40 Years Experiences of the Slab Track on Japanese High Speed Lines

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1. Introduction

- 1964 The Tokaido Shinkansen line was opened, as the first 200 km/h high speed railway in the world.
- 1965 JNR started to study on "New track structures."
- 1972 Ballastless "Slab track" was developed and applied on Sanyo Shinkansen line.

About 40 years

- 2007 1,244 line-km uses slab track.

(57 % of the Shinkansen network)

2. High speed lines in Japan

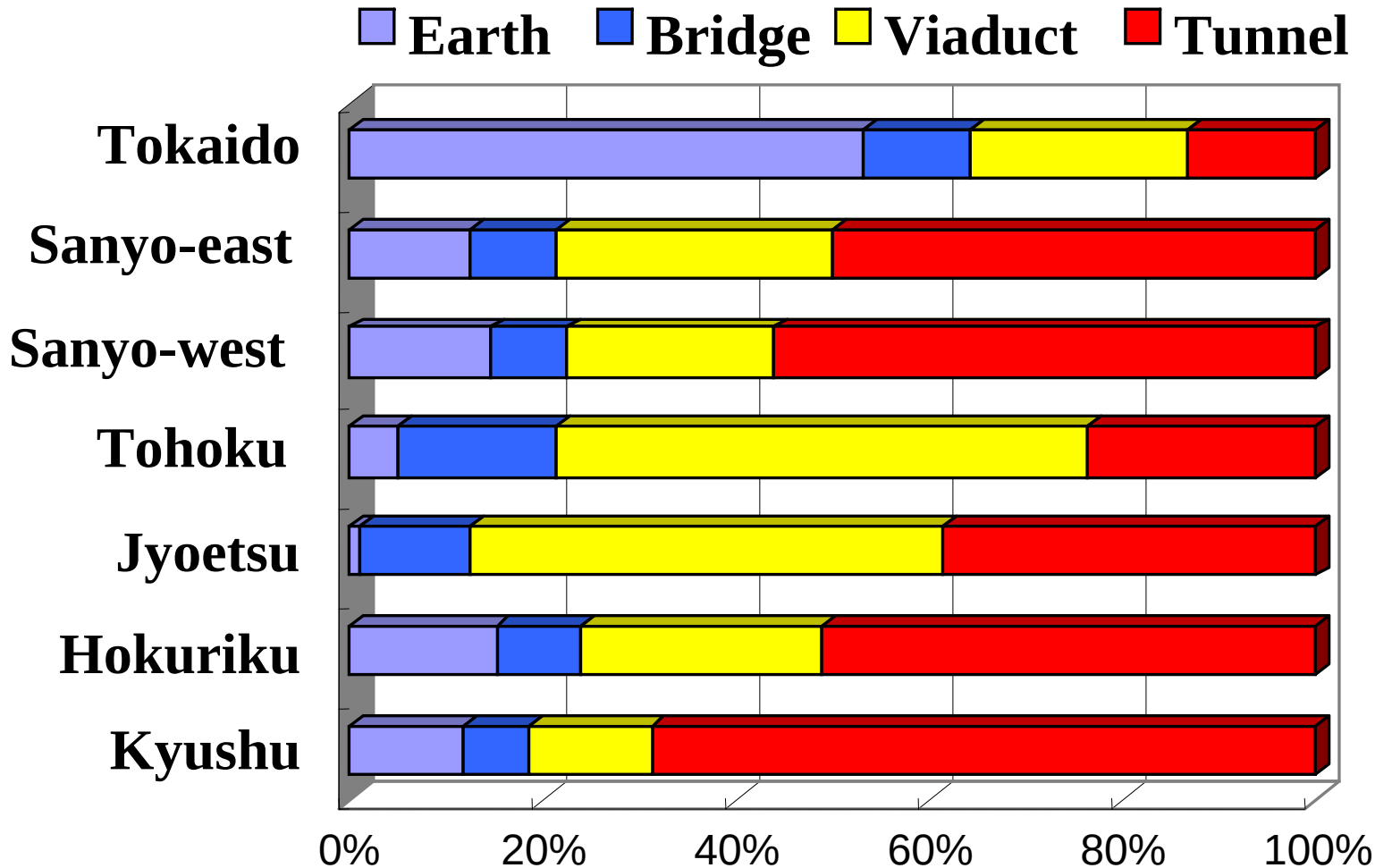
Route map of the Shinkansen lines

Blue: Operating (2,190 km)

