

Technical Guidance and implementation procedure of Sustainable Road Technologies Promoting Innovative Construction Materials and Recycling Technologies

1. Fibre-Reinforced Concrete (FRC)

Fibre-Reinforced Concrete (FRC) is a composite concrete material in which short, discrete fibres are uniformly distributed throughout the concrete mix to improve its mechanical and durability properties.

The fibres may be made of steel, polypropylene or glass. They are generally used to control cracking, to improve tensile and flexural performance, to increase toughness and impact resistance, and to enhance the durability of concrete.

Recommended Location:

- Fibre-Reinforced Concrete may be considered for Pavement Quality Concrete (PQC) in rigid pavement sections subjected to heavy traffic, industrial roads, intersections, bus bays and areas subjected to repeated braking and acceleration.
- It may be adopted in place of conventional plain cement concrete pavement, subject to structural design and laboratory validation.

Reference:

The design and construction may be carried out with reference to:

- IRC:58-2015 – Guidelines for the Design of Plain Jointed Rigid Pavements for Highways.
- IRC:SP:46-2013 – Guidelines for Design and Construction of Fibre Reinforced Concrete Pavements.

- Applicable MoRTH Specifications.

Expected Outcomes:

- Improved crack control, impact resistance and pavement durability.
- The exact benefit depends strongly on the fibre type, dosage, concrete grade, pavement thickness, joint details and construction quality.
- A well-designed FRC pavement may be expected to show smaller crack widths, slower crack propagation, better fatigue resistance and potentially a longer maintenance interval compared with an equivalent conventional concrete pavement.

Approximate Cost:

For 7.00 m × 1 km: approximate cost **□656 lakh/km (□6.56 crore/km).**

- A dosage of 25 kg/m³ for steel fibres and 2.5 kg/m³ for polypropylene fibres has been considered.
- The rate has been arrived at considering an assumed CBR value, assumed traffic intensity and assumed design mix results, with the following provisions:
 - Earthwork for box cutting
 - Granular Sub-base Grade III
 - Granular Sub-base Grade V
 - Dry Lean Concrete (DLC)
 - Pavement Quality Concrete of M40 grade with fibres
- Any additional provision warranted at site, based on requirement, shall be worked out separately and included in the project cost.

2. Pervious Concrete for Sustainable Pavements

Pervious Concrete is a special type of concrete consisting of cementitious material, coarse aggregate, limited or no fine aggregate, water and suitable admixtures, producing an interconnected pore structure that allows rainwater to pass through the pavement. IRC:44-2017 specifically includes provisions for pervious concrete mix proportioning and describes its permeability characteristics.

Recommended Location:

- Pervious concrete may be considered for parking areas, footpaths, shoulders, service roads, pedestrian areas, low-volume roads, bus-bay surroundings and urban areas requiring storm-water infiltration.
- It may be adopted in place of conventional impervious concrete/asphalt surfaces where rainwater infiltration, reduction of surface runoff and groundwater recharge are important considerations.
- It should preferably be used where the subgrade has adequate infiltration capacity and suitable drainage arrangements can be provided.

Reference:

The design and construction may be carried out with reference to:

- IRC:44-2017 – Guidelines for Cement Concrete Mix Design for Pavements, including provisions for pervious concrete.
- IRC:SP:62-2014 – Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads, where applicable.
- IS 456:2000 and relevant IS specifications for concrete materials.

- Applicable MoRTH Specifications.

Expected Outcomes:

- Rapid infiltration of rainwater.
- Reduction in surface runoff and water stagnation.
- Potential groundwater recharge.
- Improved storm-water management in urban areas.
- Reduction in the requirement for conventional surface drainage at suitable locations.

The performance depends strongly on permeability, void content, concrete strength, subgrade infiltration capacity, rainfall, pavement thickness, traffic and maintenance against clogging.

Approximate Cost:

For 7.00 m × 1 km: approximate cost **₹300–350 lakh/km (₹3.00–3.50 crore/km).**

The estimate may include:

- Earthwork/subgrade preparation
- Granular drainage layer
- Pervious concrete pavement
- Edge restraint
- Drainage/filter arrangements
- Curing and construction provisions

The exact cost shall be established based on the required permeability, pavement thickness and drainage system.

3. Ground Granulated Blast Furnace Slag (GGBS)

Ground Granulated Blast Furnace Slag (GGBS) is a finely ground cementitious material obtained from granulated blast-furnace slag generated during iron production. It can be used as a supplementary cementitious material in concrete, replacing a portion of conventional cementitious material.

