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Review and Evaluation of Track Designs for Joint High-Speed Rail and Heavy Freight Operations

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13. ABSTRACT
An increasing number of railway track segments in the U. S. will soon be required to carry both high-speed passenger and heavy freight traffic. In some cases, conventional track structures (i.e., ballasted crosstie tracks) may not be adequate for both types of service. They may not be capable of retaining the tight tolerances required for higher speed passenger service and withstand heavy freight axle loads without incurring excessive rates of track degradation. In order to address the needs of both types of rail traffic, an alternative track structure may be necessary to ensure adequate stability and reliability. However, any alternative design should be affordable in initial construction costs, allow greatly reduced maintenance requirements, and be maintainable within a realistic budget. There are a number of alternative track designs with potential for joint high speed and heavy freight operations. This report summarizes the review and evaluation of alternative designs developed and used in a number of countries, and the selection of several track forms to be further evaluated by actual field-testing. The review is focused on the main design features and characteristics of each track form and its performance results from testing and modeling. The evaluation of each track form is carried out based on factors including: potential for providing stability with both types of traffic, initial construction costs and ease of construction, reduced maintenance, ease of maintenance, durability and component life, and track availability.

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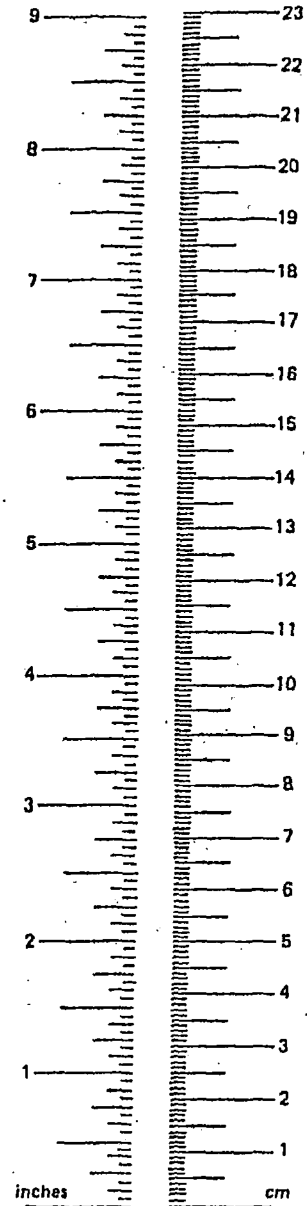
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.50	centimeters	cm
ft	feet	30.00	centimeters	cm
yd	yards	0.90	meters	m
mi	miles	1.60	kilometers	km
		AREA		
in^2	square inches	6.50	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.80	square meters	m^2
mi^2	square miles	2.60	square kilometers	km^2
	acres	0.40	hectares	ha
		MASS (weight)		
oz	ounces	28.00	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.90	tonnes	t
		VOLUME		
tsp	teaspoons	5.00	milliliters	ml
Tbsp	tablespoons	15.00	milliliters	ml
fl oz	fluid ounces	30.00	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.80	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0 76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



* 1 in. = 2.54 cm (exactly)

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.40	inches	in
m	meters	3.30	feet	ft
m	meters	1.10	yards	yd
km	kilometers	0.60	miles	mi
		AREA		
cm^2	square centim.	0.16	square inches	in^2
m^2	square meters	1.20	square yards	yd^2
km^2	square kilom.	0.40	square miles	mi^2
ha	hectares (10,000 m^2)	2.50	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.10	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36.00	cubic feet	ft^3
m^3	cubic meters	1.30	cubic yards	yd^3
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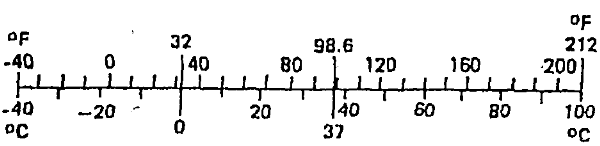

Executive Summary

There are a number of alternative or new track designs with the potential for joint high speed and heavy freight operations. These designs have been developed in a few different countries and vary in their design features and in their intended operation conditions, but all must address the basic factors including economics, reliability, durability, environment, construction workability, and maintenance costs.

In this report, track structures with the potential for combined high-speed and heavy freight operations are identified and reviewed concerning their design features and performance results from testing and modeling. For selecting several track forms for further testing at the Federal Railroad Administration's Transportation Technology Center in Pueblo, Colorado, these track forms are also ranked based on a number of evaluation criteria. Based on the review and evaluation results, frame sleeper track and embedded rail systems were selected for further field testing, noting that direct fixation slab track and independent dual block slab track are also being evaluated under a separate Portland Cement Association Slab Track Cooperative Research and Demonstration Program.

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1.0 INTRODUCTION

With the growth of urban areas and the increased congestion on highways and airports, more and faster railroad passenger service may be needed across the United States to help meet transportation demands. In some cases, economic and practical limitations will require passenger and freight trains to share at least some segments of the same tracks and rights-of-way.

In some cases, conventional track structures may not be adequate for both types of service. They may not be capable of retaining the tight tolerances required for higher speed passenger service and withstanding heavy freight axle loads without incurring excessive rates of track degradation.

This report summarizes the review and evaluation of track designs that have the potential to maintain required tolerances for higher speed passenger service while also withstanding heavy axle loads from freight service. A wide range of track designs developed in various countries are reviewed and evaluated. Several track forms are selected as candidates for further evaluation by actual field testing.

2.0 CONVENTIONAL VERSUS ALTERNATIVE TRACK STRUCTURES

Most of the currently available track forms that have the potential for joint high speed and heavy freight operations are identified and reviewed in this report. These forms are listed below (the first three forms are ballasted tracks; the last six are unballasted):

1. Conventional ballasted track with concrete or wood sleepers (crossties)
2. Ladder sleeper track (ballasted and ballastless)
3. Frame sleeper track
4. Embedded rail systems (the Dutch design and the Balfour Beatty design)
5. Cast-in sleeper slab track
6. Booted sleeper slab track forms including independent dual block track
7. Floating (pre-cast) slab track
8. Direct fixation slab track
9. Deck track

In general, conventional ballasted track with cross ties (sleepers) offers the following advantages and disadvantages:

- Lower capital cost and familiarity
- Ease of adjustment for alignment and level by ballast tamping
- Porous ballast material reduces noise and vibrations
- Maintenance doable with current equipment technologies
- High costs associated with inspection and maintenance, considerably higher for high-speed rail
- High lifecycle cost
- Geometry degradation over time; considerably higher with heavier axle loads
- Ballast breakdown and attrition over time, considerably higher with heavier axle loads
- High maintenance leads to loss of track availability
- Shooting up of ballast particles at high speed results in damage to wheels and rails

Conventional crosstie track may be reaching the limits of its economic advantage over alternative track structures. As traffic density, wheel loads, and train speeds increase, conventional track requires significantly greater track time for maintenance. In many situations, obtaining track time for maintenance may be difficult. The high cost of train delays, and thus track time, will lead to a trend more in favor of high initial cost but low maintenance track designs. In general, the alternative or new track structures offer the following potential advantages and disadvantages.

- Lower maintenance
- Higher availability of track
- Higher quality of track geometry, resulting in improved high-speed performance
- Higher lateral resistance and lower subgrade pressure
- Lower lifecycle costs
- Ease of computer simulations due to components with better-defined mechanical properties
- Limited experience with joint passenger and freight traffic
- Higher noise levels in most cases
- Higher capital cost

3.0 REVIEW OF TRACK STRUCTURES

This section gives an overview of each of the track forms with potential for high-speed passenger and heavy freight service. For detailed information, refer to the papers and reports included in the bibliography.

3.1 Conventional Ballasted Track with Cross Ties (Sleepers)

Ballast functions in track in a number of ways. It provides resilience and damping between sleepers and the subsoil. It provides adjustment for track geometry. And ballasted track is easy to adjust in cases where track settlement and roughness have occurred. Although a great deal of research has been conducted, few materials can match the cost-effectiveness and energy absorbing characteristics of ballast.

Wooden sleepers in traditional ballasted track are susceptible to wear and degradation over time, which can lead to frequent gage misalignment. Concrete sleepers can be used to overcome this weakness by providing a more rigid and durable rail support. However, the resilient effects of wooden sleepers are lost when using concrete sleepers, but can be partially regained by using rubber pads at rail seats. Sole pads can also be placed between concrete sleepers and ballast to help distribute load and reduce ballast pressure.

Ballasted track with concrete sleepers is currently used for shared passenger and freight service (e.g., the Northeast Corridor of Amtrak). In France, dual block concrete sleepers resting on ballast (Figure 1) are used on the TGV (Tren de Grande Vitesse) high-speed line. Compared with mono concrete sleepers, dual block sleepers provide higher lateral track resistance and require less concrete material.