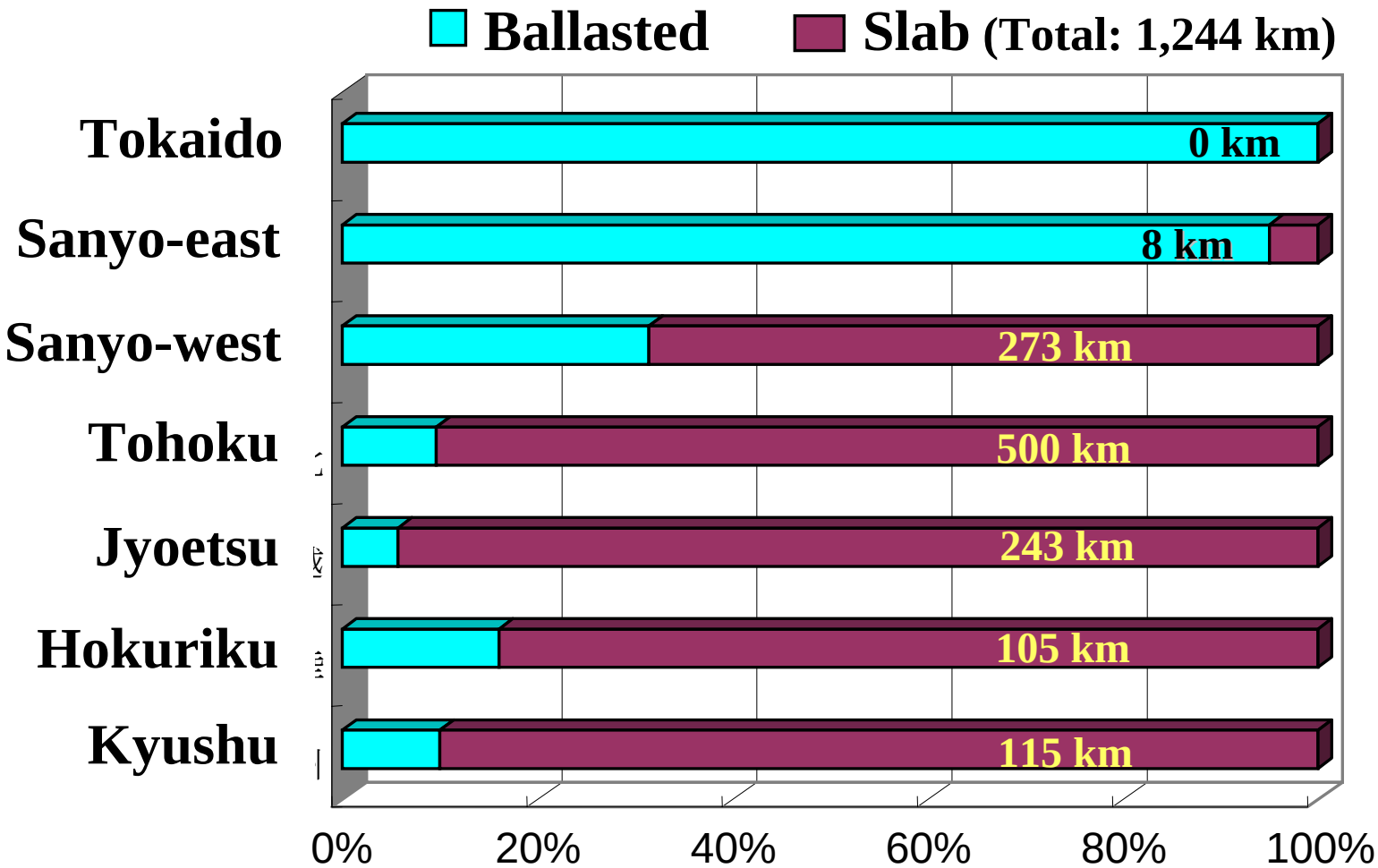
Red : Under construction (579 km)

Others: Planned

Infrastructure of Shinkansen



Track structure of Shinkansen



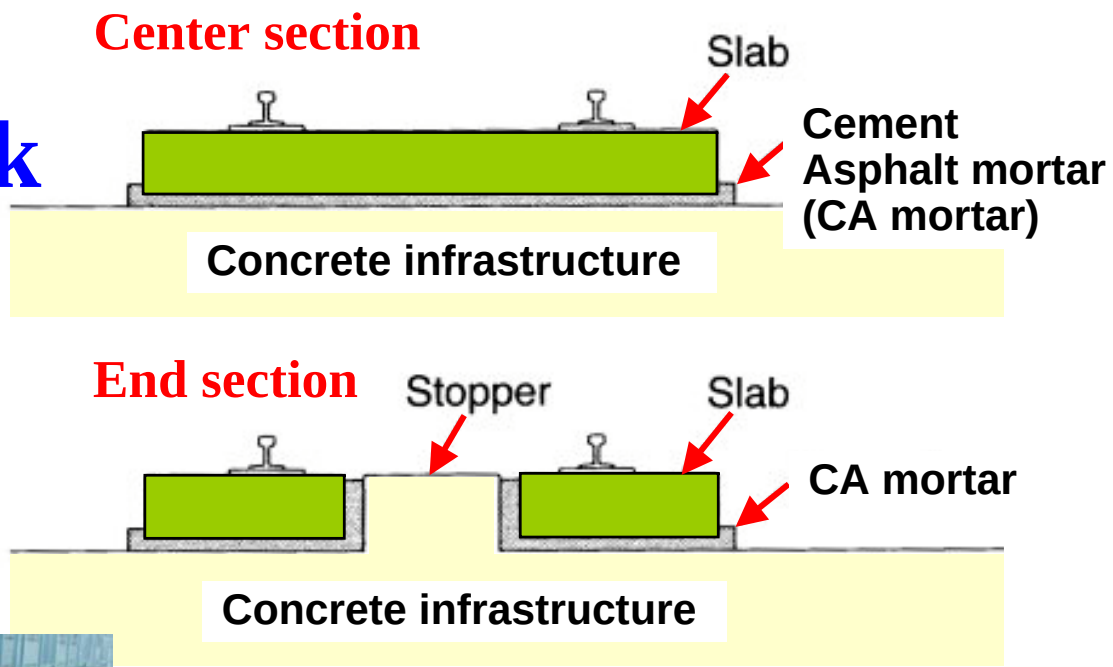
3. Design concept of the slab track

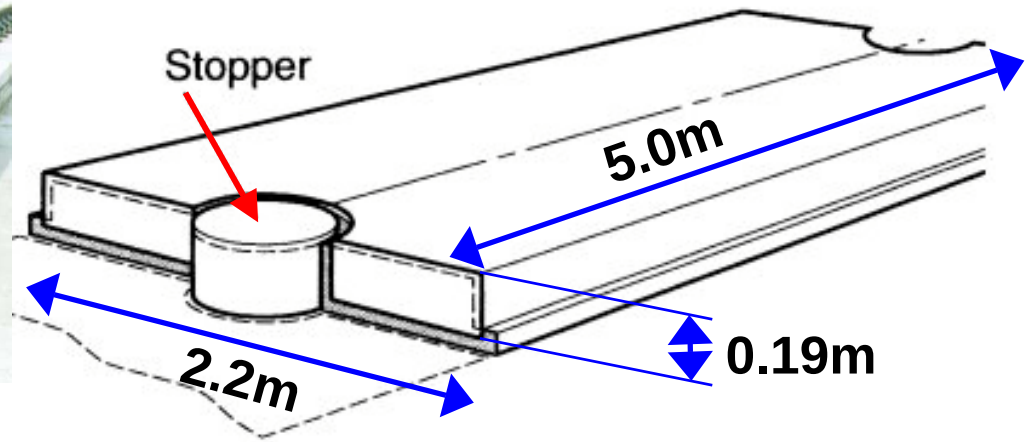
In 1965, the former Japanese National Railways (JNR,) started to develop "New Track Structures." The design targets were:

