

Study of Railway 1:15 Turnout Geometry at Kulai Station (KI08) For Electrified Double Track Project (EDTP)

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Abstract

This study aimed to study the crucial part in turnout types 1:15 that have been used for Section 4 which in Kulai (KI08) on Electrified Double Track Project (EDTP) from Gemas to Johor Bahru. The primary focus was on assessing the consequences of out tolerance measurement for KI08 that potentially derailment to happen. In fact, it investigated track gauge measurement, balancing of the guard rail and contact between stock rail and switch rail for both straight or main line and curved line. Every investigated part got measurement and tolerance that is very crucial from safety aspects. Out tolerance measurement will lead to narrow or wider track gauge that will cause derailment to happen and the same consequences apply for balancing of guard rail and contact between stock rail and switch rail too. By investigated these part in turnout types 1:15, this paper aimed to provide comprehensive understanding the crucial part in turnout. Last but not least, the findings offered valuable insights into the importance of keep the measurement in turnout is within tolerance since the turnout is used for changing train direction.

1. Introduction

The use of turnouts, also known as railroad switches, dates back to the 18th century when they were used in the first mine railways in England (Fendrich, Fengler, 2013). Turnouts enable trains to switch between different tracks without interruption of the journey, which distinguishes them from other special designs like traversers or turntables. The points mechanism, created in 1832 by English engineer Charles Fox (Wolmar, 2014) is the essential part of a turnout. The points are moved from one track to the next by the mechanism, which is triggered by a lever attached to a pull rod. As train travel speeds up, there has been a recent push for innovative approaches to enhance railroad switches and crossings. The goal of these modifications is to reduce the dynamic load, which often rises with velocity and affects both the structural components' wear and the comfort of the vehicle's ride (Raif, *et al.*, 2017). The design of railway turnouts significantly affects train safety in several ways. Firstly, the geometric center, design, and geometry of turnouts can force speed limits, which in turn affect capacity constraints and safety (Kampczyk A, 2020). Efficient turnout design is crucial for preventing failures that can lead to delays and cancellations of trains, negatively impacting the quality of service, railway safety, and operating costs. Furthermore, the dynamic load generated by trains and the elastic properties of the turnout support structure are influenced by the design of turnouts, which in turn affect safety (Hamarat, M., Papaelias, M., & Kaewunruen, S., 2021). Railway turnout, according to Kaewunruen, Sussman and Einstein (2015), is a structural grillage system made up of steel rail, sleepers, ballast, foundation, screw spikes, crossings, closures, points, rubber pads, and steel plates. Railway turnout systems are often made up of intricate connections with unique geometries (sizes and dimensions), curvatures (angles and slopes), and profiles. Track geometry for

turnouts is indeed important. It is considered one of the most crucial quality parameters for railway tracks and turnouts, according to a paper on track geometry quality assessments (Markus *et al.*, 2023).

Any railway track in the world including Malaysia need a turnout in order to allow the trains to change from other track to another one. As example, a train coming from main line and want to go to loop line will passed by turnout. Turnouts provide a certain amount of operational flexibility in a mostly inflexible railway system by enabling track changes while a train is in motion. This allows for the effective utilization of the infrastructure for scheduled activities as well as temporary flexibility in the event that system outages occur. Railway turnout geometry refers to the specific design and layout characteristics of a turnout, which allows trains to move from one track to another. The geometry of a turnout is crucial for ensuring safe and efficient train operations. After turnout is placed on the track, geometry inspection of turnout need to be done to ensure all the characteristic on the turnout meet the right requirement. Since the function of turnout is to change train's direction, it is very important to keep the crucial part in turnout such as gauge measurement, position of the guard rail and contact between stock rail and switch rail to avoid derailment at turnout. This paper aimed to study the crucial geometry part on turnout and to investigate the impact of out tolerance turnout geometry. The KI08 turnout located at Kulai Station that has been used to change train direction from up loop line to up main line which is specific CH is 723797 will be the focus of this project. This project will be conducted in Section 4 of EDTP Project where 1:15 type of turnout has been used for KI08. It will describe the geometry of turnout including gauge measurement of the turnout for straight and curve line, position or balancing of the guard rail and contact between stock rail and switch rail.