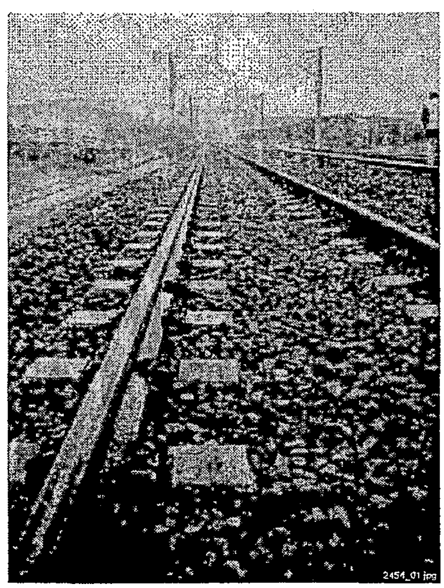

Figure 1. TGV Line – Ballast Track with Dual Block Sleeper

3.2. Ladder Sleeper Track

The concept of using longitudinal sleepers in track design has been around for as long as ballasted track itself. An advantage of using longitudinal sleepers is that they lie parallel to the rails and therefore provide the rails with continuous support. France, Japan, and the Soviet Union actively pursued track designs using longitudinal sleepers in the 1940s through 1960s. However, none of the older designs (Figure 2) was successful. Failures were attributed to their inability to maintain constant track gage and their overall overweight structure.

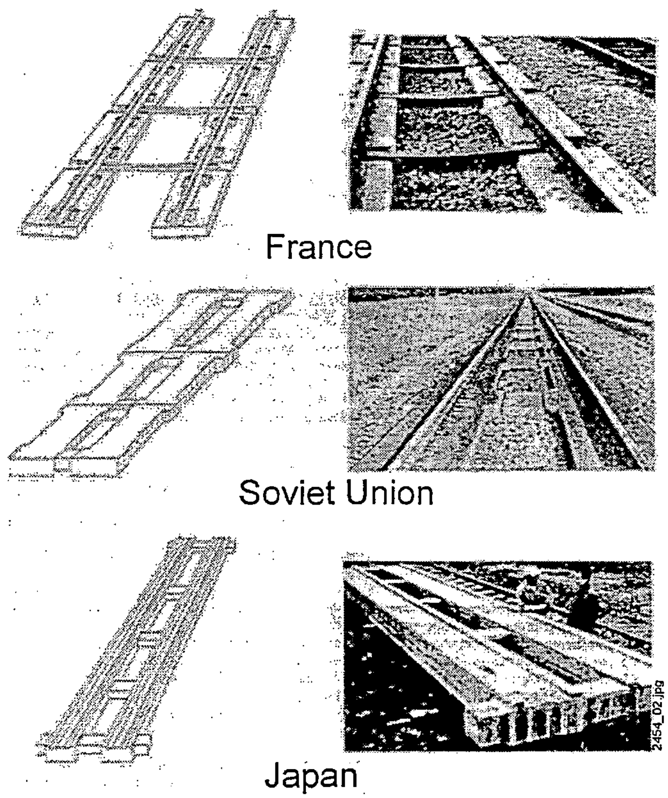

Figure 2. Unsuccessful Longitudinal Sleeper Designs

Since 1993, Railway Technical Research Institute (RTRI) in Japan has been developing a new track structure known as ladder sleeper track. As Figure 3 shows, ladder sleeper track consists of two longitudinal concrete beams connected by transverse steel pipes, which act as gage ties. Most ladder sleepers are designed to be placed in ballast with at least 10 inches of ballast depth, as Figure 4 shows. However, the floating version is designed to rest on asphalt or concrete base suitable for viaducts or in tunnels, as Figure 5 shows.

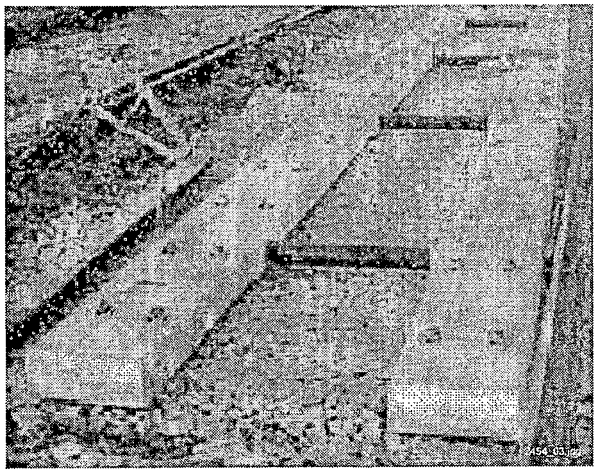

Figure 3. Ladder Sleeper

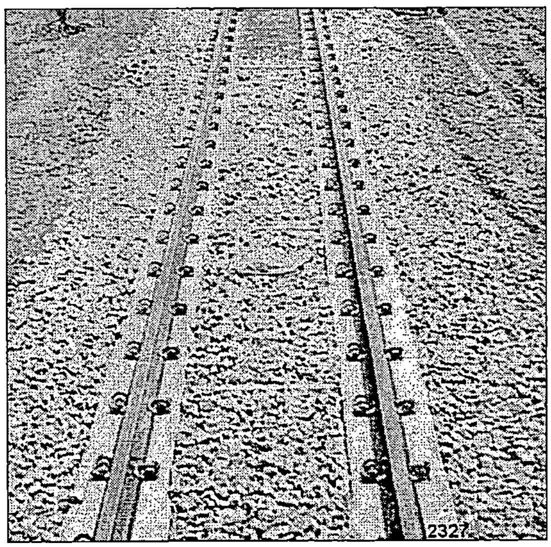

Figure 4. Ballasted Ladder Sleeper Track

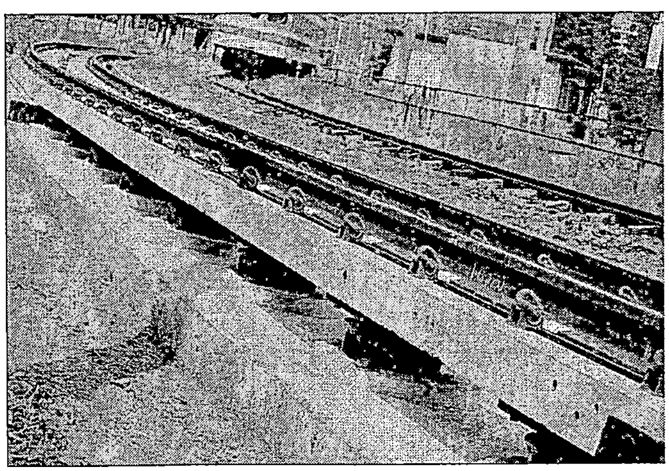

Figure 5. Non-Ballasted Ladder Sleeper Track

Figure 6 shows some of the details of the ladder sleeper developed by RTRI for heavy axle load application in North America. The concrete beams come in lengths of 6, 9, 12, or 15 meters and are 45 centimeters wide. Steel pipe connects two beams at an interval of 3 meters, and rail fastening is installed at a spacing of 75 centimeters. Pandrol e-clips with or without base plates are used to secure the rail to the sleepers. Rubber pads can be placed between the rail and sleeper and between the sleeper and ballast to improve resilience and load distribution.

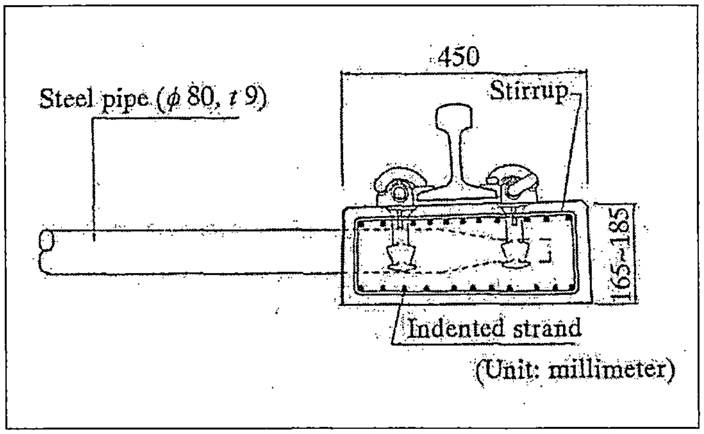

Figure 6. Details of Ladder Sleeper for Heavy Axle Load

The first test of the ladder sleeper track was on a 100-meter section of a JR (Japan Railway) East narrow gage freight line in 1996. In 1997, a 54-meter section was installed and tested for 150 MGT of heavy axle load traffic in a tangent section of the High Tonnage Loop (HTL) at the Federal Railroad Administration's Transportation Technology Center (TTC), Pueblo, Colorado. Later in 1998, another 45-meter section was installed in a 5-degree curve of HTL and was tested for 100 MGT.

