Proven Preventive Measures for Resilient Slab Track Systems

Insights from High-Speed, Semi-High-Speed

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Outline

1. Evolution of Slab Track systems

2. Global preference for Slab Track systems

3. Cost share of Precast Slab Track

4. Process of manufacturing & installation of Slab Track

5. Key factors influencing resilience of Slab Track

6. Correlation matrix for resilient Slab Track

7. Engineering recommendations for Slab Track's resilience

1. Evolution of Slab Track System

1960s – 1980s

Early Development
Japan (Shinkansen) Germany (Rheda)
- Designed to replace ballast
Focus: **stability and low maintenance**

Speed: *Up to 210 km/h*

1990s – 2000s

System Diversification
- Wider adoption across Europe and Asia
(precast and cast-in-situ designs)
Focus: **Easy construction and vibration control**

Speed: *Up to 250 km/h*

2000s – 2010s

Rapid System Integration
- Slab track became standard for **HSR lines**
Focus: **fastening technologies**

Speed: *250–350 km/h*

2010s – Present, Modern Era

Dominance of Precast Concrete Slab Track
(rapid installation and high precision)
Focus: Integration with **AI**, **digital QC, and LCC optimization**

Speed: *350–400+ km/h*

2. Global preference for Slab Track system

2.1. Precision & quality

2.2. Fast construction & reduced disruption

2.3. Enhanced durability

2.4. Lower Life-Cycle maintenance

2.5. Reliability Proven

2.1. Precision and quality

- Factory-produced under controlled conditions
- Ensures dimensional accuracy and uniform performance

Illustration of allowable tolerances for slab track in European and Asian projects

Item	Inspection	Tolerance (mm)
1	Length	±6.0
2	Width	±4.0
3	Thickness	±4.0
4	Dowel spacing	±1.0
5	Interior fastener shoulder distance	±1.5
6	Exterior fastener shoulder distance	±1.5
7	Planarity	±2.0
8	Arch rise dimension	±0.3
9	Slop deviation	±0.5
10	Deviation of the bearing surface	±0.7

Item	Inspection	Tolerance (mm)
1	Length (longitudinally)	±3.0
2	Length (diagonally)	±3.0
3	Width	±3.0
4	Thickness	+3.0
5	Space between inserts	±1.0
6	Diameter at semi-circle portion	±3.0
7	Twist	±1.0
8	Slant at insert	±1.0

2.2. Fast construction and installation

- Precast elements allow rapid installation
- Ideal for projects requiring minimal operational downtime

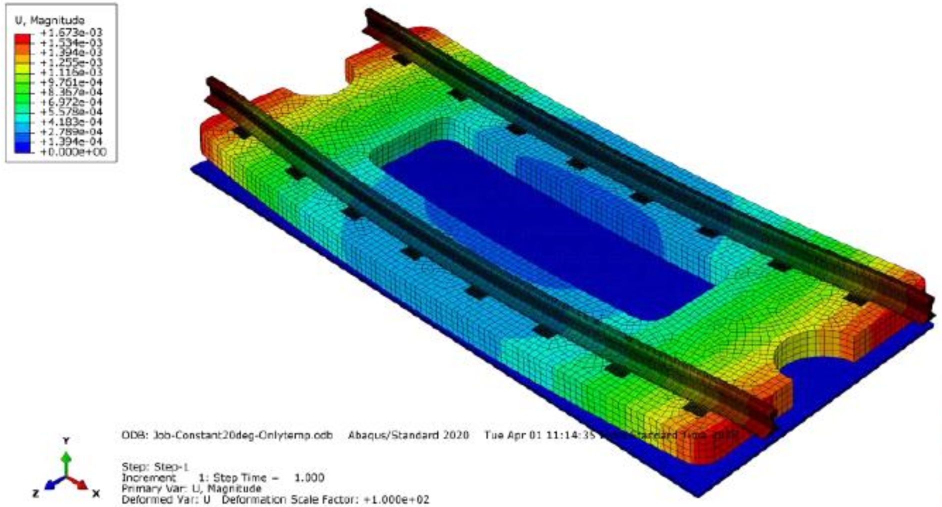
Precast Slab Track
Production cycle: 20 hours