(1) A construction cost shall be less than twice as much as that of ballasted track.
(2) Elasticity and lateral/vertical strength shall be greater than those of ballasted track.
(3) A construction rate shall be at least 200 m/day.
(4) Track irregularities due to substructure deterioration shall be within the allowable range.
(+/-50 mm vertically, +/-10 mm laterally)

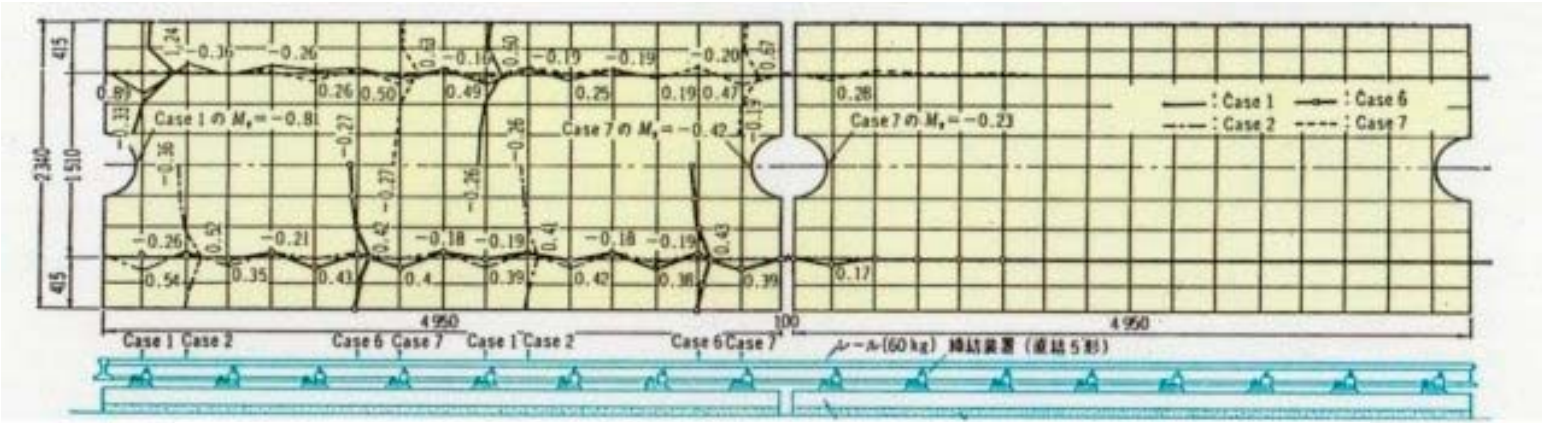
In 1972, the developed ballastless track structure was named "Slab track" and applied first on the Sanyo Shinkansen line.