Results of testing at TTC showed no structural or component problems, no tamping required for the test sections, and an average of 2 inches of track settlement. Figure 7 shows the test results of track settlement in the 5-degree curve (Wakui et al, 2001). Observed problems included rail clips at insulated joints falling out periodically, higher settlement at sleeper joints, and requirement of frequent spot tamping at transitions to the conventional track.

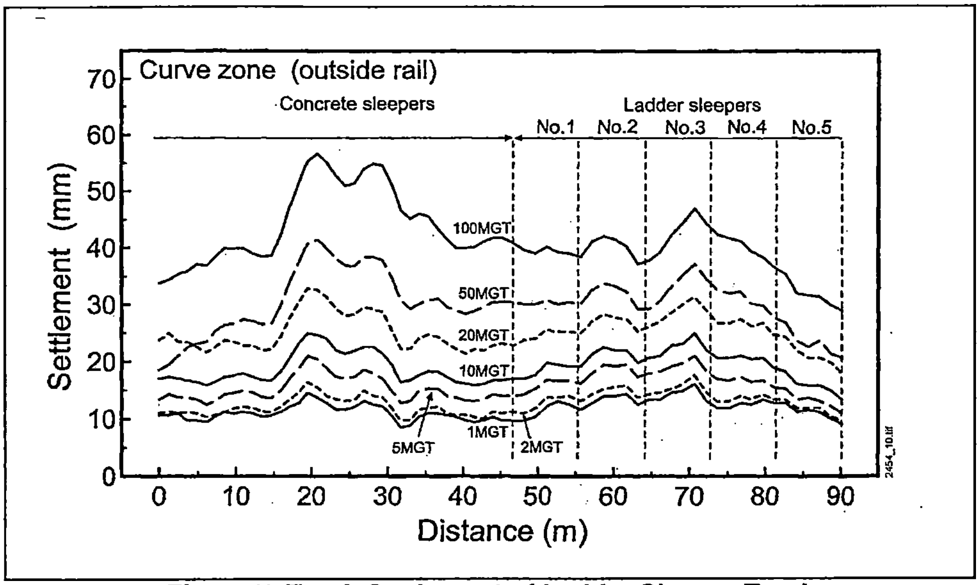

Figure 7. Track Settlement of Ladder Sleeper Track

RTRI concluded, based on modeling and laboratory test results, that ladder sleeper track can reduce ballast pressure by half, and produce settlement rates 8 times less than traditional concrete sleeper track. Modeling results also indicated that ladder sleeper track has excellent lateral strength to prevent buckling. The other cited benefits by RTRI researchers included that the design reduces short wave track irregularities and rail corrugation, and bridges across weak sections of subgrade.

One of the weaknesses of ladder sleeper is that it does not offer the same resistance to creep as crossties. The use of transverse steel plates, shown in Figure 8, can be used to resist creep.

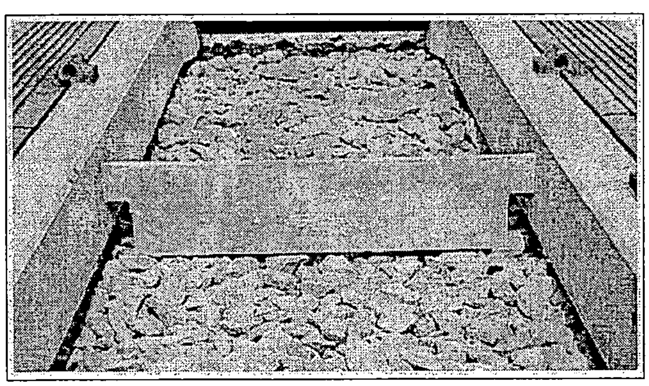

Figure 8. Transverse Steel Plate Used to Resist Creep

3.3 Frame Sleeper Track

Frame sleeper track is another type of ballasted track form developed in Austria. As Figure 9 shows, this type of track consists of two longitudinal concrete beams connected with cross beams.

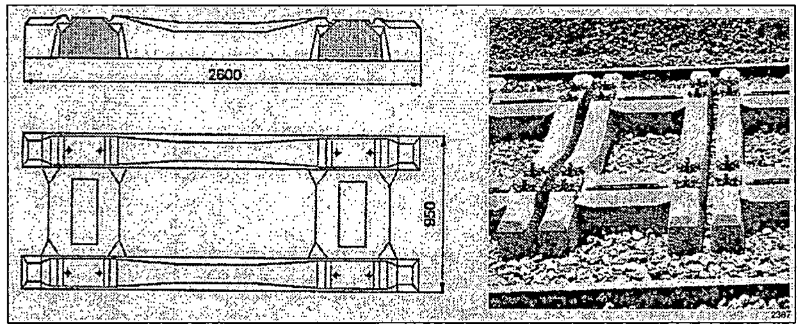

Figure 9. Frame Sleeper Track

With this design, the advantages of both longitudinal sleepers and cross ties are built into the frames. Each frame has four rail fasteners located near the corners of the frame, and the rails are almost continuously supported. Elastic pads can be placed under the rails and under the sleepers to improve track resilience and load distribution.

The frame sleeper track form was initially developed in Austria for use under 25-ton axle loads. However, an alternative version was later developed for use under 39-ton axle loads in North America.

The first test section of frame sleeper track was 130 meters long and was installed in Wien, Austria, in June 1999. This site was installed to test options for fully mechanized laying and maintenance (Figure 10).

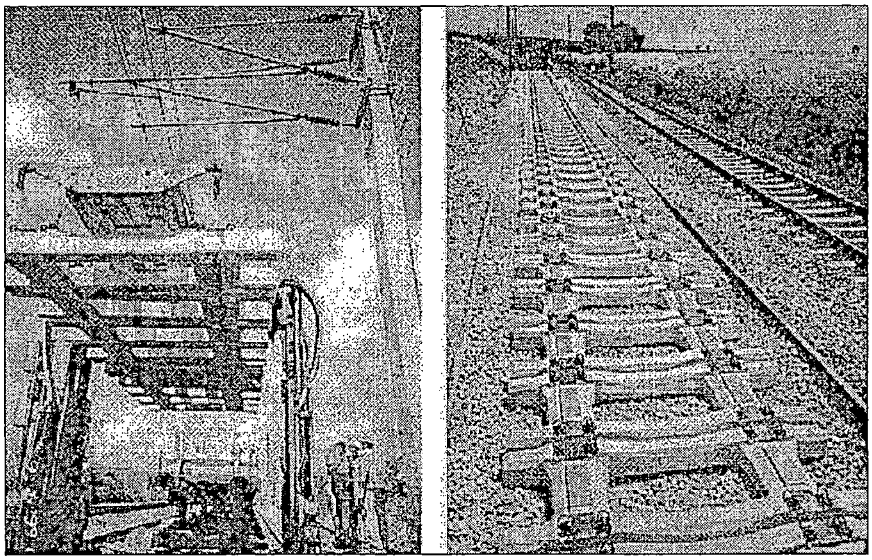

Figure 10. Laying of Frame Sleepers

A second 0.6 kilometer test site was installed in September 1999. This site included both tangent and shallow curve (Figure 11). For this test site, extensive measurements were taken including track settlement, lateral track resistance, rail stress, subgrade pressure, ground vibration, and airborne noise.

