Investigation of prestressed concrete sleeper’s vibration located at KM71.75 And KM79

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Abstract. Train has been one of the essential and convenient transportation choices for community nowadays. Instead of carrying a passenger, these types of facilities also can be used to transport material across our country. With the increasing usage of train every year, the rate of accidents has also increased dramatically. Therefore, the importance of studying about the railway can contribute to building better and comfort railway track which can deliver their services at its best for an extended period. This study focused on the measurement of the deflection of concrete sleepers which affect the performance of the railway track. Lack of actual deflection value from the site can be problematic to ensure the quality of the track itself. The method used for the analysis is by using the Sirius-M instrument which can be recorded and analyses the acceleration of the concrete sleepers when receiving the loading wave from a moving train. The data of acceleration then can be transformed into deflection form by applying double integration. From the data collection, it shows that the maximum deflection at northbound at KM79 is 13.72 mm for freight train and 1.5 mm at southbound for six set commuter train. As for KM 71.75, the maximum deflection at northbound is 0.57mm for ETS and 1.5mm at southbound for six set commuter train. Thus, from this research, the actual deflection value from both sites were achieved.

1. Introduction
From work to holiday trips, train services have been a popular choice in Malaysia to travel around the country. Fortunately, there are 7 distinct sorts of train utilities presently working in Malaysia. These train utilities on the two primary railroad lines in Malaysia, the West Coast Railway Line and the East Coast Railway Line, just as two train lines interfacing Kuala Lumpur to Port Klang and the Batu Caves. Most of the train administrations are on electric trains, with diesel-controlled administrations in activity just on the East Coast Railway Line and on the stretch of the West Coast Railway Line toward the South of Gemas. All of the train facilities are organised by Keratapi Tanah Melayu Berhad (KTMB) [1]. Prestressed Concrete Sleepers (PCS) are structures that support railway system and absorb variable loading from the train that pass along the rail [2]. One of the ways to improve our rail track system may start with better data collection which leads to correct maintenance decision [3]. This investigation was carried out to obtain the deflection of concrete sleepers when receiving the load waves from the moving train. Past researcher notes that ballasted track has many advantages; for
example, the construction costs are comparatively low, the maintenance and repair of track and its components are convenient, it has high damping and very good drainage properties, and noise can be controlled [4 - 6]. This research focuses on the behavior of concrete sleepers when receiving a load from the train. The variable that considered from this experiment was the type and condition of underlying soil strata and analyse from past review [7]. The measurement of concrete sleepers behavior will be obtained in terms of acceleration and vibration of the concrete sleepers. Instrument Sirius M was selected to measure those parameters. From the theoretical, the value of acceleration can be double integrated to convert into the deflection value.

The sites chosen were KM71.75 and KM79. Both sites are located far away from the nearest electrical source thus limiting the capability of the team continuously collect data. The site locations were determined by considering the soil strata such as paddy field area and hilly area. The train type involve in data collection are northbound and southbound for both test site which included Electric Train Services (ETS), 6 set commuter and freight train. Several studies have concerned themselves with the structural performance of concrete sleepers, focusing on crack development, fatigue and impact behaviour [8]. Thus, this study will provide better insight into what impact of soil conditions on the behavior of concrete sleepers when receiving a load from moving train [9]. Furthermore, this research can demonstrate the performances of concrete sleepers in terms of deflection from two soil conditions and propose new considerations for the maintenance work of the rail track. In addition, this study can be used to help another researcher to design concrete sleepers while considering the type of soil especially for problematic soil in Malaysia. The method used in this research also can be useful in the future to the industry of commuter especially for measuring the performance of the pre-stress concrete sleepers under the rail track [10].

2. Site investigation
A group of researchers from Faculty of Civil Engineering Universiti Teknologi MARA Cawangan Pulau Pinang led together with Keretapi Tanah Melayu Berhad (KTMB) have conducted a site investigation. Upon agreement with KTMB, two (2) sites were chosen to be investigated. The site was picked by KTMB because it is known as a non-problematic and also a problematic site condition (in terms of PCS movement). The sites chosen were KM71.75 and KM79. Figure 1 shows one of the site location chosen for site investigation. By using Sirius M, data of deflection can be collected at both site by detecting the vibration on the PCS while contacting with commuter, ETS and freight train. The data will be in acceleration unit (mm/s²) and converted to deflection (mm) through double integration method.