2. Methodology

A flowchart illustrates the discrete stages of a procedure in a consecutive arrangement. It is a general-purpose tool that may be used to define a range of processes, such as a manufacturing process, an administration or service process, or a project plan. When designing and planning a process, flowcharts can assist in identifying the critical stages and provide a broader perspective of the operation as shown in Figure 1

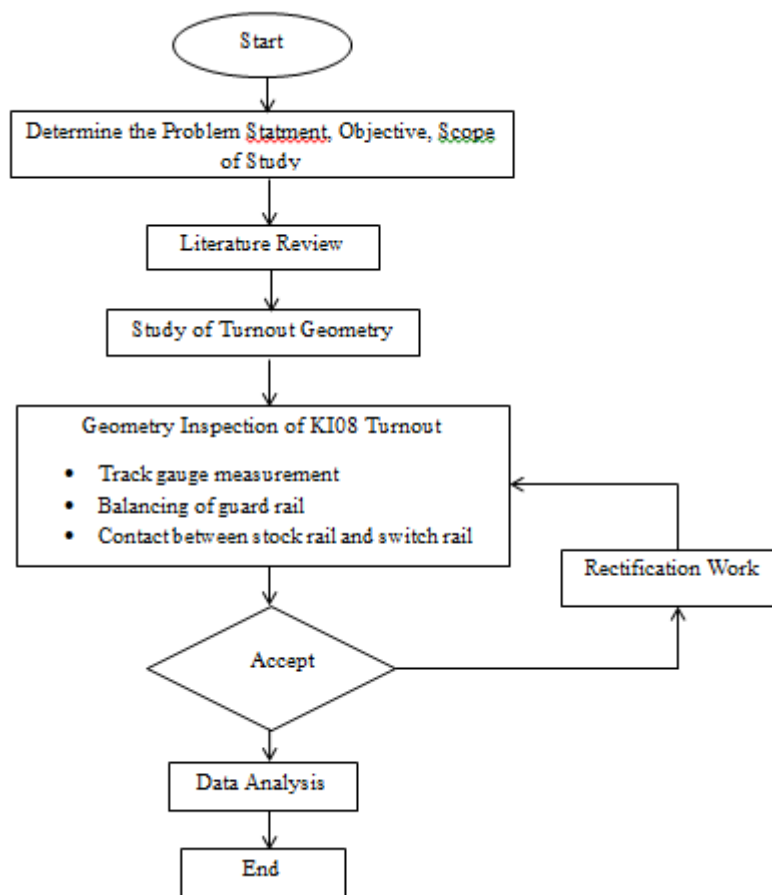


Fig. 1 Flowchart methodology

2.1 Track Gauge Measurement

Track gauge is the distance between the inner sides of two parallel rails on a railway track. In this project, meter gauge has been used which refers to a type of railway track gauge where the distance between the inner sides of the two rails is one meter (1,000 millimeters). However, there is slightly difference between plain track and turnout where at some points, the track gauge is wider than normal plain track.

Figure 2 above shows how track gauge measurement data being obtained by using track measurement gauge. Measurement of gauge for every related number of sleeper must be taken and need to within the allowable tolerance. The method apply for both main line and curved line which is determined by the position of the switch rail either the turnout condition going to straight line or curved line.



Fig. 2 Measuring track gauge at turnout

2.2 Balancing of The Guard Rail (Check Rail)

The check rail flange way gap in a rail turnout (or switch) refers to the space between the check rail and the running rail. The check rail is a shorter rail that helps guide the wheel flange of the train through the diverging route of the turnout. The balancing of the guard rail is essential to ensure smooth and safe passage of the train wheels as they move through the turnout.

Position of the check rail is located as shown in Figure 3 for straight check rail and curve checkrail. Making sure the guard rail is appropriately positioned and spaced in relation to the running rail is necessary for guard rail balancing. This procedure is essential to the guard rails' ability to prevent derailments and direction of the train wheels.

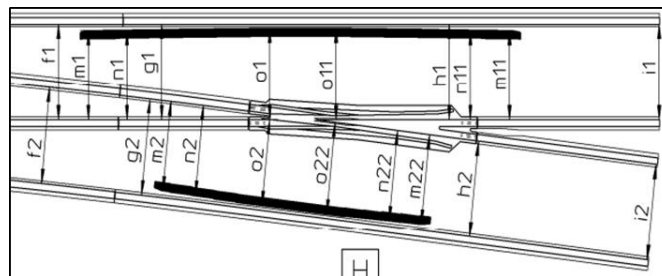


Fig. 3 Guard rail layout on turnout

The check rail flangeway gap is the space between the running rail and the guard rail. Table 1 below shows the location that need to measure on turnout for both straight checkrail and curve checkrail as example $m1'$, $m11'$, $m2'$, $m22'$ and etc.