Structure of the slab track

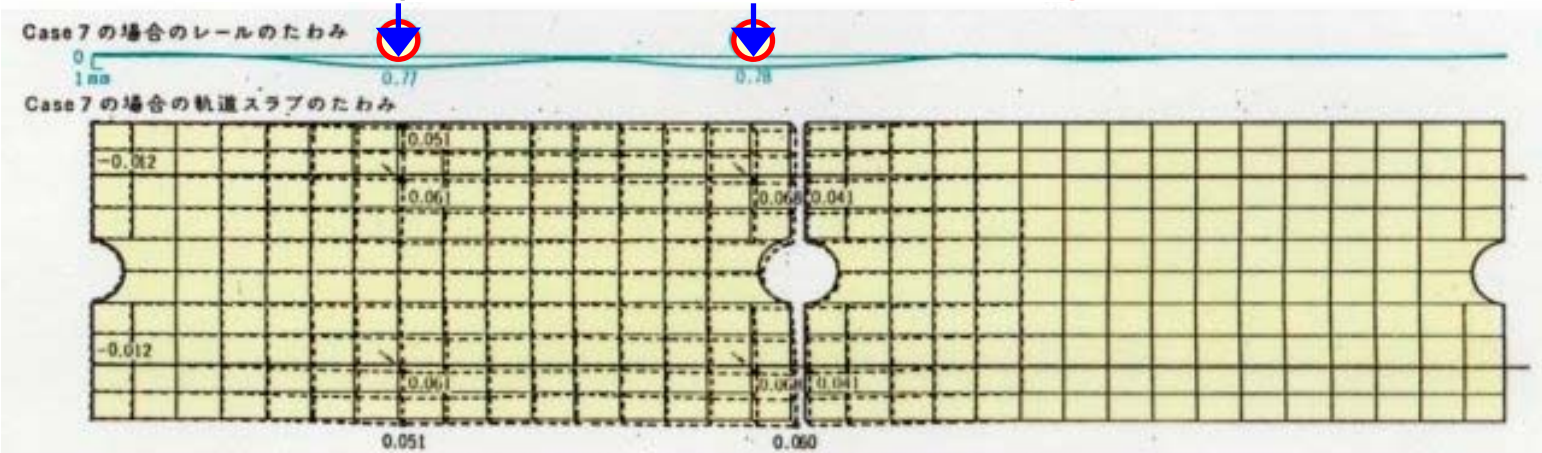




FEM analysis of track slab

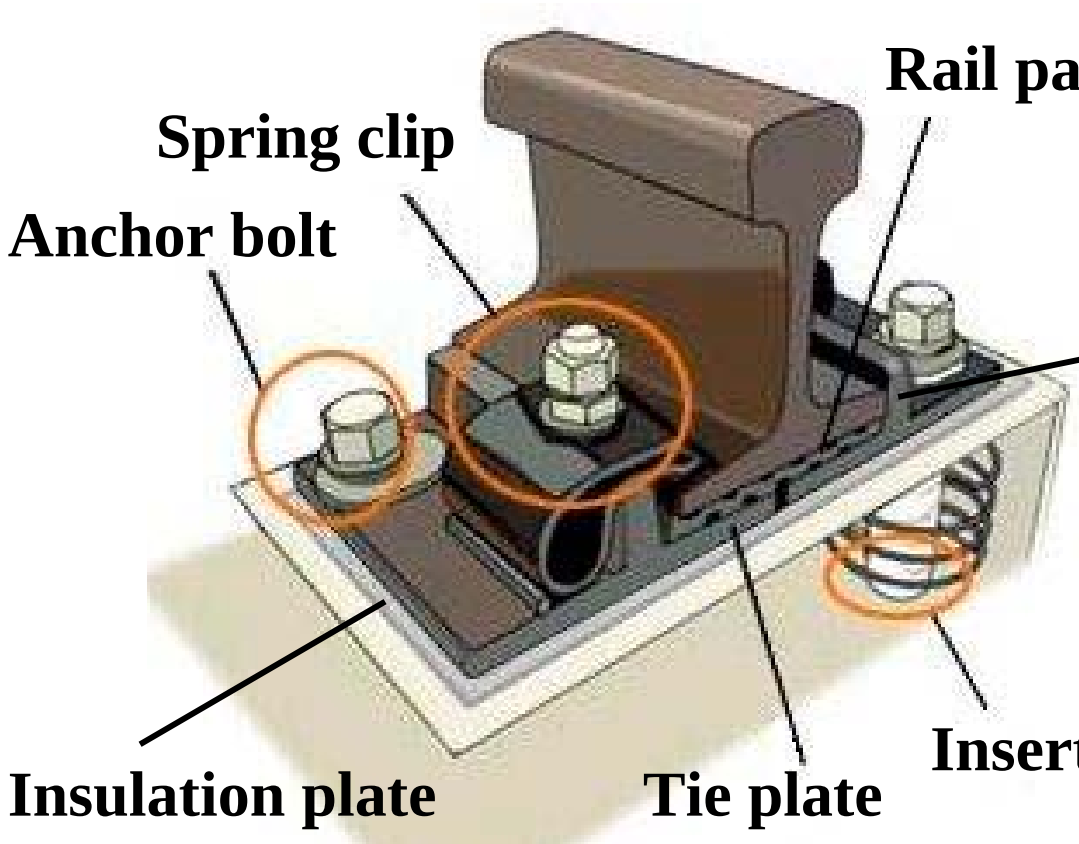


Example of calculation result of bending moment



Example of calculation result of displacement

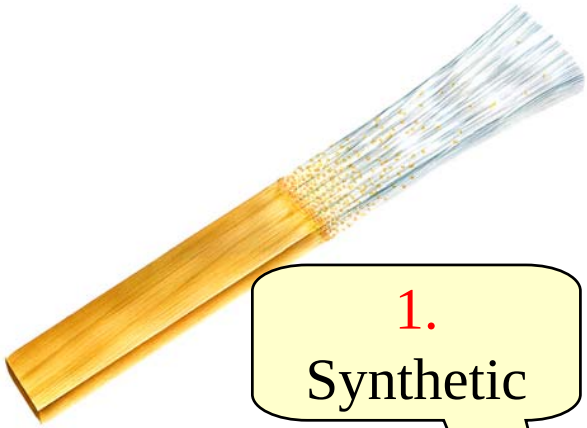
Rail fastening system (Type-8)

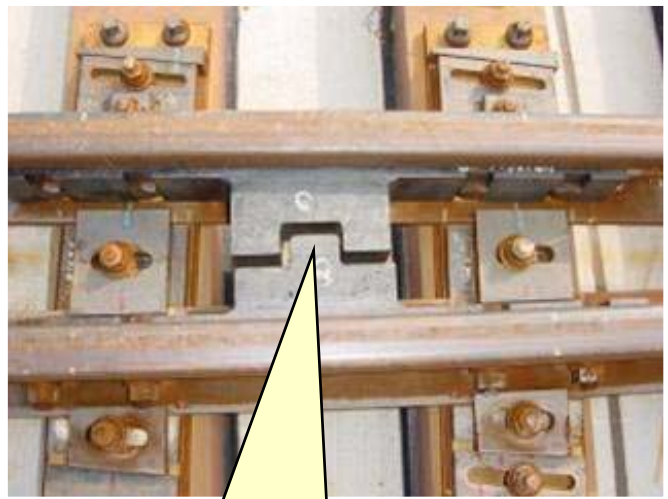


Vertical: +/-30mm

Lateral : +/-10mm

Turnouts on slab track





1. Synthetic sleeper

2. Double tie plate

3. Longitudinal movement stopper

Comparison of performance

Items	Ballasted	Slab
(1) Construction cost	Good	Poor
(2) Construction speed	Even	Even
(3) Construction precision	Even	Even
(4) Durability	Poor	Good
(5) Elasticity	Even	Even
(6) Maintainability	Even	Even
(7) Ballast scattering	Poor	Good