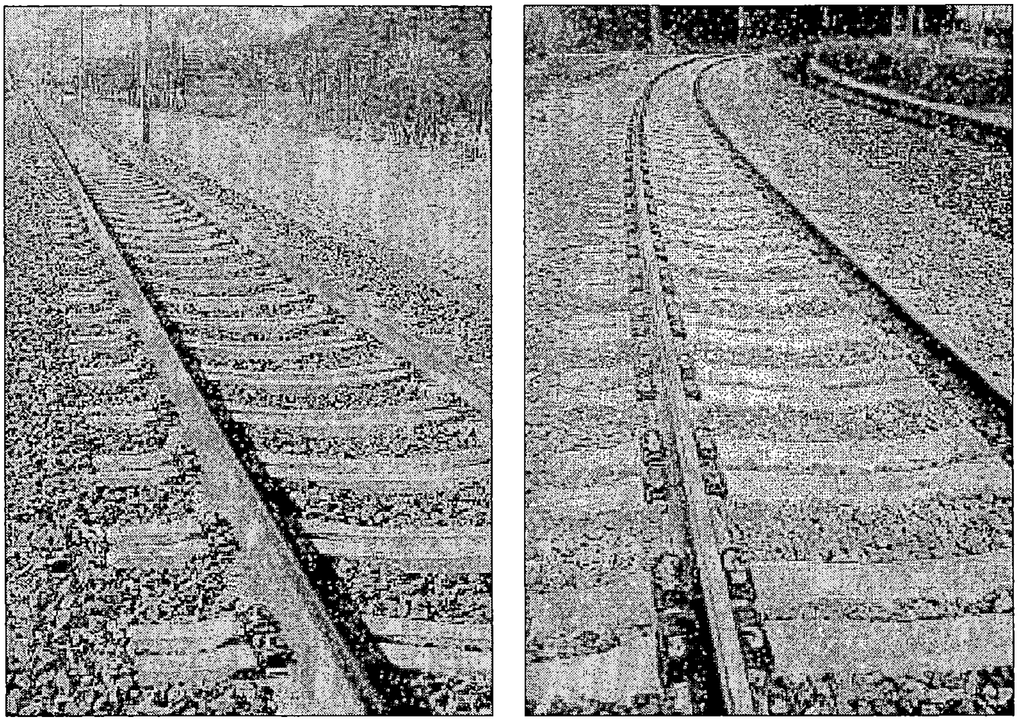

Figure 11. Frame Sleepers in Tangent and Curve Track

A third frame sleeper track section was installed later in an area that has steep gradient and sharp curves. In this area, frame sleeper track was installed as a remedy to reduce maintenance problems and costs. However, no performance results have been published at this writing.

Theoretical analysis and test results from the first two tests have shown that ballast pressure can be reduced by 20 to 50 percent compared with conventional track, leading to reduced settlement and track roughness. The uniformity of track deformation and ballast pressure for the frame sleeper track can be seen in the results shown in Table 1 (Riessberger, 2002). Frame sleeper track also offered high lateral track stiffness and resistance. Some problems that occurred early in the testing were high frequency vibration and hairline cracks in the concrete frames. There were also large settlements in transitions, similar to those observed in the testing of ladder sleepers at TTC discussed earlier.

Table 1. Deflections and Ballast Stresses for UIC60 Rails on Frame Sleeper Track under 200 kN Wheel Load

	Wheel over Mid-frame	Wheel over Cross-sleeper	Wheel over Gap
Rail deflection (mm)	4.0	4.1	4.1
Ballast deflection (mm)	2.9	3.0	3.0
Pressure under sleeper ends (N/mm^2)	0.18	0.19	0.19
Pressure under rail (N/mm^2)	0.12	0.12	0.12
Pressure under sleeper center (N/mm^2)	0.12	0.12	0.12

The study by the Austrian researchers also indicates that the capital cost of frame sleeper track is slightly higher than traditional track, but savings in maintenance can compensate for this. Their analysis has shown that frame sleeper track is about the same economically as traditional ballasted track over a 50-year lifetime.

3.4 Embedded Rail Systems

There are two types of embedded rail systems with potential for shared passenger and freight operation. One system was developed in the Netherlands and is known as Embedded Rail Structures (ERS). In ERS, the rails are embedded in a visco-elastic compound with only the rails head exposed (Figure 12). The track support comes from a concrete slab with troughs (Figure 13) on either side of the track. The rails are cast into the troughs using a corkelast compound, and therefore are continuously supported. Setting of the compound takes between half an hour and two hours. As Figures 12 and 13 show, traditional fastening is completely avoided in this type of track structure. A plastic tube is embedded on the outside of the rail to reduce the amount of corkelast compound used. In addition to the corkelast compound, a rubber strip underneath the rail provides additional resilience.

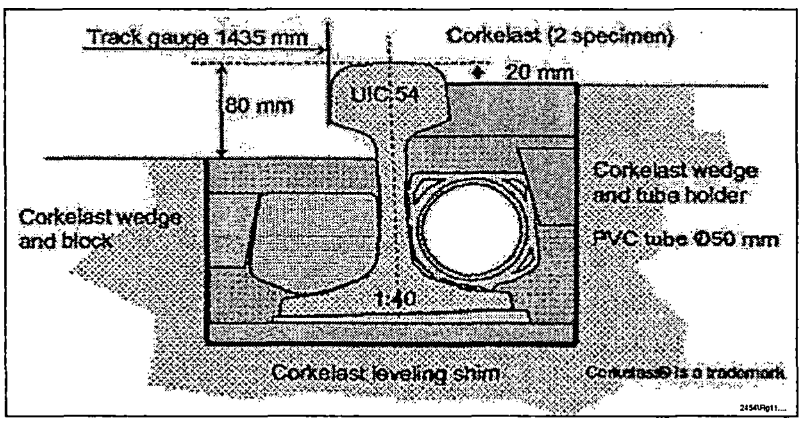

Figure 12. Rail Embedded in Corkelast Compound

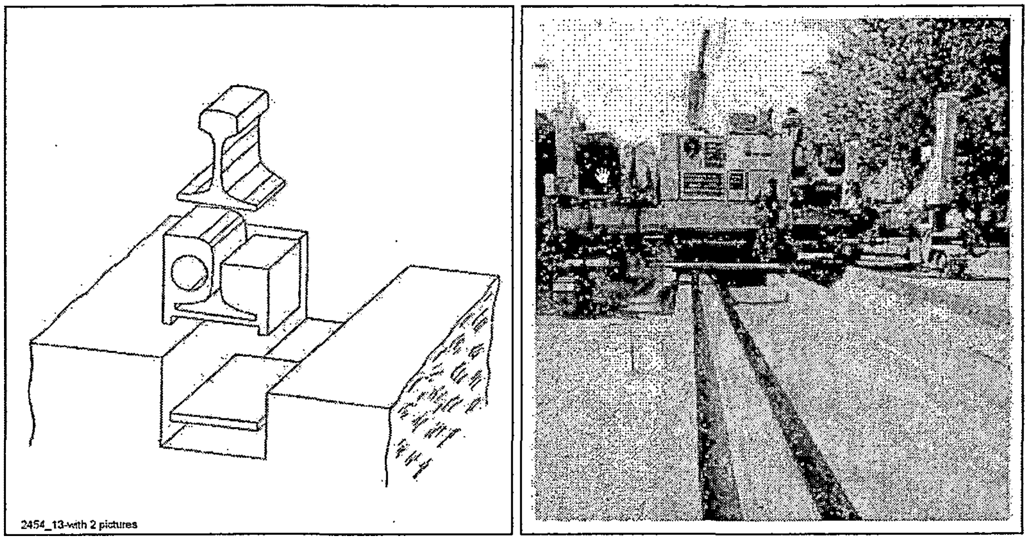

Figure 13. Construction of ERS

ERS has been used in the Netherlands and in Germany for many years. In Germany, this type of track is sometimes referred to as an Infundo or Edilon system. Use of ERS track in the Netherlands began in the 1960s for use on bridges. Since 1976, it has also been used for level crossings on heavy rail. Recently, a 3-kilometer section of ERS, as Figure 14 shows, was built near Best, Netherlands. Figure 15 shows use of ERS in a tunnel.

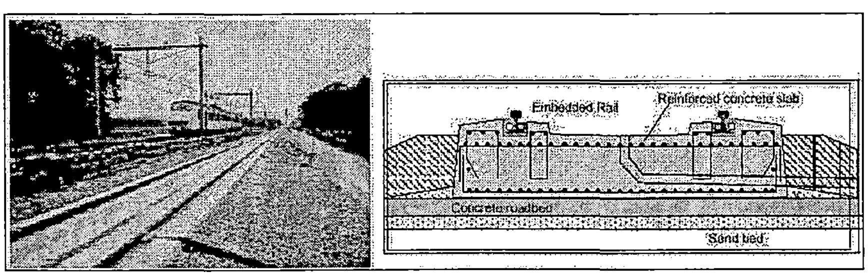

Figure 14. ERS near Best, Netherlands

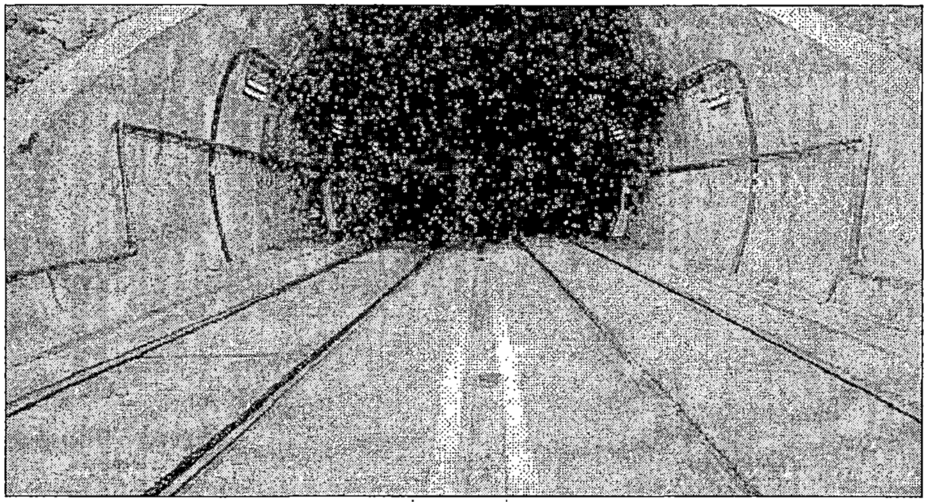

Figure 15. ERS in Tunnel

According to published reports (see bibliography) by the researchers in the Netherlands, ERS can be built quickly and easily with about a 50 percent higher construction cost than ballasted track, but with maintenance costs only 40 percent of what is required for ballasted track. The construction costs depend, to a large extent, on the amount of elastic compound used. Table 2 shows a comparison of construction and maintenance costs between the ballast track and the embedded rail structure (De Man and Scheepmaker, 2000).