Recommended Location:

- GGBS may be considered as a partial replacement for cement in PQC, DLC, concrete drains, culverts, medians and other cement-concrete works, including structural concrete works such as bridge components.
- It is particularly suitable for large-volume concrete works, where reduction in cement consumption and improvement in durability are desirable.
- It may be considered for concrete works in coastal and aggressive environments, subject to mix design and durability requirements.

Reference:

The design and use may be carried out with reference to:

- IS 16714:2018 – Ground Granulated Blast Furnace Slag for use in Cement, Mortar and Concrete.
- IS 456:2000 – Plain and Reinforced Concrete – Code of Practice.
- Applicable MoRTH Specifications.

Expected Outcomes:

- Reduction in consumption of conventional cement.
- Reduction in embodied carbon associated with cement production.

- Improved long-term durability.
- Reduced heat of hydration.
- Improved resistance to permeability and certain aggressive environments.

The benefits depend on the replacement percentage, concrete grade, curing period, strength development, exposure condition and quality of GGBS.

Approximate Cost:

- For a 7.00 m × 1 km concrete pavement, assuming GGBS replaces a portion of cement: approximate total cost **₹550–600 lakh/km (₹5.50–6.00 crore/km)**.
- For cement concrete works such as bridge components, drains, culverts, etc.:
 - i) Conventional Concrete: Approximate cost – **₹16,287 per m³**
 - ii) GGBS Concrete: Approximate cost – **₹15,971 per m³**

4. Geosynthetics in Flexible Pavements

Geosynthetics are polymeric materials such as geotextiles, geogrids, geomembranes and geocomposites used in road construction to perform functions such as separation, filtration, reinforcement, drainage and confinement.

Recommended Location:

- Geosynthetics may be considered within or beneath the GSB/sub-base layer where reinforcement is required due to weak subgrade conditions, inadequate bearing capacity or potential aggregate-subgrade intermixing.
- The use of geogrids may be considered at weak subgrade locations to improve the structural performance and service life of the pavement by providing tensile reinforcement and confinement of the granular layer

Reference:

The principal reference shall be IRC:SP:59-2019 – Guidelines for Use of Geosynthetics in Road Pavements and Associated Works.

It may be used along with IRC:37-2018 – Guidelines for the Design of Flexible Pavements and applicable MoRTH Specifications. IRC:37-2018 specifically recognises the use of geosynthetics and refers to IRC:SP:59 for field/laboratory investigation and reinforced-layer assessment.

Expected Outcomes:

- Reduction in contamination of GSB by subgrade soil.
- Improved confinement and load distribution.
- Potential reduction in aggregate requirements.

- Improved pavement performance over weak subgrades.

The benefit depends on geosynthetic type, tensile strength, aperture size, subgrade CBR, traffic, layer thickness and installation quality.

Approximate Cost:

For 7.00 m × 1 km: approximate cost **₹300–320 lakh/km (₹3.00–3.20 crore/km).**

The estimate may include:

- Earthwork/subgrade preparation
- Granular drainage layer
- Geogrid Reinforcement
- Granular Base layer
- Bituminous Base (DBM)
- Bituminous Wearing Surface (BC)

The exact cost shall be established based on the required permeability, pavement thickness and drainage system.

5. Cement-Treated Sub-base and Base (CTSB/CTB)

Cement-Treated Sub-base/Base (CTSB/CTB) is a pavement layer formed by mixing soil, aggregates, reclaimed materials or suitable granular materials with cementitious stabilisers to obtain a stronger and stiffer layer than an untreated granular layer.

IRC:37-2018 specifically provides provisions for both Cement Treated Sub-base (CTSB) and Cement Treated Base (CTB).

Recommended Location:

- High-volume traffic corridors.
- Heavy-duty and industrial roads.
- Roads requiring higher structural capacity.
- Locations where reduction in granular-layer thickness is desirable.
- Weak or variable subgrade locations, after suitable stabilisation studies.

Reference:

The design and construction may be carried out with reference to:

- IRC:37-2018 – Guidelines for the Design of Flexible Pavements.
- IRC:SP:89 (Part I)-2010 – Guidelines for Soil and Granular Material Stabilization Using Cement, Lime and Fly Ash.
- IRC:SP:89 (Part II)-2018 – Guidelines for the Design of Stabilized Pavements.
- Applicable MoRTH Specifications.

IRC:37-2018 gives a minimum CTSB thickness of 200 mm and provides strength/design provisions; it also covers CTB as a cementitious base layer.

Expected Outcomes:

- Increased pavement foundation stiffness.
- Improved load distribution.
- Improved resistance to deformation.
- Potential reduction in granular-layer thickness.
- Improved performance under heavy traffic.
- Potential reduction in overall pavement thickness after structural analysis.