4. Construction procedure

(1) Slab manufacturing

(2) Temporary rail laying

(3) Slab carrying

(4) Slab laying

(5) Slab adjusting

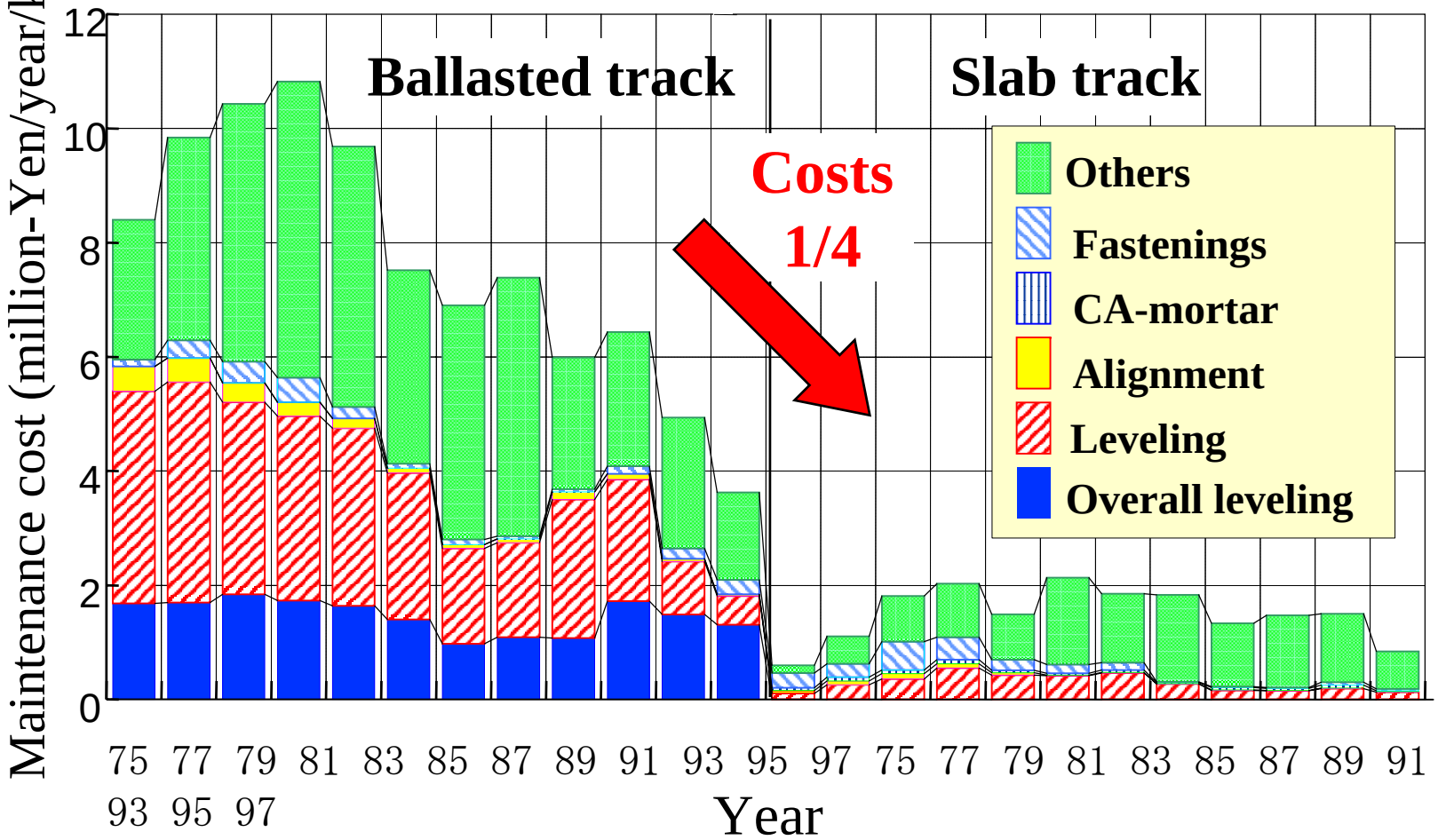
(6) CA-mortar injection

Construction speed of slab track (m/day)

Works	Standard Procedure	Fast Procedure	
(1) Slab manufacturing	200 m	300 m	Addition of formworks
(2) Temporary rail laying	800 m	1600 m	2-parties
(3) Slab carrying and laying	200 m	400 m	Using double track
(4) Slab adjustment	200 m	400 m	2-parties
(5) CA mortar injection	250 m	500 m	24-hours work

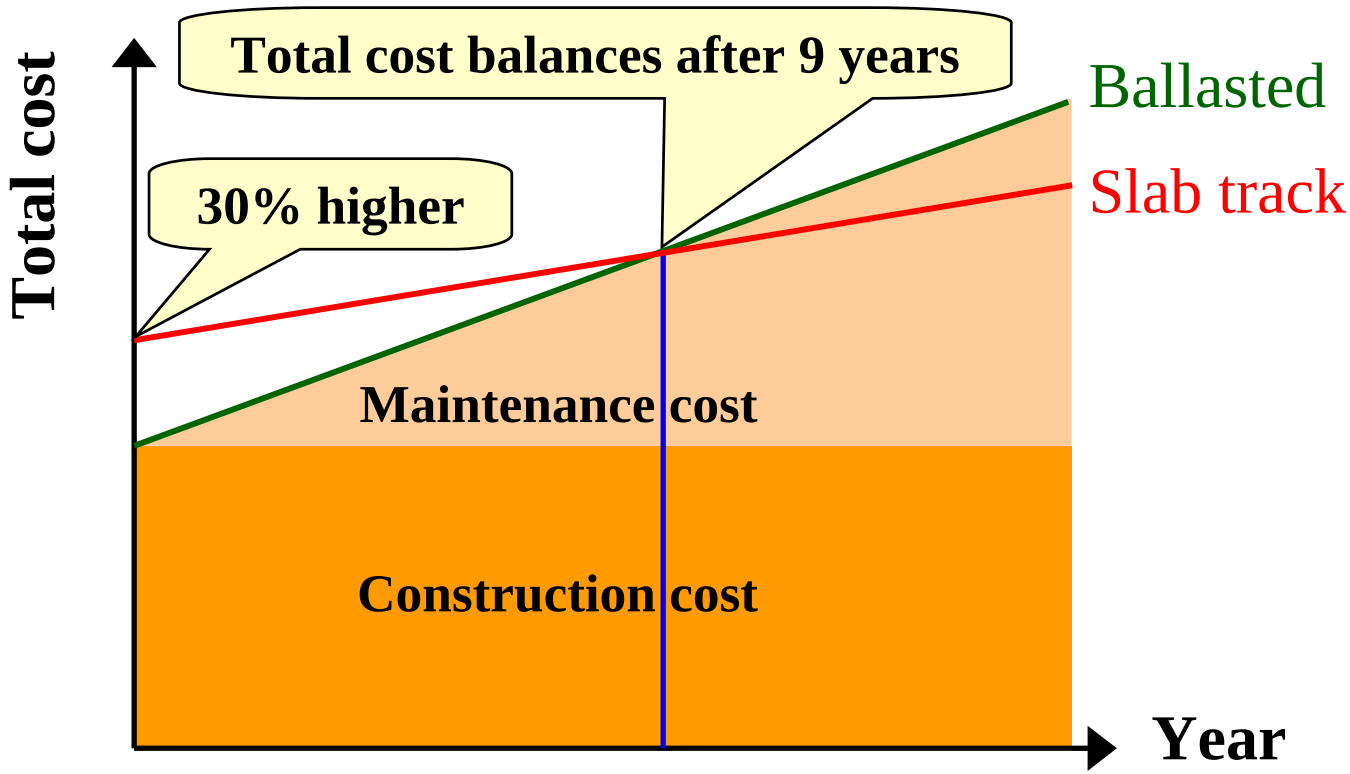
5. Construction and maintenance cost

Comparison of maintenance cost (Sanyo Shinkansen)



