CURRENT TRENDS IN DERAILMENT COUNTERMEASURES IN COMMUTER RAILWAYS

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1. INTRODUCTION

The research into derailment countermeasures in railways is gaining ever more importance as more high speed trains are running on slab tracked railway tracks. This is because high speeds make trains prone to derailment, and the repair of slab track after derailment is difficult and cost extensive.

This paper summarizes the trend in the use of derailment countermeasures adopted in the commuter railway lines around the world to identify the prevailing best practices. Commuter railways with design speed of 60-150 kph in the countries of interest, i.e., Japan, UAE, France, UK, Australia, Malaysia, South Korea, Taiwan, Italy, Chile, Egypt, India, Philippines, and Thailand are focused upon in this article. We limit our investigation to the commuter railway lines in each countrys' capital city (or major city). The information presented in this paper was gathered from various visual sources on the internet such as user uploaded videos of operation lines on youtube, wikipedia, homepage of lines.

The main aim is to understand the policy of usage of derailment countermeasures on the various commuter railway tracks around the world.

2. TYPES OF DERAILMENT COUNTERMEASURES

The purpose of a derailment countermeasure is to either prevent the derailment from happening (derailment prevention) or to contain the damage to track and cars by preventing any deviation after the derailment has happened (deviation prevention). Table 1 gives a (non-exhaustive) list of some of the derailment and deviation prevention countermeasures.

Table 1 List of derailment countermeasures.

Derailment Prevention
· Check rail · Early earthquake warning and train stopping system · Speed detection box before sharp curves and ATS · Collapse prevention/ Seismic reinforcement · Sway reduction of structure · Sway reduction of carriage · Improved rail fastening device (various methods) · Improved rail joints (various methods)
Deviation prevention
· Guard rail · Derailment upstands/ Derailment guard concrete blocks/ Derailment kerbs

Out of these countermeasures, this paper focuses on the check rails (Fig. 1a), guard rails (Fig. 1b) and upstands (Fig. 1c) since these are the most commonly used and capital intensive systems. Further, the check rail at turnouts are also excluded since these are an essential part in the design of turnouts and are hence used everywhere.

(a) Check rail (b) Guard rail (c) Concrete upstands

Figure 1 Examples of countermeasures for derailment prevention (a), and deviation prevention, (b) and (c).

Table 2 Summary of information on the use of various derailment countermeasures in commuter railways.

•	Observed
-	No information available
No	Not present

Start of Operation	GDPpc	Commuter railway line		Curve		Bridge		Viaduct	Seismic risk	Limit Speed (kph)
				CR	GR	CR	GR	US		
1863	G1	London Subway,	UK	•					VL	80
1883	G1	Utsunomiya Line,	JP				•		H	120
1885	G1	Yamanote Line,	JP	•		•			H	90
1889	G1	Chuo Line,	JP	•		•			H	130
1894	G1	Sobu Line,	JP	•		•	•		H	120
1900	G1	Paris Metro Line 2, 3, 5,	FR		•		•		VL	70
1914	G1	Keihin-Tohoku Line,	JP	•		•			H	90
1932	G1	Chuo-Sobu Line,	JP	•		•			H	120
1955	G2	Rome Metro Line B,	IT					-	H	90
1975	G1	Keiyo Line,	JP			•			H	100
1980	G2	Seoul Subway Line 1,	KR					-	VL	80
1980	G2	Rome Metro Line A,	IT					-	H	90
1984	G3	LRT Line 1,	PH	•					M	80
1987	G1	Docklands Light,	UK	•					VL	80
1996	G2	LRT Lines,	MY			•		•	L	60
1997	G2	Tamsui–Xinyi Line,	TW	-	-	-	-	•	H	80
1998	G2	Kelana Jaya line,	MY					No	L	80
1999	G3	MRT Line 3,	PH			•			M	60
1999	G3	BTS Sukhumvit line,	TH	•				•	L	80
2002	G3	Delhi Metro,	IN					•	M	100
2003	G3	LRT Line 2,	PH	•					M	80
2005	G2	Santiago Metro Line 4,	CL					No	H	80
2009	G1	Dubai Metro Red,	AE					No	VL	95
2010	G3	Airport Rail Link,	TH					•	L	120
2011	G1	Dubai Metro Green,	AE					No	VL	95
2012	G3	Cairo Metro Line 1, 2, 3,	EG					•	L	100
2014	G2	Rome Metro Line C,	IT					-	H	90
2017	G2	Ui LRT,	KR						VL	180
2017	G2	MRT Airport line,	TW			•		•	H	80
2018	G2	Skypark Link,	MY	•		•		No	L	100
2018	G1	Skyline,	AU					•	VL	95
2019	G1	Metro North West line,	AU					•	VL	100
2019	G2	Gimpo Goldline,	KR	•				No	VL	80
2019	G2	Santiago Metro Line 3,	CL					No	H	80
2020	G2	Circular Line,	TH	•				•	H	80

Keywords: Check rail, Derailment countermeasure, Guard rail, Upstand
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Check rails (CR): The rails which may come in contact with the inner surface of the wheel, e.g., during the run of vehicles through the curve. The clearance between running rail and check rail should be of the order of 41-44 mm [1].