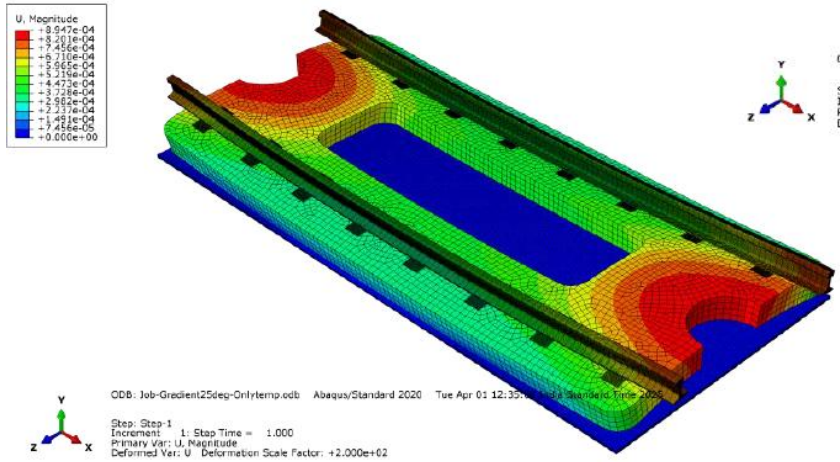
100 km Single Track (scenario for discussion)

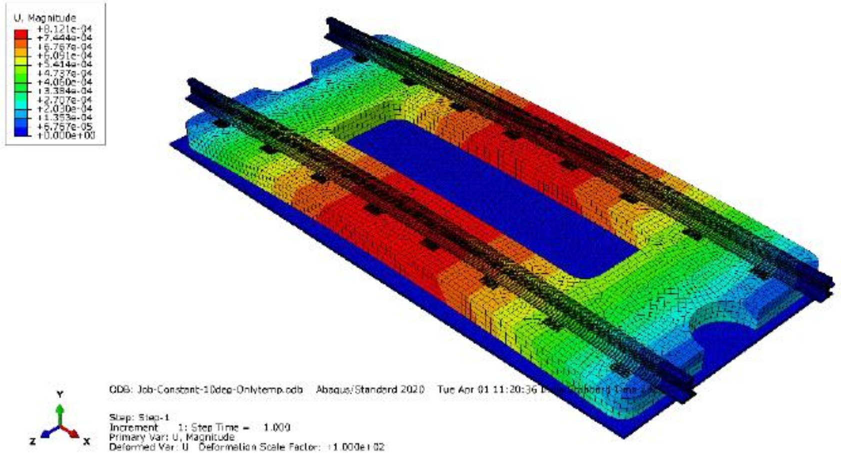
Slab production rate	100 slabs/day
Total production period	≈8 months
Installation rate	200m/day
Total installation period	≈4 months
Total production and installation period	6 months (2 months buffer stock for slabs)

2.3. Enhanced durability

- High resistance to fatigue, weathering, and environmental effects
- Maintains stability and alignment over long service life







2.4. Lower Life-Cycle maintenance

- Minimal ballast cleaning, tamping, or realignment required
- Reduced maintenance costs and extended service intervals

Construction cost VS Maintenance cost

Focus	Construction Cost	Maintenance Cost	Key Findings / Conclusions	Reference
Sanyo Shinkansen (Japan)	1.5x higher for slab track	¼ of ballasted track	Life-cycle costs balance ≈12 years	Ando et al.
High-speed lines (up to 360 km/h)	Competitive if <1500 €/m	Uncertain but potentially lower	Net Present Value nearly equal for both systems over 35 years	Rivier et al. (SNCF)
72 km section (320–360 km/h)	Slightly higher initial cost, compensated by savings in maintenance.	Lower due to stability of track	2–6% reduction in earthworks and ≈3.5% in civil engineering costs; cost balance over 50 years	Zabée (TGV Eastern Line)