Table 2. Cost Comparison (De Man and Scheepmaker, 2000)

Track System	Investment Costs	Maintenance Costs
Ballasted track	100%	100%
Embedded Rail	149%	40%
Notes: (1) All costs are based on existing construction and maintenance techniques. (2) Time period concerned: 50 years. (3) Interest rate: 5%.		

To add the slab track situations in the United States, Table 3 shows another comparison of construction and maintenance costs between the ballasted track and slab tracks in general (Kucera et al, 2002).

Table 3. Cost Comparison (Kucera et al, 2002)

Track System	Construction Costs per Mile	Maintenance Costs per Mile
Ballasted track	$1,000,000	$50,000
Slab Track	$1,3000,000	$10,000
Assuming a time period of 50 years with joint freight traffic (39-ton axle load) and high-speed operation (200 mph), payback is then 7.5 years		

Some of the design issues of ERS are related to the compound as well. To minimize construction costs, the volume of compound used should be as little as possible. However, using larger amounts of compound reduces the acoustic noise level by minimizing the open area of the rail from where the noise radiates. Fatigue tests of ERS track showed that the most vulnerable component was the corkelast compound.

The advantages of ERS track cited in the published reports (see the Bibliography) include ride comfort because of continuous support, elimination of track buckling, and low noise due to nearly complete embedding of rail. In addition, continuous rail support reduces wear and corrugation, and can lead to the use of smaller rail sections. The nearly isolated rail also eliminates stray currents.

Another embedded rail system is the one recently developed by Balfour Beatty in United Kingdom. In this system, a non-traditional replaceable rail is embedded in a concrete trough as Figure 16 shows. A layer of grout resides between the rail casing and the concrete track slab to provide support and resilience. Inside the rail casing is a resilient pad that can be replaced after excessive wear.

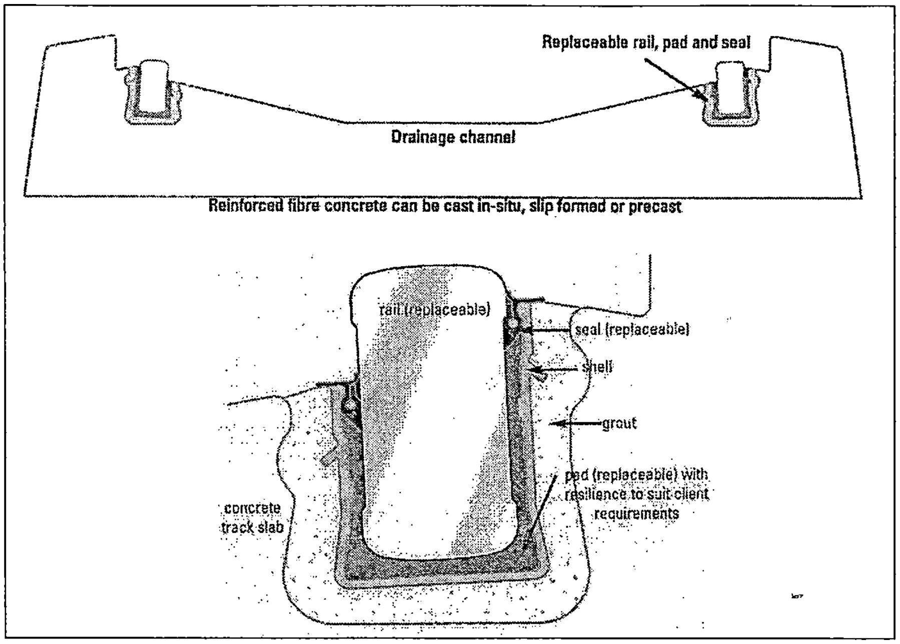

Figure 16. Balfour Beatty Embedded Rail Design

3.5 Cast-In Sleeper Slab Track

In Germany, cast-in sleeper slab track is the main slab track form used for high-speed lines. In this system, a pre-assembled panel (including rails and sleepers) is positioned on a concrete base and cast into position using concrete fill. The most common system is called the "Rheda" system, as Figure 17 shows. One of the advantages of the Rheda system is that the correct gage and rail cant are guaranteed due to factory fabrication of the pre-assembled panel.

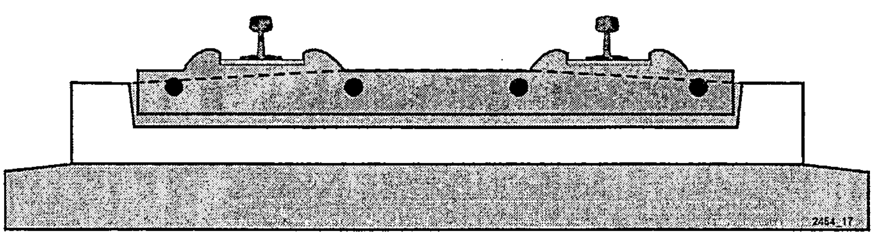

Figure 17. Rheda Classic System

There have been three decades of experience with slab track in Germany, and more than 450 kilometers of high-speed rail lines have been built with slab track. The oldest slab track section was installed in the Rheda station in 1972 (Figure 18). The Rheda design has evolved in several aspects including use of dual-block sleeper instead of mono-sleeper to reduce weight and costs and to improve the bond between sleeper and the base slab. Figure 19 shows several of the latest forms.

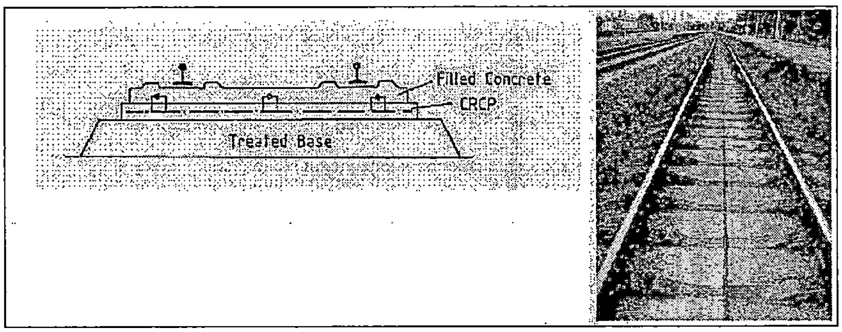

Figure 18. Rheda Classic at Rheda Station

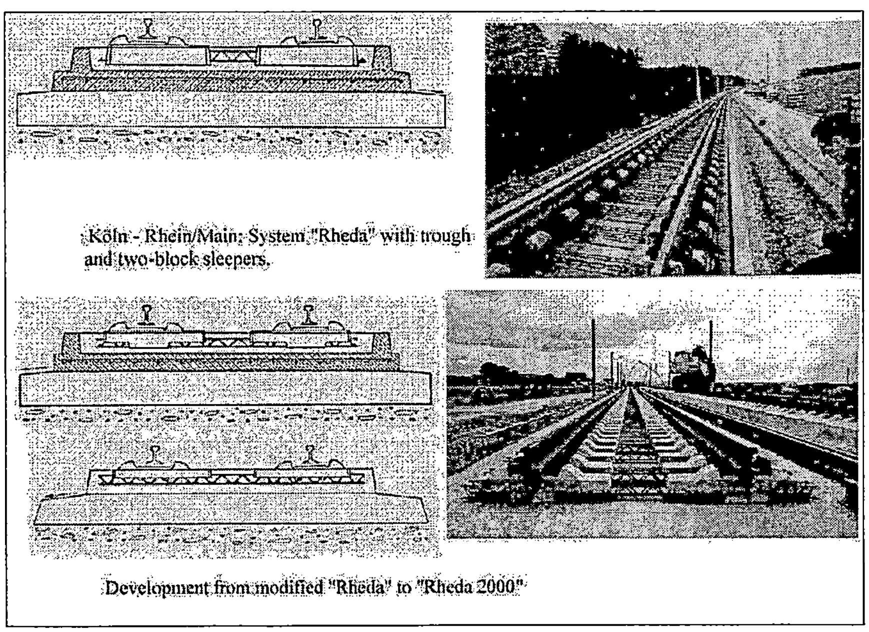

Figure 19. Latest Forms of Rhede Design

In a typical Rheda design, longitudinal reinforcement is 20 millimeters in diameter and the amount of reinforcement is 0.8-0.9 percent of the cross section. With this kind of reinforcement, normal cracking (less than 0.5 mm) occurs at spacing between 1 and 2 meters. The slab can be built with concrete or asphalt. Of all slab track lines in Germany, about 75 percent are built with a concrete base layer and the remaining 25 percent use an asphalt base layer. The slab layer is rested on a 30-centimeter thick cement or bituminous treated base, which rests on a granular base layer.