Table 1 Checkrail flange way gap

Check Rail Flangeway Gap (for reference)				
Straight Checkrail	$m1'$		$m11'$	
	$n1'$		$n11'$	
	$o1'$		$o11'$	
Curve Checkrail	$m2'$		$m22'$	
	$n2'$		$n22'$	
	$o2'$		$o22'$	

Data for this table can

be obtained from measuring

the gap between check rail and nearest running rail (small gap) by using track measurement gauge as shown in Figure 4 below. Some calculation is required in order to obtain the gap measurement by using Equation (1). In addition, the calculation is referred to manufacture of KI08 1:15 turnout requirement by Vossloh.



Fig. 4 Measuring checkrail flange way gap

$$\text{Balancing of guard rail} = \text{Distance between running rail} - \text{checkrail flangeway gap} \quad (1)$$

2.3 Contact Between Stock Rail and Switch Rail

Theoretically, there is supposedly maximum 1mm gap between stock rail and switch rail for both main line and curved line. The allowable tolerance (1mm) shows how crucial it is in order to avoid any failure happened. Proper contact ensures a smooth transition of train wheels from the stock rail to the switch rail, guiding the train onto the desired track.

1mm feeler gauge is used in this part as shown in Figure 5 to ensure there is no gap over 1mm for contact between stock rail and switch rail. In other words, if the feeler gauge can through pass between it, some rectification work is needed until meet the requirement.



Fig. 5 Feeler gauge

3. Result and Discussion

This project will be expected to explore the geometry of 1:15 turnout at Kulai Station including analyze an important parts in turnout related to geometry through turnout geometry inspection checklist. It is expected for the turnout meet the right requirement for every component in turnout as example, track gauge for main line and curved line, balancing of the guard rail and gap between stock rail and switch rail. All the component have their own criteria and tolerance that need to be within the tolerance. It is important for each part to within tolerance in order to avoid any accident happen such as train derailment.

3.1 Track Gauge Effect On Turnout

For safe operation, the train wheels must remain correctly aligned on the rails, which is maintained by maintaining an accurate gauge. Turnouts include changing tracks, and in order to keep the train from jumping the tracks, they must be precisely aligned. Precise gauge measurement guarantees smooth train movement via turnouts, preserving the effectiveness of the rail system.

Table 2 shows the data for track gauge measurement at turnout for main line and curved line. It shows that every gauge on selected number of sleeper from sleeper number three until 63 is within tolerance. It is

important to ensure the gauge is following the right specification. The greater possibility of derailments is the main danger associated with a narrow gauge. The train may derail if the gauge is too narrow because the wheels may not fit the tracks adequately. An excessively small rail gauge makes trains less stable. Accidents may result from this instability, particularly around corners.

Table 2 On site data for track gauge measurement

Sleeper No	Main Line			Curved Line		
	Code	Theory	Real	Code	Theory	Real
3	tg3	1000		tg3'	1000	
6	tg6	1003	1004	tg6'	1003	1004
9	tg9	1004	1004	tg9'	1004	1003
12	tg12	1003	1002	tg12'	1003	1002
15	tg15	1002	1001	tg15'	1002	1000
18	tg18	1000	1001	tg18'	1000	1001
21	tg21	1000	1001	tg21'	1000	1001
24	tg24	1000	1001	tg24'	1000	1001
27	tg27	1000	1001	tg27'	1000	1001
30	tg30	1000	1000	tg30'	1000	999
33	tg33	1000	999	tg33'	1000	1000
36	tg36	1000	1000	tg36'	1000	1001
39	tg39	1000	998	tg39'	1000	1000
42	tg42	1000	1000	tg42'	1000	1000
45	tg45	1000	1000	tg45'	1000	1000
48	tg48	1000	1000	tg48'	1000	1001
51	tg51	1000	1000	tg51'	1000	1000
57	tg57	1000	1001	tg57'	1000	1000
60	tg60	1000	1000	tg60'	1000	1002
63	tg63	1000	999	tg63'	1000	1000

3.2 Balancing of Guard Rail On Turnout

Measurement of the guard rail can be obtained after calculation is made. Table 3 below shows the result after measurement work on site is done for gap between guard rail and nearest running rail or flangeway gap for straight and curved guard rail. Table 4 shows the measurement data for balancing of the guard rails after the calculation by using Equation 1 is done. Balancing of the guard rail stated in the table is within tolerance without any error at any point.