The performance depends on cement content, UCS, material gradation, curing, moisture, layer thickness and construction quality.

Approximate Cost:

For 7.00 m × 1 km: approximate cost **₹250–300 lakh/km (₹2.50–3.00 crore/km)** for a typical CTSB, CTB-based flexible pavement configuration.

6. Reclaimed Asphalt Pavement (RAP)

Reclaimed Asphalt Pavement (RAP) is the processed material obtained by removing existing bituminous pavement through milling or excavation and processing it for reuse in new pavement layers.

RAP can be incorporated into new bituminous mixes or used in suitable recycled pavement layers after characterisation and mix design. IRC:120-2015 specifically deals with recycling of bituminous pavement materials.

Recommended Location:

- Road strengthening works.
- Rehabilitation and reconstruction work.
- Bituminous base and binder courses.
- Suitable wearing-course mixes, subject to mix design.
- Projects where sufficient existing bituminous pavement is available for reclamation.

Reference:

The design and application may be carried out with reference to:

- IRC:120-2015 – Recommended Practice for Recycling of Bituminous Pavements.
- IRC:37-2018 – Guidelines for the Design of Flexible Pavements.
- Applicable MoRTH Specifications.

IRC:120-2015 covers both hot and cold recycling approaches and the use of reclaimed pavement material.

Expected Outcomes:

- Reuse of existing pavement materials.
- Reduction in virgin aggregate requirement.

- Reduction in virgin bitumen requirement.
- Reduction in disposal of milled pavement material.
- Reduction in transportation of new materials.
- Potential reduction in project cost.
- Promotion of circular economy in road construction.

The benefit depends on RAP quality, binder content, aggregate gradation, RAP percentage, processing, rejuvenator requirement and mix design.

Approximate Cost:

For 7.00 m × 1 km: approximate cost **₹180-230 lakh/km (₹1.80-2.30 crore/km)** for a suitable RAP-based bituminous pavement configuration.

7. Steel Slag Aggregate in Bituminous Concrete Layers

Steel slag aggregate is a processed aggregate obtained from steel-making slag and suitably treated for use in road construction. After appropriate processing, ageing and testing, it can be considered as a partial or substantial replacement for natural aggregate in selected pavement layers.

Recommended Location:

- High-traffic roads.
- Bituminous base and binder courses.
- Wearing courses where suitable skid resistance and aggregate strength are required.
- Locations near steel-producing areas where processed steel slag is economically available.

Reference:

The use may be considered with reference to:

- IRC:SP:121-2018 – Guidelines for Use of Iron, Steel and Copper Slag in Construction of Rural Roads.
- Guidelines for utilisation of processed steel slag aggregates in road construction developed by CSIR-CRRI and released through NITI Aayog.
- IRC:37-2018 – Guidelines for the Design of Flexible Pavements, where applicable to pavement-layer materials.
- Applicable MoRTH Specifications and relevant IS specifications for aggregates and bituminous mixtures.

IRC:37-2018 also recognises slag among materials that may be used in appropriate granular pavement layers, subject to the applicable requirements.

Expected Outcomes:

- Utilisation of industrial waste in road construction.
- Conservation of natural aggregates.
- Reduction in disposal of steel slag.
- Potential improvement in aggregate strength and skid resistance.
- Reduction in environmental impact associated with extraction of natural aggregates.
- Promotion of circular use of industrial by-products.

The suitability depends strongly on expansion potential, ageing/weathering, gradation, durability, abrasion, source characteristics and quality control.

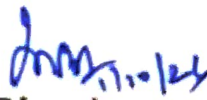
Approximate Cost:

For 7.00 m × 1 km: approximate cost ₹190–240 lakh/km (₹1.90–2.40 crore/km) for a suitable bituminous pavement configuration using processed steel slag aggregate.

Summary of Approximate Costs (7.00 m × 1 km)

No.	Technology	Approx. Cost (₹ lakh/km)	Nature of Estimate
1	Fibre-Reinforced Concrete	656	Total pavement cost
2	Pervious Concrete	300-350	Total pavement cost
3	GGBS in Concrete Pavement	550-600	Total pavement cost
4	Geosynthetics	300-320	Total pavement cost
5	CTSB/CTB	250-300	Total pavement cost
6	Reclaimed Asphalt Pavement	180-230	Total pavement cost
7	Steel Slag Aggregate	190-240	Total pavement cost

Note: The above rates are indicative and are based on assumed design inputs. Project-specific estimates shall be prepared based on site investigation, structural design and the prevailing Schedule of Rates.


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