In Germany, slab track is the preferred track form for high-speed lines. German experience has shown that slab track requires little or no maintenance after installation and is expected to maintain proper track position with little maintenance over an operating period of 60 years. The tolerances required during construction are very tight, with a required construction accuracy of 2 millimeters. In comparison with conventional ballasted track structure, the justifiable construction cost for slab track is 1.4 times that of ballasted track.

3.6 Booted Sleeper Slab Track

The booted sleeper track structure is another variant of the slab track design. With this design, rubber boots are placed between the concrete base and sleeper blocks. The resilient and damping properties of the structure can be adjusted by inserting resilient pads into the boots.

There are two types of booted sleeper systems, one of which is the Sonneville system (Figure 20). This system is characterized by the use of removable independent dual blocks and is used by Hong Kong West Rail in 27 kilometers of tunnel tracks. This system is also used in the English Channel tunnel. Benefits of this system include a top-down construction that ensures tight geometry tolerance, low vibration due to superior "tune" capability in resilience, and good electrical insulation.

The Stedef system is similar to the Sonneville system, but uses a steel bar to connect sleepers for gage maintenance (Figure 21).

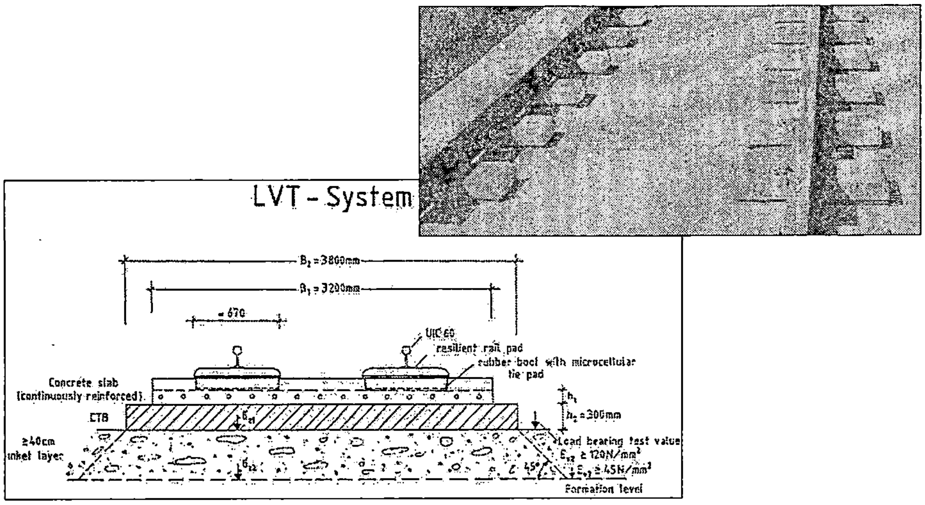

Figure 20. Sonneville Booted Sleeper

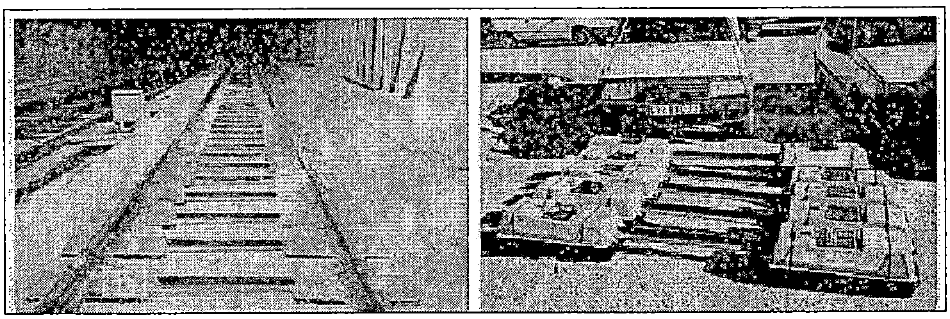

Figure 21. STEDEF Booted Sleeper

3.7 Floating Slab Track

Various forms of floating slab tracks are used in Japan, Hong Kong, and Germany with good results. The term "floating" means that the upper portion of the structure (the pre-cast slab) is not directly affixed to the lower portion, but "floats" on the base slab with sealant mortar or elastic bearings in between.

In Japan, the floating slab is the main slab track form for the high-speed lines. A total of 2700 kilometers of floating slab track has been installed, and 2200 kilometers of it is on Shinkansen high-speed lines. There has been a history of over 30 years of generally good performance with this type of track. Figures 22 and 23 show several forms of the floating slab track used in Japan.

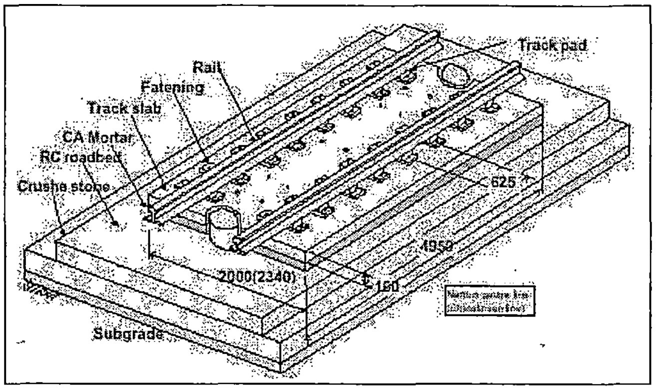

Figure 22. Floating Slab Track with Concrete Roadbed on Earthworks

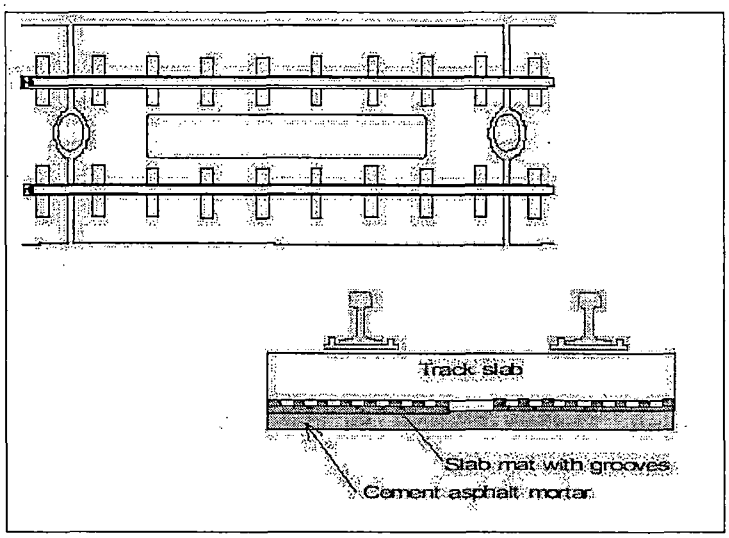

Figure 23. Floating Frame Shaped Slab and Vibration Reducing Slab

Construction costs of slab track in Japan are 1.3 to 1.5 times those of ballasted tracks, but maintenance costs are only 25 percent of those required for ballasted track. Figures 24 and 25 show the results obtained in Japan (Ando et al, 1999). According to the Japanese experience on its high-speed lines, the extra investment in construction can be redeemed in only 2-6 years of operation.