Table 3 On site flangeway gap measurement

Straight Checkrail	m1'	64	m11'	65
	n1'	53	n11'	56
	o1'	44	o11'	45
Curve Checkrail	m2'	46	m22'	65
	n2'	55	n22'	55
	o2'	54	o22'	44

Table 4 Balancing of the guard rail

Balancing of The Guard Rails					
m1	935	936	m11	935	934
n1	945	947	n11	945	943
m2	935	935	m22	935	935
n2	945	945	n22	945	946

Figure 6 and 7 shows the attitude of wheel when passing by the guard rail at turnout for straight and curved line. Thus, it shows how crucial it is to keep the distance between guard rail and running rail in the right

measurement. If the positioning of the guard rail is huge compared to the supposed value, the guard rail are not functioning at all since the main reason of guard rail is for safety purposed which is to prevent derailment to happened. Vice versa, if the guard rail measurement getting narrow, it will hit by flange of the wheel and causing derailment to happen.

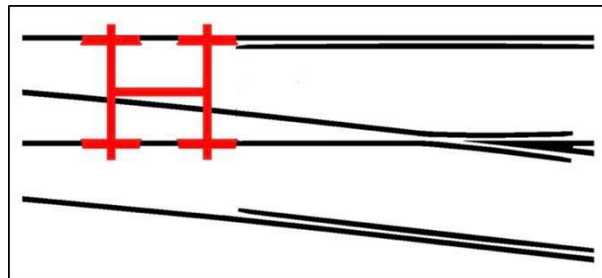


Fig. 6 *Wheel running at straight guard rail*

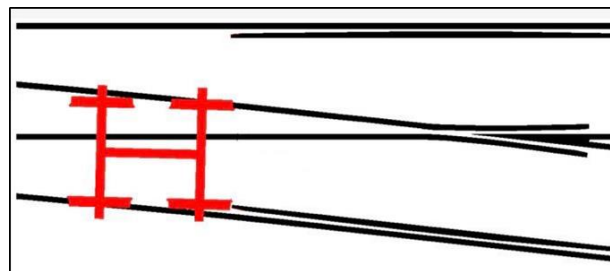


Fig. 7 *Wheel running at curved guard rail*

Figure 8 shows the position of wheel during going through the guard rail. Supposedly if all the measurement of gauge is correct, there is no contact between wheel and guard rail either on straight or curved guard rail. Furthermore, it shows why guard rail on turnout need to be placed on the right position and precise measurement.

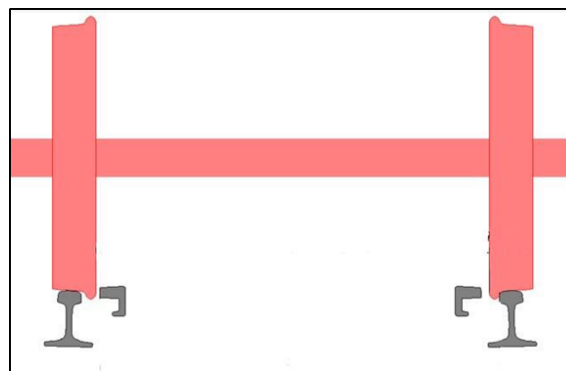


Fig. 8 *Cross section of wheel through guard rail*

3.3 Contact Between Stock Rail and Switch Rail Influenced Derailment

Allowable gap between stock rail and switch rail is supposedly maximum 1mm only. Since 1mm feeler gauge cannot penetrate between stock rail and switch rail, it should be good. Figure 9 above shows the situation when the contact between stock rail and switch rail is within tolerance (gap below 1mm). A train's wheels may go smoothly from one rail to another without running the risk of derailing if the distance is kept up. The switch rails are positioned to guide the train down the main track while it is at rest. The stock rails and switch rails are parallel to one other. One of the point blades travels away from its matching stock rail when the switch rails move, while the other moves in the other direction. The train may now follow this continuous rail line onto the diverging track.