Comparison of total cost

Life Cycle Cost (LCC)



The lighter weight reduce the dead load of viaducts.
The lower height reduce the cross section area of tunnels.

Typical maintenance works

The slab track has high durability and needs considerably less maintenance works, but ...

Typical maintenance works of the slab track are;

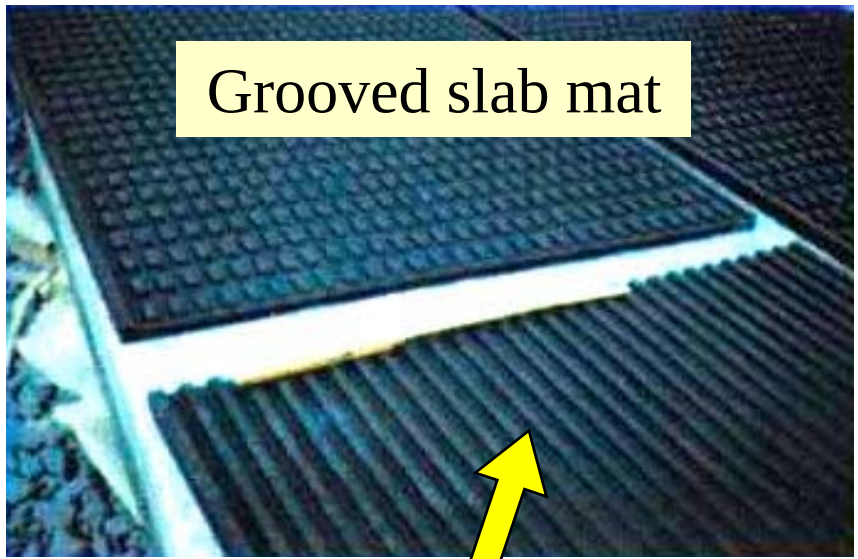
(1) Repair of cracks on the surface of CA mortar.
(2) Repair of rail fastenings.
(3) Correction of long-wave alignment irregularities.

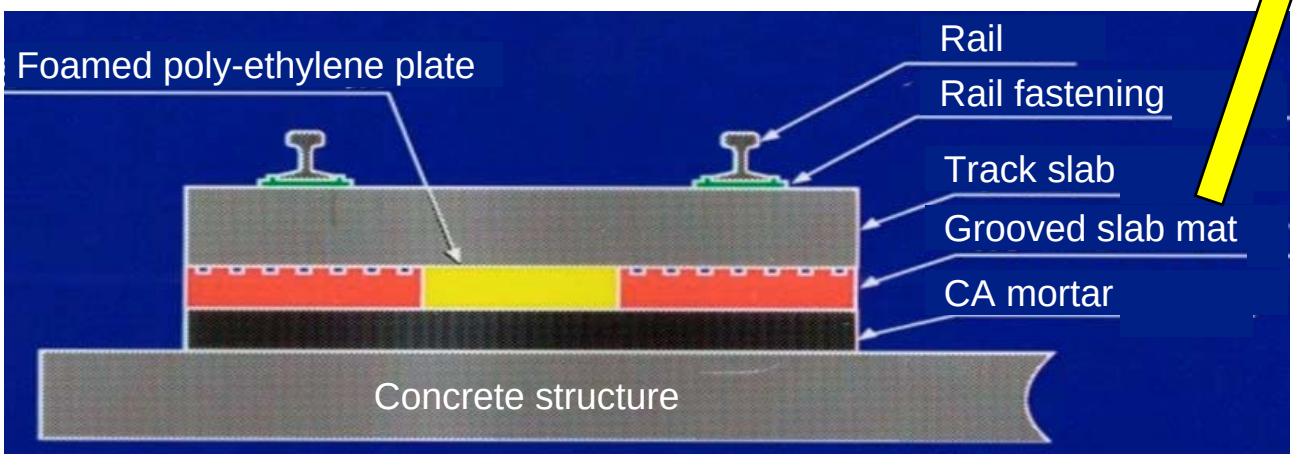
Almost no repair has been done for track slab, except;

(1) In a few cases, surface damage by freezing and thawing.
(2) As the exceptional case, some track slabs have been replaced in Kanmon undersea tunnel by salt content of leaked seawater.

