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Copper Slag, Geotextiles, and Sustainable Rural Road Construction

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Copper Slag, Geotextiles, and Sustainable Rural Road Construction

A sustainable road uses suitable waste materials without losing safety or durability. Copper slag, geotextiles, and cold mix are the exam favourites, and 2026 added a plastic-road milestone and a fresh steel-slag claim.



A rural road being carpeted under the Pradhan Mantri Gram Sadak Yojana scheme. Photo by খাঁ শুভেন্দু, CC BY-SA 4.0, via Wikimedia Commons.

At a glance

Four materials, one exam question, one 2026 milestone

01
Copper slag

Smelting waste, tested and graded as road aggregate.

02
Geotextile

A fabric that separates, filters, or drains weak soil.

03
43,700 km

Rural roads completed using waste plastic, as of mid-2025.

04
2026

A Union minister’s steel-slag cost claim, and a CRRI milestone.

Aggregate. The grains or stones that make up a road layer.
Leaching. Substances washing out of a material when water passes through it.
Geotextile.A fabric of coir, jute, or synthetic fibre placed within road layers.
Cold mix. Asphalt made with a bitumen emulsion, needing far less heating than hot mix.

Copper Slag: Smelting Waste as Road Aggregate

Must Know

Copper slag is the hard material left after copper ore is smelted. It is different from copper metal itself.

- **As aggregate.** A road engineer can process and grade slag to replace some quarried sand or stone in a designed base or approved layer.
- **Testing required.** The material must pass tests for particle size, strength, and water behaviour, plus checks for possible metal leaching.
- **The environmental risk.** Rainwater can **leach heavy metals like arsenic and cadmium** from untested slag left at a smelter site.

Indian Roads Congress guidance, **IRC SP:121-2018**, covers iron, steel, and copper slag use in rural roads.

Watch this trap: waste is not automatically safe because it's reused. Copper slag needs grading, strength, and leaching checks before it goes anywhere near a road.

> **Quick check 1.** Copper slag is a copper-smelting byproduct that needs testing before road use. *(True or False?)* See answer ↓

Geotextiles and Cold Mix: What They Actually Do

Must Know

A **geotextile** is a fabric placed in or beside road layers, made from coir, jute, or synthetic fibres.

- **On weak ground.** It separates soft soil from road stone.
- **Extra functions.** It can filter water, help drainage, or reduce erosion.
- **A possible saving.** Some designs need less stone once the soil gains support — site-specific, not guaranteed.

Cold mix asphalt uses a bitumen emulsion instead of a hot-mix plant. The emulsion helps bitumen mix with aggregate near the site, usually **needing less heating and cutting emissions**. It still uses bitumen, and performance depends on weather and design. NRIDA warns some cold mixes are sensitive to moisture. A wet site may need another design.

> **Quick check 2.** Cold mix asphalt is considered more sustainable than hot mix mainly because it uses no bitumen at all. *(True or False?)* See answer ↓

What PMGSY Has Actually Used

Good to Know

Pradhan Mantri Gram Sadak Yojana (PMGSY) is India's rural-road programme. It has tested several new materials and methods over the years.

- **Copper slag pilots.** A 2018 government answer reported 8.60 km built using copper slag.
- **Geotextile pilots.** The same answer reported 67.26 km using geotextile for subgrade improvement. Coir and jute textiles were reported separately.
- **Dated, not current.** These are pilot figures from 2018, not national totals today. NRIDA's 2023-24 report groups several slag types together, without showing copper slag alone.

Local availability, laboratory results, traffic, cost, and approved specifications guide each choice on the ground.

> **Quick check 3.** PMGSY reported pilot road lengths using copper slag and geotextiles in a 2018 government answer. *(True or False?)* See answer ↓

Waste Plastic Roads: The Scaled-Up Success Story

Great to Know

Unlike copper slag's small 2018 pilots, waste plastic in road construction has scaled up nationally.

- **Sanctioned.** 56,875 km of road works sanctioned using waste plastic, as of 31 July 2025.

- **Completed. 43,700 km already completed** using waste plastic by that date.
- **A mandatory floor.** States and UTs must use waste plastic in at least 70% of road length that involves the hot-mix process.
- **Independently studied.** Performance studies by seven institutes, supervised by IIT Madras, found waste-plastic roads can outperform conventional roads on surface strength.

Remember: waste plastic is used within the bitumen mix, not as a separate structural layer like a geotextile or a slag-based aggregate base.

Weighing the Whole Road Life

Great to Know
Replacing some quarried aggregate may reduce fresh extraction. Reusing slag may also reduce stockpiles near a plant. Cold mix can reduce fuel used for heating, and geotextiles can improve a weak base or protect a slope.

But a distant slag source may require long truck trips, and processing, transport, and future repairs all have their own impacts. **Compare the whole road life**: a cheaper first build can cost more if it fails early or pollutes water.

Match the material to the road problem

Choice	Main job	Possible gain	Check first
Copper slag	Tested aggregate in an approved layer	Less fresh stone	Strength, grading, leaching, haul distance
Geotextile	Separate, filter, drain, or reinforce	Stronger weak ground, less erosion	Soil, water, fabric life, placement

Choice	Main job	Possible gain	Check first
Cold mix	Bituminous surface for suitable roads	Less heating and plant fuel	Moisture, traffic, curing, specification
Waste plastic	Additive within the bitumen mix	Diverts plastic waste, adds surface strength	Correct dosage, mix-plant compliance

Could a distant copper-smelter's slag still make a road greener?