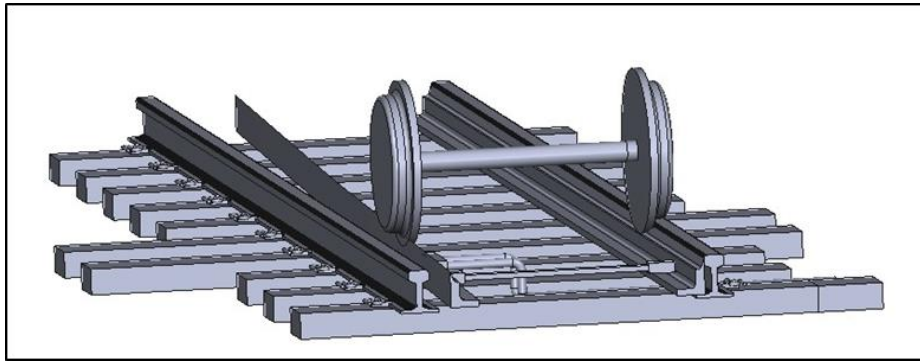


Fig. 9 3D

turnout (within tolerance)

drawing of

Figure 10 below shows the situation when the contact between stock rail and switch rail is out of tolerance which is the gap between it is exceeding the supposed value 1mm. Technically, one of the wheel is supposedly located on the switch rail as shown in Figure 9. The distance between stock rails is increasing toward the end of turnout. Meaning that, if both side of the wheel are located on stock rail, derailment will happen since the width of the wheel is only 1 meter. Maintaining the gap between the stock rail and the switch rail is crucial for the safe and efficient operation of railway turnout. A properly maintained gap ensures that the wheels of a train can smoothly transition from one rail to another without the risk of derailment.

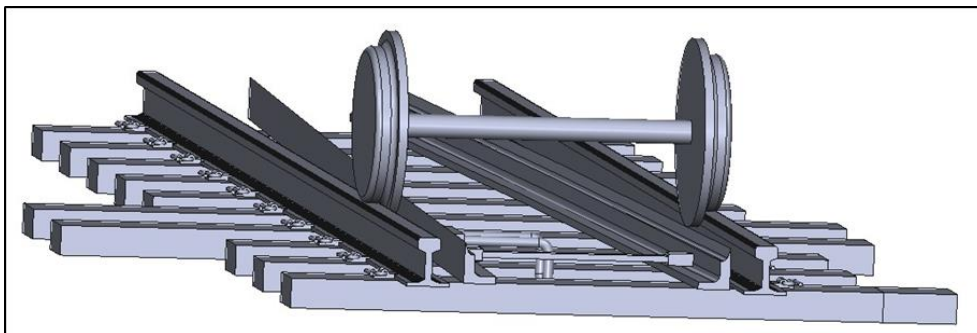


Fig. 10 3D drawing of turnout (out tolerance)

4. Conclusion

In conclusion, this research aimed to analyze turnout geometry for 1:15 type of turnout at Kulai for EDTP project. Railway turnout geometry is a crucial aspect of railway infrastructure, enabling trains to switch from one track to another efficiently and safely. The design and implementation of turnouts require meticulous planning and precision to ensure smooth and reliable train operations. Several key elements are central to turnout geometry, including the track gauge, balancing of the guard rail and contact between stock and switch rail.

Measurement of track gauge at turnouts is an essential part of railway safety and upkeep. By maintaining the proper gauge, derailments and other mishaps that may arise from gauge widening or narrowing at the turnout are avoided. In railway operations, safety is the first priority, and sustaining safety depends on accurate gauge readings. In order for railway systems to operate safely and effectively overall, guard rails or balancing at turnouts are essential. These parts are essential for making sure wheels stay in the right alignment while they go around a turnout's intricate geometry. Guard rails guide the wheels through the turnout, especially at the crucial frog and switch locations, preventing wheel flange climb and derailments. Same goes with contact between stock rail and switch rail where the gap between it will cause failure to happen if it is out of allowable tolerance.

Based on the motion analysis for track gauge measurement, balancing of guard rail measurement and contact between stock rail and switch rail on the turnout, it can be concluded that track geometry of turnout is a crucial things in order to avoid from derailment or any accident happened.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper as follows: **Study of Railway 1:15 Turnout Geometry at Kulai Station (KI08) for Electrified Double Track Project (EDTP):** Mohammad Lutfi Hakimi Bin Ahmad Yazid, **Supervisor:** Karthigesu A/L Nagarajoo. All authors reviewed the results and approved the final version of the manuscript.

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