2.5. Reliability proven

- Proven performance in high-speed, metro, and heavy-haul systems
- Supports long-term **reliability and safety goals**

Slab Track System in East and Southeast Asian countries

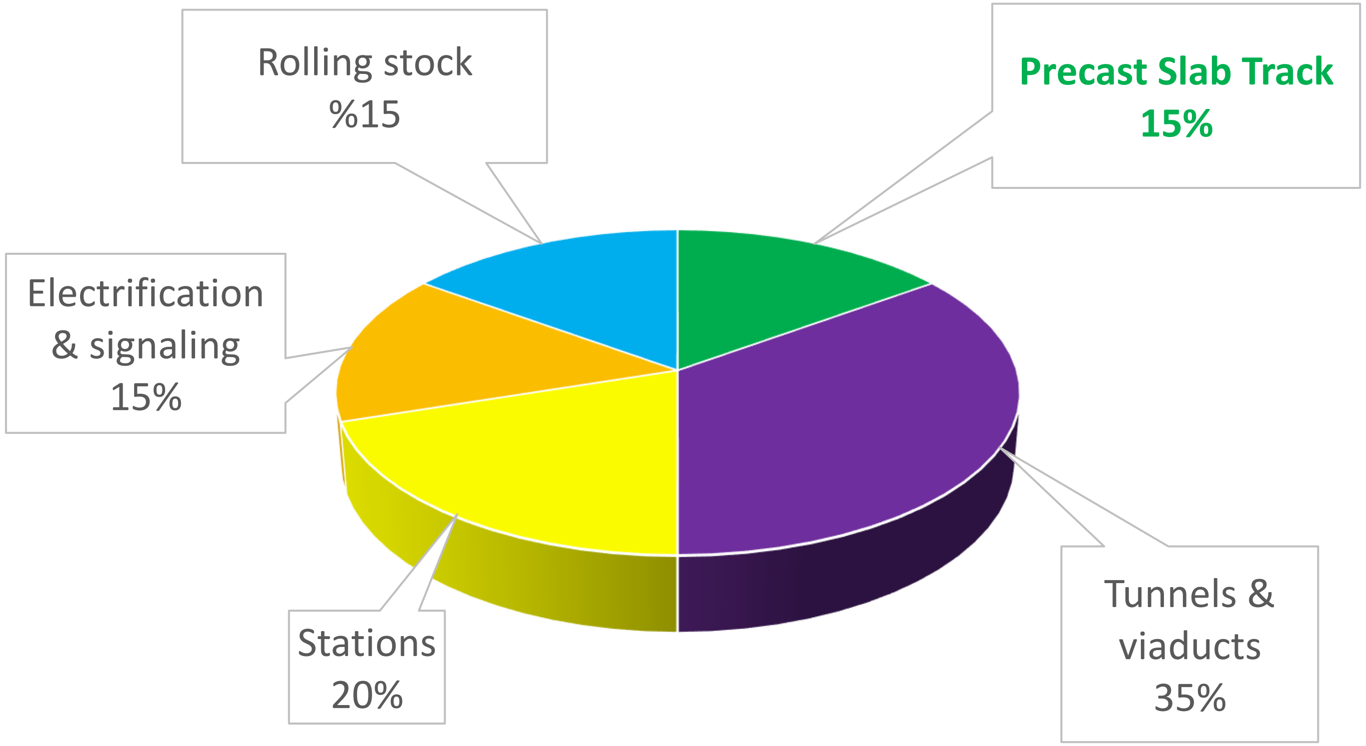
Country	Operational Length (km)	Typical Speed (km/h)	Slab Track System	Key Example Line(s)	Remarks
China	~48,000	300–350	**CRTS I/II/III**	Beijing–Shanghai, Wuhan–Guangzhou, Beijing–Hong Kong	World’s largest slab-track network
Japan	~3,700	240–320	**Shinkansen Slab Track**	Tokaido, Tohoku, Kyushu Shinkansen	Pioneer; benchmark for precision & reliability
South Korea	~1,100	300–320	**Hybrid Slab (Japanese-influenced)**	Gyeongbu, Honam KTX	Mix of embedded & direct-fixation slab
Taiwan	350	300	**Japanese Shinkansen**	Taipei–Kaohsiung HSR	Same system as Japan, adapted for local climate
Indonesia	142	350	**CRTS (Chinese)**	Jakarta–Bandung HSR	First operational HSR in Southeast Asia