Possibly, but distance matters. Engineers should compare the processing needed, the trucking distance, and the quarrying it avoids. They should also weigh the leaching risk and the road's expected life. The source material being waste is not the only factor. A local source is not always available, and hauling slag hundreds of kilometres can erase the environmental gain it was meant to provide. "Sustainable" describes a comparison across the whole road's life, not a label that attaches automatically to any recycled material.

Quick check 4. A local slag source always cuts a road's total emissions, even if processing and repairs rise. *(True or False?)*

See answer ↓

Steel Slag's 2026 Claim: A Different Material

Great to Know

Steel slag comes from steelmaking, not copper smelting. Both can become road aggregate after suitable processing and testing, but their chemistry and expansion risks can differ.

- **The 2026 claim.** In a 12 September 2026 release, a Union minister made a bold claim. Steel-slag roads *can* cut construction cost by about 40%. Their strength can reach up to four times that of conventional roads.
- **Cited projects.** A 1.85 km road at Raigarh, and a 40 km Odisha work order.
- **A separate 2026 milestone.** CSIR-CRRI marked its Platinum Jubilee in July 2026. By then, over **1,200 km of Indian roads** already used CRRI technologies like Steel Slag Roads and MSS+.

Watch this trap: these are stated project claims, not universal design guarantees. Don't transfer a steel-slag project's cost or strength claim to copper slag — they're different materials from different industries.

> **Quick check 5.** Copper slag and steel slag come from the same industrial process. *(True or False?)* See answer ↓

Exam Edge

Previous Year Question: UPSC CSE Prelims 2020, Q78

Quick Q&A

If copper slag's PMGSY pilots were only 8.60 km back in 2018, why does the exam still test it?

The exam tests a concept, not a pilot's size. Certain industrial byproducts and fabrics can replace some conventional road materials with a smaller footprint. Waste plastic shows this idea scaled up

nationally, to over 43,700 km.

Does the 2026 steel-slag cost claim mean every future rural road should use it?

No. It’s a reported project claim from specific pilots at Raigarh and in Odisha. Local soil, traffic, slag chemistry, and maintenance needs still have to be tested site by site before any material is approved.

Related: see the wider guide to India’s transport infrastructure for how rural-road quality fits the bigger picture.

MCQ on Sustainable Rural Road Construction

Try 6 practice questions on copper slag, geotextiles, cold mix, and steel slag.

🎲 More Environment and Ecology Practice

Practice MCQs

1. Copper slag, used as a sustainable material in rural road construction, is a byproduct of which industrial process?

A. Copper smelting

B. Aluminium refining

C. Steel manufacturing

D. Cement production

See answer ↓

2. What is the main environmental risk from copper slag left at a smelter site?

A. It releases greenhouse gases directly

B. Rainwater can leach heavy metals like arsenic and cadmium from it

C. It emits carbon monoxide continuously

D. It causes ozone layer depletion

See answer ↓

3. Cold mix asphalt technology is considered more environmentally sustainable than hot mix asphalt mainly because it

A. Is produced at much lower temperatures, saving energy and cutting emissions

B. Requires no aggregate materials

C. Uses no bitumen at all

D. Contains recycled plastic exclusively

See answer ↓

4. In rural road construction, the use of which of the following is preferred for ensuring environmental sustainability or to reduce carbon footprint?

1. Copper slag
2. Cold mix asphalt technology
3. Geotextiles
4. Hot mix asphalt technology
5. Portland cement

A. 1, 2 and 3 only

B. 2, 3 and 4 only

C. 4 and 5 only

D. 1 and 5 only

See answer ↓

5. Steel slag can be the material for which of the following?

1. Construction of base road
2. Improvement of agricultural soil
3. Production of cement

A. 1 and 3 only

B. 2 and 3 only

C. 1, 2 and 3

D. 1 and 2 only

See answer ↓

6. As of CSIR-CRRI's Platinum Jubilee launch in July 2026, over how many kilometres of Indian roads already use its technologies like Steel Slag Roads and MSS+?

A. 91,000 km

B. 280 km

C. 16 km

D. 1,200 km

See answer ↓

Answer Key

1. **A.** Copper slag is a byproduct of copper smelting, and can replace natural sand or aggregate in road construction. ↑ Q1
2. **B.** Copper slag is a glassy waste by-product that still contains heavy metals from the original ore. When stored improperly, rainwater leaches these metals into surrounding soil and groundwater. ↑ Q2
3. **A.** Cold mix asphalt is produced at lower temperatures than hot mix asphalt, reducing energy use and greenhouse gas emissions during production. ↑ Q3
4. **A.** Copper slag, cold mix asphalt, and geotextiles all reduce carbon footprint and resource use. Hot mix asphalt and Portland cement are both energy-intensive to produce. ↑ Q4
5. **C.** Steel slag genuinely works for road base construction, agricultural soil improvement, and cement production. All three are correct. ↑ Q5
6. **D.** CSIR-CRRI's technologies already run on over 1,200 km of Indian roads, including nearly 280 km of Steel Slag Roads specifically. ↑ Q6

Quick-check answers

1. **True.** ↑ 1
2. **False.** ↑ 2
3. **True.** ↑ 3
4. **False.** ↑ 4
5. **False.** ↑ 5

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