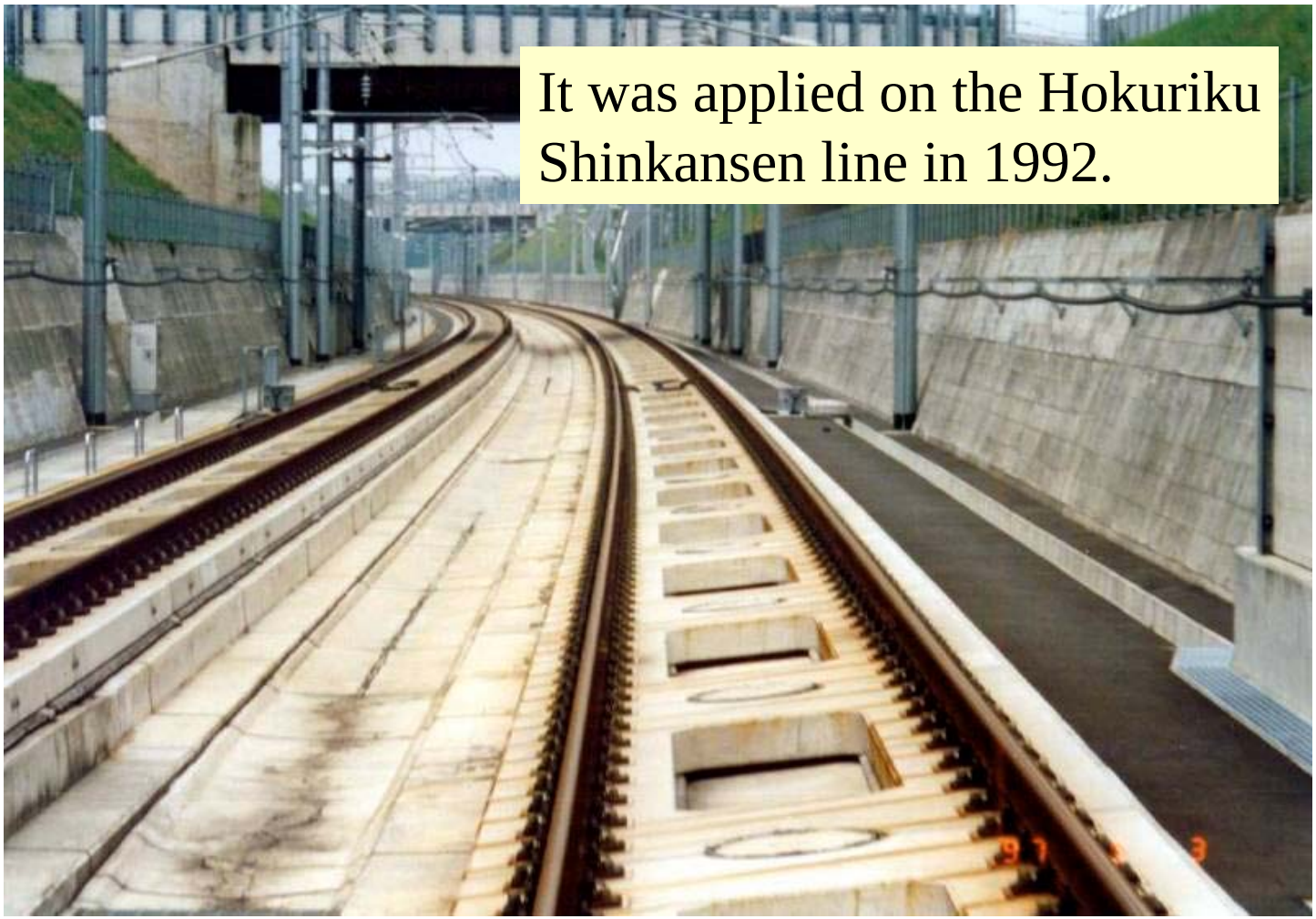
6. Variation of the slab track

(1) Type-G anti-vibration slab track

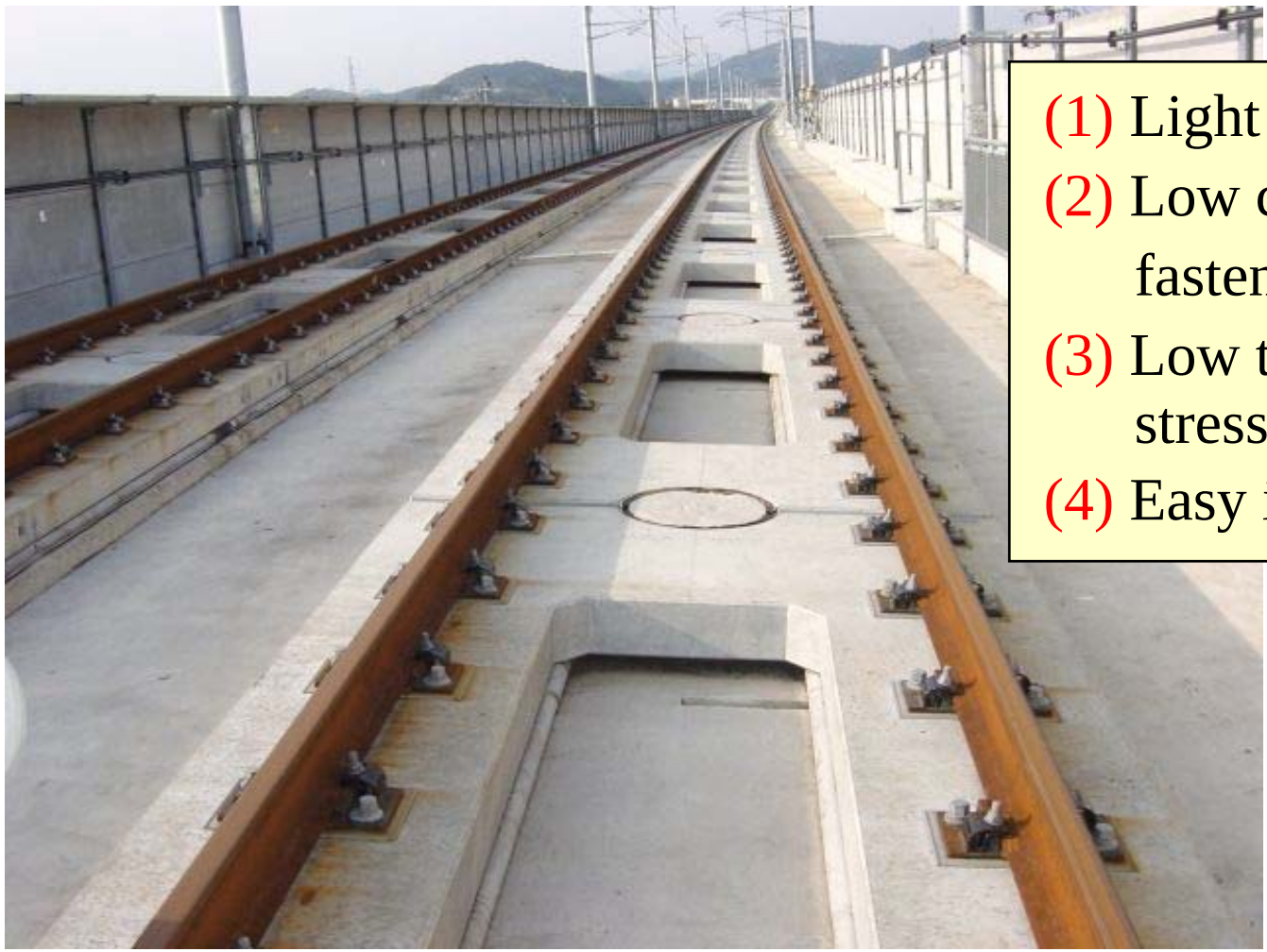




(2) Frame-shaped slab track on soil structures



(3) Frame-shaped slab track



(1) Light weight
(2) Low cost (8 to 7 fastenings/slab)
(3) Low temperature stress
(4) Easy inspection

7. Overseas extension of the Shinkansen

High speed lines in the world

Year	Nation	Train	Opening / Today speed
1964	Japan	Shinkansen	200 / 300 km/h
1981	France	TGV	260 / 300 km/h
1988	Italy	ETR	250 / 300 km/h
1991	Germany	ICE	280 / 300 km/h
1992	Spain	AVE	300 km/h
1994	Belgium	Talys	300 km/h
2004	Korea	KTX	300 km/h
2007	Taiwan	THSR	300 km/h

The others: UK, Sweden, Finland, Norway, USA, China, etc.

Taiwan high speed rail

Length:	345 km