3. Cost share of Precast Slab Track

Precast Slab Tracks' cost account for **10–20%** of the total project cost

While the track is a significant expense, other major costs include:

- Tunnels & viaducts
- Stations
- Electrification & signaling
- Rolling stock



4. Process of Manufacturing and Installation of slab track

- Reinforcement cage making
- Mould cleaning and preparation
- Reinforcement cage placement
- Pre pour inspection
- Concrete pour
- Compaction
- Finishing
- Initial curing
- Demoulding
- Post pour inspection
- Geometry inspection
- Secondary curing (if required)
- Storage yard
- Site delivery
- Site storage
- Shoulder installation
- Slab shifting to viaduct
- Slab laying
- Longitudinal, Lateral, Vertical slab alignment
- Grouting

5. Factors influencing resilience of Slab Track – Pre pouring stage

	Mould Cleaning	Mould Geometry	Reinforcement Cage Quality	Inserts Fixation
Typical Defects (on slabs)	• Poor surface finish • Bugholes • Edge defects	• Rounded edges • Uneven surfaces • Gaps in mould joints	• Uneven cover cage • Bond issues • Cage deformation	• Misaligned inserts • incomplete embedment • Defects around inserts
Preventive Measures	• Remove hardened con. • Inspect corners, joints, and insert locations • Apply release oil • Clean insert seats	• Verify dimensions, flatness & alignment • Ensure proper joint closure	• Place and secure cage using cover blocks and spacers • Rebars to be clean, rust-free, and properly fixed	• Fix inserts using jigs or clamps • Inspect after final positioning before pouring

5. Factors influencing resilience of Slab Track – Pouring stage

	Concrete Quality	Uniform concreting	Finishing	Curing
Typical Defects (on slabs)	• Segregation or bleeding • Variation in strength and durability	• Uneven concrete pouring • Voids, honeycombing	• Uneven surface • Tolerance in level • Surface cracking	• Shrinkage cracks • Reduced strength and durability
Preventive Measures	• Proper batching and mix design • Proper concrete transportation • Fresh concrete tests	• Pour in layers • Uniform vibration across entire slab • Adequate vibration frequency	• Finish surface according to design tolerance • Avoid overworking the surface	• Begin curing immediately after finishing • Use wet covers, curing compounds, or steam curing

5. Factors influencing resilience of Slab Track – Post pouring stage

	Concrete Maturity	Demoulding	Lifting	Factory Layout	Storage yard
Typical Defects **(on slabs)**	• Cracking • Deformation	• Chipping • Spalling • Surface damage	• Cracks due to bending • Reinforcement stress during lifting	• Slab damage during handling or transport	• Surface cracking • Staining
Preventive Measures	• Specified curing period • strength tests before demoulding • Monitor maturity	• Proper demoulding tools • Gradual and uniform release pressure	• Correct lifting points and anchors • Check crane capacity before lifting	• To have a liner set up • Plan clear movement and handling zones	• Proper ground condition • Storage in designated areas • Maintain drainage