Guard rails (GR): The rails that prevent a derailed axle from moving in the transverse direction more than it is allowed to. The clearance between running rail and guard rail should be 180 mm or more [1].

Derailment upstands (US) are concrete low walls that act as barrier wall to keep trains on-line should the train derail. The height of the wall averages 800 mm with a width of 400 mm [1].

3. COUNTRY-WISE OBSERVATION

Some important observations country-wise are discussed here. Japan being a highly earthquake prone country, the railway lines make good use of derailment countermeasures, particularly check rails. Check rails were observed at the road overpass, railway crossings, major bridges, sharp curves. Guard rails were observed on few major steel bridges while upstands were not observed on any line. In some lines, e.g. in Philippines, United Kingdom it was observed that the use of derailment countermeasures was avoided by operating the trains at very low speeds when passing over bridges, transition sections or when approaching sharp curves. The Skypark line in Malaysia was observed to be the only recently constructed railway line with check rails on elevated sections throughout the line. In the case of Skyrail, Australia that started operation in 2018 after replacing the lines from 1800s, guard rails were observed at the interface from the old at-grade to the elevated section while the elevated sections have upstands on the inside of the running rails. Further, majority of the lines operational after the year 2000 are fully or mainly elevated.

4. OBSERVED TREND FOR EACH COUNTERMEASURE

Table 2 shows the summary of observation for the three countermeasures. The presence of check rails and guard rails was confirmed at curved sections of the lines and at transition sections from at-grade/elevated to bridge. The countries under focus are divided into 3 categories based on the GDP per capita (G1- GDPpc ≥ USD 40k, G2- GDPpc ≥ USD 10k and G3- GDPpc < USD 10k). The seismic risk [2] is categorized into high (H), medium (M), low (L) and very low (VL) categories. Further, the limit speed in kph and the year of start of operation of the line are also shown. The data is sorted by the year of operation.

The following observations can be derived from this figure. Upstands show a trend of increased usage in recent years with most of the elevated sections using this countermeasure. No particular trend for the usage of upstands with respect to the limit speed could be observed. In the cases where upstands are not used or the section is at-grade, guard rails are provided when bridges are encountered to prevent the rolling stock from falling off the bridge in case of accidental derailment. Check rails are provided at appropriate curves and bridges irrespective of the presence of upstands. Additionally, the vast majority of older railways lines operated mostly in G1 countries show a preference towards the use of check rails.

Given these observations, it is interesting to investigate the reason for the recent increase in the use of upstands from the perspective of future construction policy. The flowchart in Fig. 2 summarizes our hypothesis of one of the possible reasons for the observed trends.

For new constructions in an already congested city, viaducts are being preferred over at-grade and tunnels due the resulting efficiency in city planning, construction-ease and -economy.

↓ leading to an increasing prevalence of viaducts.

Deviation countermeasure are needed throughout the track to prevent rolling stock from falling off the viaduct in case of derailment.

↓

Upstands are preferred compared to check rails due to lower relative cost of concrete than steel.

↓ leading to an increasing prevalence of upstands.

However, upstands increase the superstructure dead weight and hence substructure cost, consequently increasing the project budget considerably.

↓

G3 countries under medium earthquake risk zones avoid the use of upstands whereas G2, G1 countries can afford such constructions irrespective of the earthquake risk.

Figure 2 Flowchart of observations regarding the use of upstands.

5. CONCLUSION

The selection of the type of derailment countermeasure depends a lot on the established policies, and economic status of the host country, and the past practices in the technology lending country. Going by the recent trend in this regard, our research shows an increase in the use of concrete upstands as a deviation countermeasure for their ease of construction, ease of maintenance and for being the preferred type of deviation countermeasure on viaducts. Other derailment countermeasures like guard rails are also used at derailment-prone sections of the track like sharp curves, grade change sections etc.

REFERENCES

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[2] Global Facility for Disaster Reduction and Recovery (GFERR) Administered by the World Bank, thinkhazard.org