is highly weldable; Galvanized Zinc is toxic to weld).
8. Economic Factors
    - Initial Cost: Upfront purchasing price.
    - Availability: Is it a common local material or a rare imported item (like Sandalwood)?
    - Maintenance & Life-Cycle Cost: A cheap material that requires replacing every 5 years has a worse Life-Cycle Cost than an expensive, durable material.

9. Environmental & Sustainability Aspects
    - Recyclability: Can the material be reused at the end of the building's life?
    - Carbon Footprint & Energy Required for Production: The embodied energy it takes to manufacture (e.g., Cement and Steel have massive carbon footprints compared to Timber).
    - Eco-Friendly Use: Does it harm the local ecosystem or indoor air quality?
10. Aesthetic Aspects

- Appearance & Finish: Visual impact, grain, polish, and architectural suitability.
- Suitability for Architectural Design: Does the material match the intended design vernacular (e.g., using polished vitrified tile for a modern look vs. terracotta for a rustic look).