5. Factors influencing resilience of Slab Track – Installation stage

	Transportation	Site Handling & Lifting	Grouting
Typical Defects **(on slabs)**	• Deformation • Warping • Cracking • Surface damage	• Cracks • Chipping • Anchor failure	• Voids or incomplete grout filling • Poor bond between slab and base
Preventive Measures	• Use a leveled surface • Use proper spacers • Avoid excessive stacking	• Approved lifting anchors • Safe lifting sequence • Safe crane capacity • Inspect rigging before every lift	• Proper injection sequence and equipment • Ensure complete filling and curing of grout/CAM • Monitor for leaks or segregation

6. Correlation matrix for resilient Slab Track

Defect's root cause study and analysis

1. Surface appearance defects
- Poor surface finish
- Bug holes / pinholes
- Uneven surfaces
- Discoloration and surface bleeding

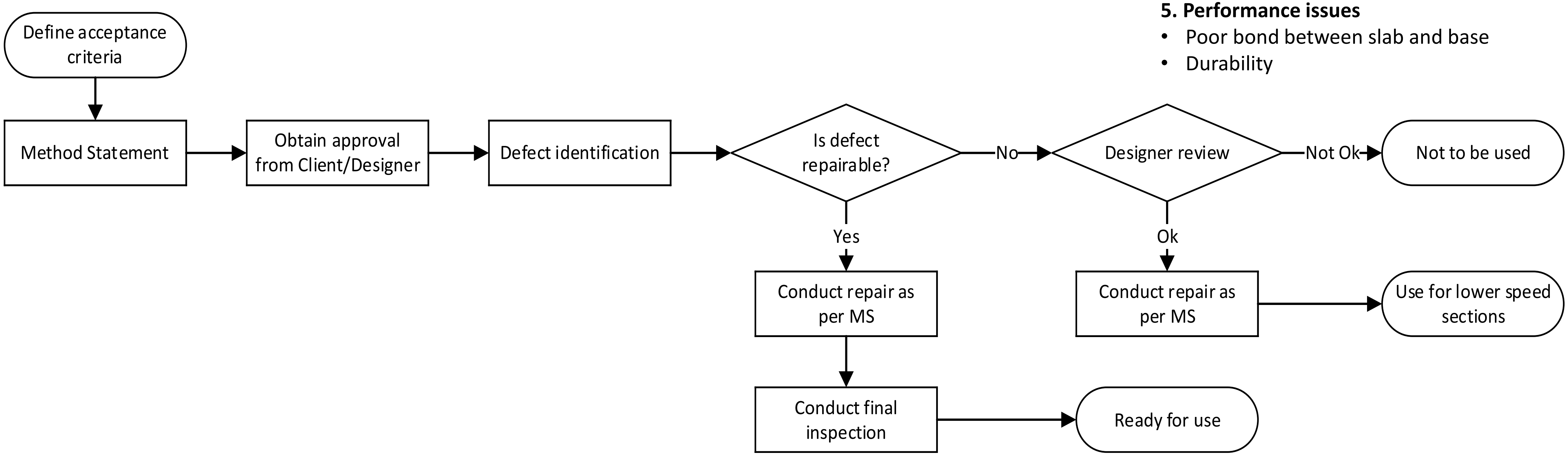
2. Edge and localized damage
- Edge defects
- Chipping
- Surface damage

3. Structural/Material defects
- Voids, honeycombing
- Drying shrinkage crack
- Plastic cracks
- Deformation

4. Insert and anchorage defects
- Misaligned inserts
- Partial embedment
- Defects around inserts
- Anchor failure

5. Performance issues
- Poor bond between slab and base
- Durability

In case of defect occurrence



7. Engineering recommendations for slab track resilience

- Train the production and installation team on every stage of implementation
- Concrete mixture optimization
- High level of automation for concrete production and distribution
- Controlled curing environment
- High level of accuracy and durability for mould and vibration system
- Demoulding criteria and equipment
- Minimize indoor handling of slab track units
- Handling and transport protocol
- Inspection procedures
- Defect identification and remedial action according to approved methods

Thank you for your attention!

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Get in Touch

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