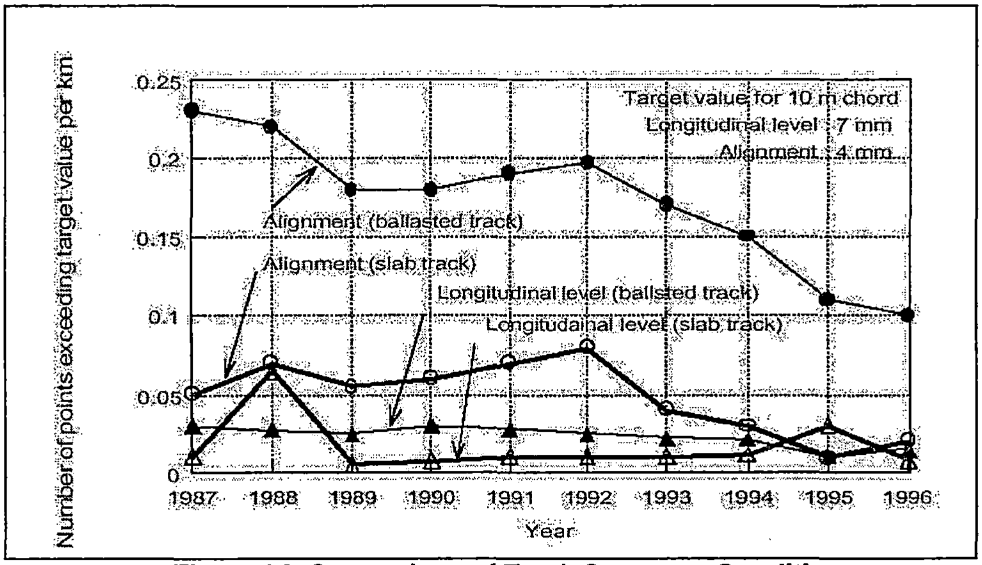

Figure 24. Comparison of Track Geometry Conditions between Ballasted Track and Slab Track

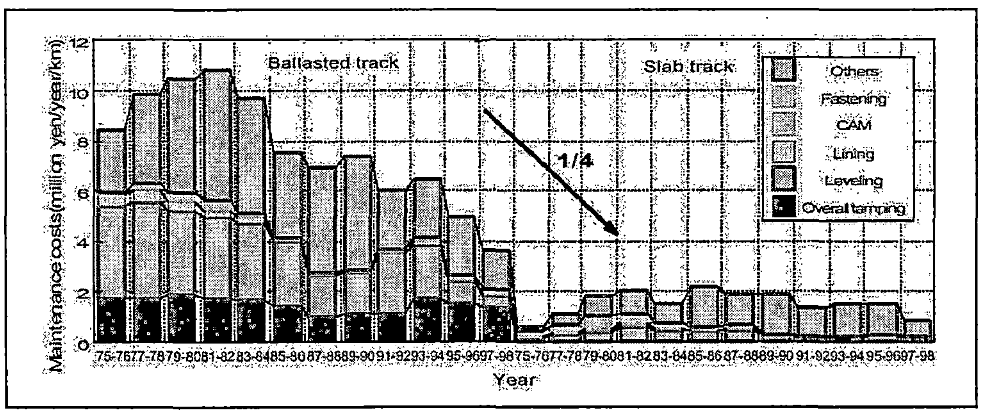

Figure 25. Comparison of Maintenance Costs between Ballasted Track and Slab Track

Figures 26 and 27 show another type of floating slab track that Hong Kong West Rail uses. In this design, vertical and horizontal elastic bearings are used to support the "floating" portion of the track. There is about 34 kilometers of this track in viaducts and tunnels on Hong Kong West Rail.

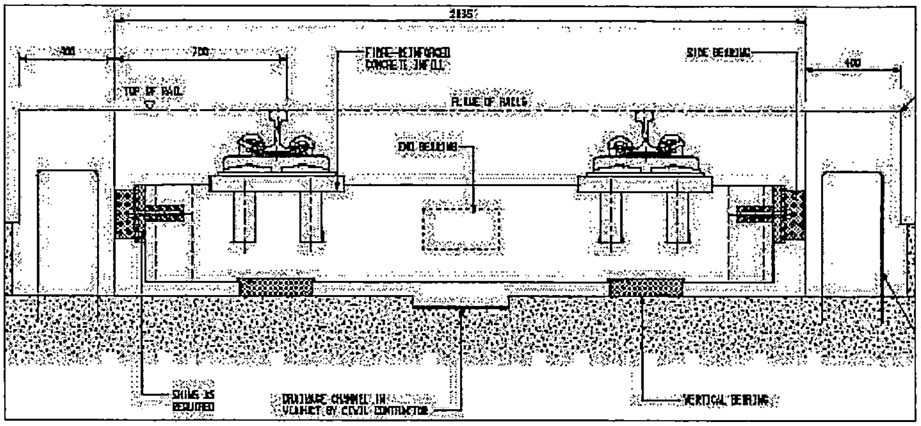

Figure 26. Floating Slab Track in Hong Kong (Cross Section)

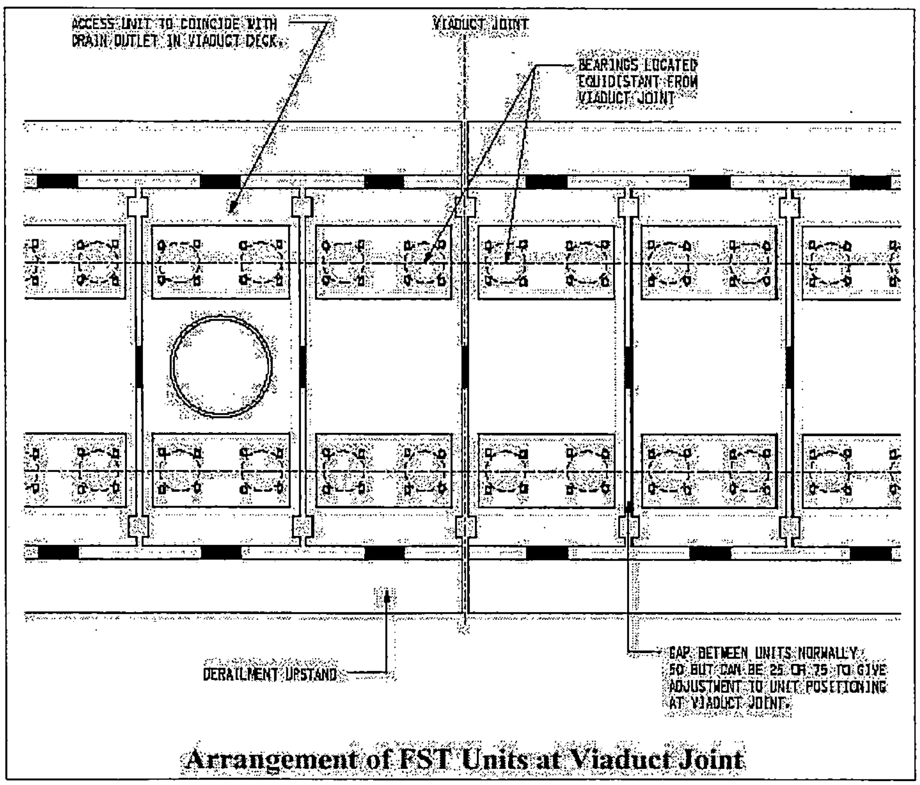

Figure 27. Top View of Floating Slab Track in Hong Kong

The Bogl system developed in Germany is also a floating slab track, similar to the one used in Japan (Figure 28).

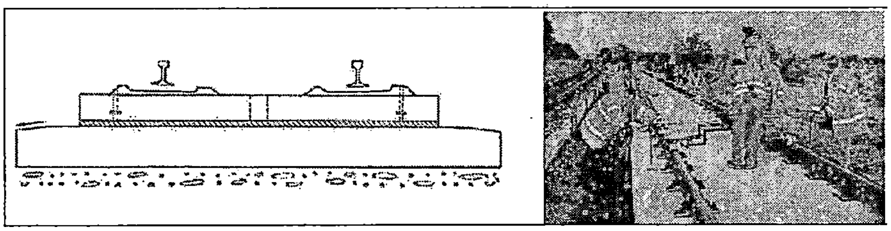

Figure 28. Bogl System in Germany

3.8 Direct Fixation Slab Track

In direct fixation slab track, the rails are directly affixed to a continuously reinforced concrete slab. Among a number of implementations, the direct fixation slab track has been used on Long Island Railroad and on Canadian Pacific Railroad.

Figure 29 shows the direct fixation slab track used on Long Island Railroad. This slab track section is 1.13 miles long and has been in service since 1980 under 12 MGT of annual tonnage (commuter and freight). The performance of this slab track has been good, except for some hairline cracks and a few broken bolts.