![Figure 1. Actual site at KM71.75.](image)

Meanwhile, Figure 2 shows how the device is located on site. As can be seen in Figure 3, the Y-direction were pointing upwards so that the team can extract the data in Y-direction only. The
piezometer was glued to the PCS by using a special type of glue that has been calibrated with the device.

![Image](image1.jpg)

**Figure 2.** Sirius-M equipments.

![Image](image2.jpg)

**Figure 3.** Piezometer Y-direction pointing upwards.

### 3. Result and discussion

At KM71.75, the results will be comparing for all train that passes through which is consist of an ETS and 6 set commuter train. The data was taken during sunny and dry condition and was taken using Sirius-M instrument and then being integrated to transform into deflection term by using Dewe software. At KM79, all train that passes through which is consist of a 6 sets commuter and a freight train will be compared based on their results. The data was taken during sunny and dry condition and the data was also taken by using coaches Sirius-M instrument and then being integrated to transform into deflection term by using Dewe software.

#### 3.1. KM 71.75

The team and with the assistance of KTMB personnel were able to gather the much-needed data at the location. After the safety briefing given by the KTMB personnel on site, the team set the equipment to capture the intended data. The data will be divided into two subsections that are northbound and
southbound. The notation northbound means that the train is going upward to northern area whereas southbound means the train is going to the south. This site is located near KTM station thus the train going northbound is slowing down where train going southbound is picking up speed. This pattern can be seen in figure provided.

Figure 4. Compilation of trains going northbound at KM71.75.

Figure 4 depicted the data captured from the trains using the KM71.75 railway track. The maximum deflection was recorded by ETS train of 0.57mm. From this figure, it clearly shown that the train were going slowly because they will stop and pick up passenger at the nearby station (less than 70m). The ETS train, although does not make a stop, also slowed down to minimize the wind effect that may resulted a vacuum and endangering the passenger waiting at the station. That is also one of the reasons of why the deflection were at minimal.

Figure 5. Compilation of trains going southbound at KM71.75.
For this location, the train is departing from station and heading towards southern area. Figure 5 clearly showed the train is gaining speed to depart. From the figure, the maximum deflection was 1.5mm recorded by 6-set-commuter train and ETS. After analysing the data, the PCS located at SOUTHBOUND vibrates more that the PCS located at NORTHBOUND.

3.2 KM79
With the help of KTMB, our team can set the gear safely to obtain any necessary information. This report will be separated into two subsections that are northbound and southbound. In results, northbound implies that the train is going upward to the north and southbound means that the train is setting off toward the south.

![Figure 6](image_url)  
**Figure 6.** Compilation of trains going northbound at KM79.

Based on Figure 6, the maximum deflection recorded was 13.72 mm initiated by a freight train. The maximum deflection occurred at a middle cart of train. It can be initiated by an uneven wheel that has an impact to the sleeper. 6-set-commuter train made a 3.4 mm deflection.

![Figure 7](image_url)  
**Figure 7.** Compilation of trains going southbound at KM79.

Figure 7 showed the data obtained by trains using SOUTHBOUND route at KM79. As can be seen, 6-set-commuter train recorded a maximum deflection of 1.5 mm. Freight train showed a almost zero
From Figure 7 depicted, it shown that the PCS at KM79 rail line has an average deflection recorded.

4. Conclusion
From the gathered data, the research team can compare and determine which area where the pcs vibrate intensively. The vibration between two (2) different sites were different thus resulting a difference in deflection. Table 1 shows the pcs vibration at different site location.

| Site location (km) | Type of train                     | Highest deflection (mm) |
|-------------------|-----------------------------------|-------------------------|
| 79                | Freight (northbound)              | 13.72                   |
| 71.75             | 6-set-commuter (southbound)       | 1.5                     |

The least maximum deflection recorded was at KM71.75 and the deflection was 1.5 mm. The site is located near KTMB station where 6-set-commuter will make a stop and other type of trains will have to slow down. The maximum deflection maybe caused by the movement of ballast underneath PCS. This occurrence has been recorded in laboratory works conducted in Faculty of Civil Engineering Universiti Teknologi MARA Cawangan Pulau Pinang. The cause of this deflection is usually related to the ballast may has not been compacted over a period of time. However, the condition of wheel of each train also can play a vital role in having an impact to the PCS. If the wheel has some irregularity (not in smooth round), the load from the train will not distributed evenly and caused the load to concentrate only at the irregular wheel location thus resulting a high vibration and then translating to high deflection.

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