Max. speed:	300 km/h
Time:	90 min.
Opened:	2007/01/05
System:	Shinkansen

Track of Taiwan high speed rail

Slab track (Japanese)
Standard track structure

Rheda track (German)
Stations and turnouts

8. Conclusions

1. The slab track has about 40 years experiences since it was developed at the end of 1960's in Japan .
2. There are approximately 2,500 track-km length of slab tracks on the Shinkansen lines.
3. High reliability and excellent LCC performance have been proven.
4. Special types (anti-vibration, on-soil and frame-shaped) of slab tracks have been developed and used.
5. The slab track is in the process of prevailing overseas.

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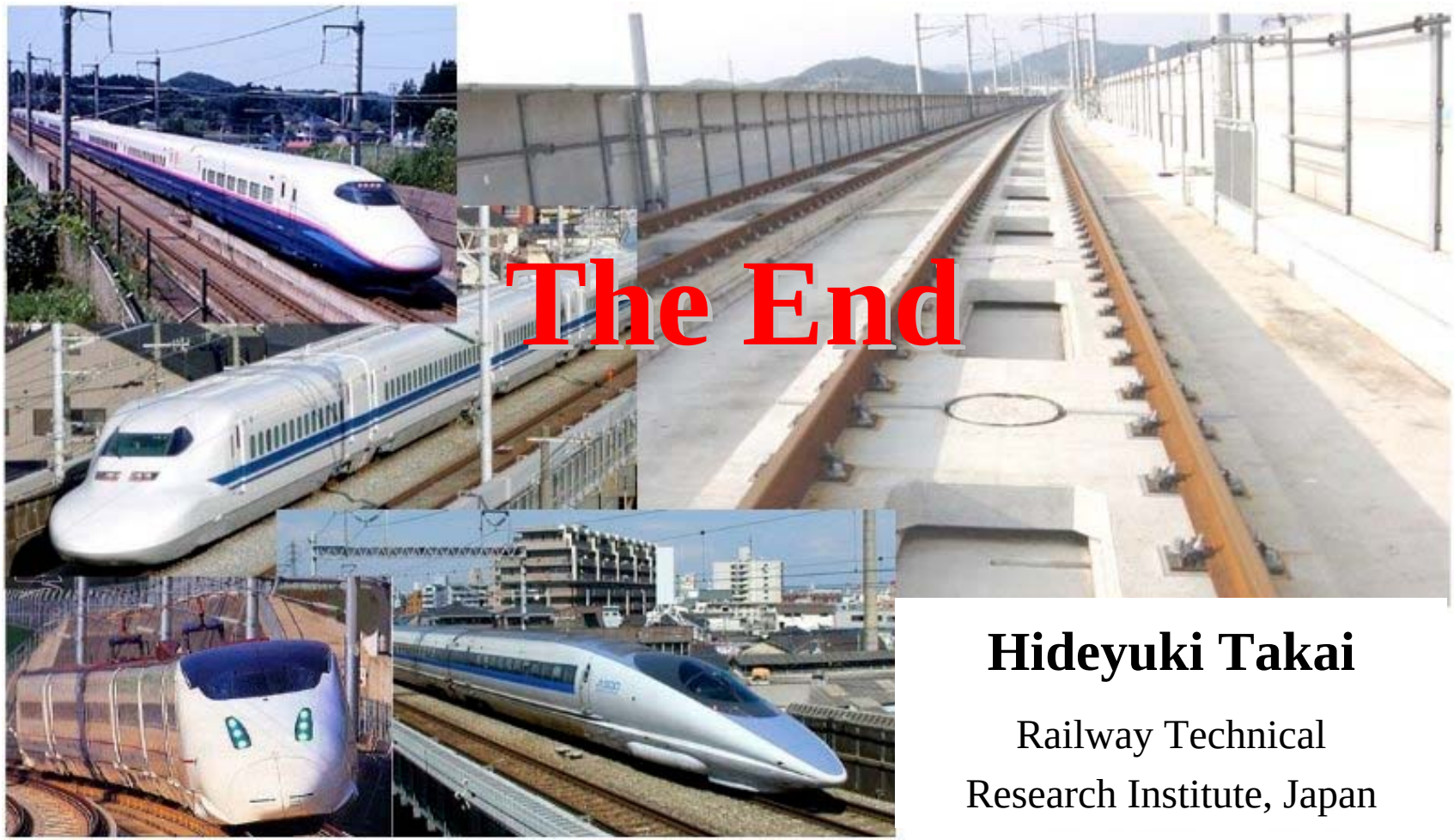

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