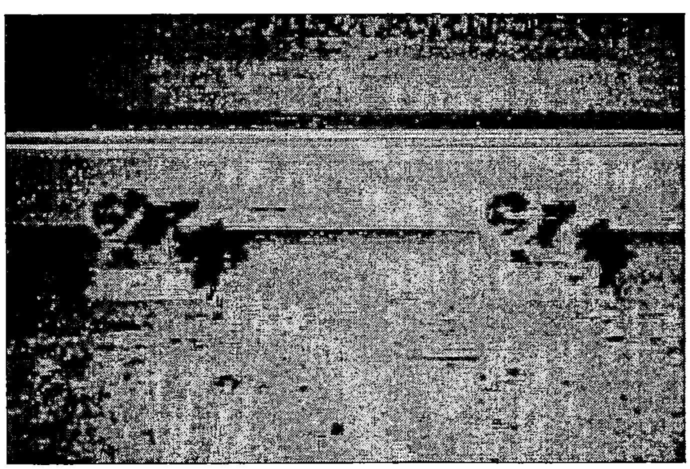

Figure 29. Direct Fixation Slab Track –
Long Island Railroad

The slab track design, recommended by AREMA, is a direct fixation form and was developed based on the slab track experience of the Long Island Railroad. Figure 30 shows the recommended design details. As shown, this design requires a concrete slab resting on a stabilized base.

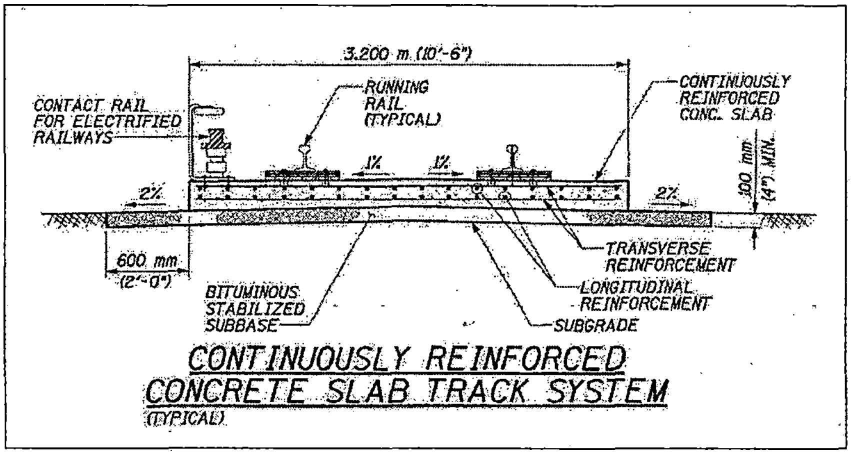

Figure 30. Direct Fixation Slab Track – AREMA Design

A 17-kilometer section in a tunnel at Rogers Pass in Canada has also used a direct fixation slab track form called the PACT system. The track was installed in 1988 and has been subjected to an annual tonnage of 90 MGT with 35-ton axle loads. To date, no surfacing or alignment operation has been necessary, although there were problems at transitions to the ballasted track and a 60-foot wet section had to be replaced.

3.9 Deck Track

Deck track is an innovative solution for rail lines built on soft soils (Figure 31). Holland Rail Consultant developed the design in 1997. In this system, the concrete deck is cast with hollows in it so that its weight is less than or equal to the soil mass removed, resulting in little pressure on track foundation. A 200-meter section of this track structure has been installed for freight service in Holland since July 1999.

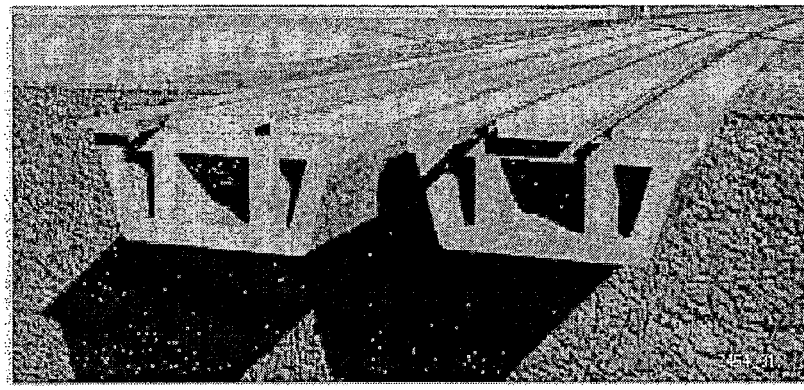

Figure 31. Deck Track

4.0 SELECTION OF CANDIDATES FOR FURTHER TESTING

As discussed previously, all track forms reviewed have the potential for use in joint high-speed and heavy freight operations. Selecting a track design depends on many factors including economics, reliability, durability, environment, construction workability, and maintenance costs. The ideal track form for any given situation will depend on the required characteristics related to these factors.

Table 4 ranks the track forms discussed, based on the evaluation criteria given below. Although this ranking is inherently subjective (1 to 4, 4 being the highest rank), it is done based on the information presented in this report. Care is taken to be as objective as possible. The ranking criteria are:

- Potential of providing stability for both high-speed and freight traffic
  - Tight track geometry
  - High lateral track resistance
  - Low ballast and subgrade pressure
- Initial construction costs and ease of construction
- Reduced maintenance and adjustability (level, gage and resilience)
- Durability and component life
- Track availability
- Noise and Vibration

Table 4. General Comparison of Various Track Forms

Attribute	Ballasted, Wood Sleepers	Ballasted, Concrete Sleepers	Frame Sleeper (Ballasted)	Ladder Sleeper (Ballasted)	Embedded Rail System	Cast-in Sleeper Slab Track	Booted Sleeper Slab Track	Floating Slab Track	Direct Fixation Slab Track	Deck Track
Potential for high speed and freight	1	2	3	3	4	4	4	4	4	4
Construction cost and ease	4	4	3	2.5	2	1	1.5	1	2	1
Maintenance cost	1	2	3.5	3	4	4	4	4	4	4
Maintenance ease	4	4	3	2.5	1.5	1	2	1	1	1
Track component durability	1	2	3	3	3.5	3.5	3.5	3.5	3.5	3.5
Track availability	1	1.5	3	3	4	4	4	4	4	4
Noise and vibration	4	4	4	4	3	1	2	2	1	1

Frame sleeper track and embedded rail system designs were selected for further evaluation by field-testing at TTC for their potential applications in the United States. Selections were based on (1) the main design features reviewed previously, (2) the comparison in Table 4, and (3) the consideration of an already active PCA (Portland Cement Association) Slab Track Cooperative Research and Demonstration Program described later in this section.

The main reason for selecting frame sleeper track is that it represents a compromise between conventional ballasted crosstie track and various slab track forms in construction costs and track maintenance, as Table 4 summarizes. In addition, two Class I railroads in the United States have expressed strong interest in testing this track form.

The main reason for selecting ERS is that it represents a great concept for providing uniform track support with its continuous rail support and with no fastening required. Additionally, extensive field tests and modeling efforts in the Netherlands and Germany have provided a solid basis for further testing in the United States.

Several other slab track forms also have great potential for joint high-speed and heavy freight operation. However, two slab track forms (direct fixation slab track and independent dual block slab track) have already been selected for further testing under a separate PCA Slab Track Cooperative Research and Demonstration Program. PCA is a trade association representing cement manufacturers in the United States and Canada. The following defines the scope of the PCA research program:

- Two slab track designs – Direct Fixation, Independent Dual Block
- Develop design methodology
- Design test sections
- Test in CTL Laboratory
- Test at TTC
- Life cycle cost study
- Publish design guide

5.0 SUMMARY AND CONCLUSIONS

The railroad industry in the United States has been slow to adopt new track structures due to high initial capital costs and uncertainty of new technologies. However, the current need for rail lines to safely and cost-effectively carry both high-speed and freight traffic has created a demand for improved track structures. In some cases, conventional track structures are not capable of retaining the tight tolerances required for higher speed passenger service while simultaneously withstanding heavy freight axle loads. To address the needs of both types of rail traffic, an alternative track structure may be necessary to ensure adequate stability and reliability.

There are a number of alternative or new track designs with the potential for joint high speed and heavy freight operations. These designs have been developed in a few different countries and vary in their design features and in their intended operation conditions, but all must address the basic factors including economics, reliability, durability, environment, construction workability, and maintenance costs.

In this report, track structures with the potential for combined high-speed and heavy freight operations are identified and reviewed concerning their design features and performance results from testing and modeling. For selecting several track forms for further testing at TTC, these track forms are also ranked based on a number of evaluation criteria. Based on the review and evaluation results, frame sleeper track and ERS were selected for further field testing, noting that direct fixation slab track and independent dual block slab track are also being evaluated under a separate PCA Slab Cooperative Research and Demonstration Program.

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