ASEAN Journal of Engineering and Technology, 2 (1): 07-18, 2022
e-ISSN: 2710 - 5741

DOI: 10.26666/rmp.ajte.2022.1.2

A Review on Modes of Failure of Rail Track Structure in Railway Transportation

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Abstract: *The train is one of the main transportations to move or transfer loads, including people and goods from one place to another on wheeled vehicles running on a railways track. Since, the railways were exposed to extreme conditions, the purpose of the design structure for the railways is to overcome the circumstances. Furthermore, the same train running track was used year after year for nearly a decade. Mechanical failure will occur to the rail structure as the material will defect when subjected to constant and high impact load. The challenging part is how to detect this failure to avoid any catastrophic incident to the train. When a material fault can be recognised earlier, the maintenance work required, and the material's life prediction can be determined, harmful scenarios involving the train can be avoided in the future. In this paper, to better understand this matter, the mechanical failure on the railway running track will be reviewed. The mode of failure involved in the rail track structure includes fatigue failure, buckling effect, shear failure, and corrosion. The significance of this mechanical failure will be emphasised for the sake of this mode of transportation's safety.*

Keywords: Railways structure, Mechanical failure, Rail Track, Mode of Failure

1. Introduction

The locomotive engine railways became the first transportation that could carry a heavy load in a long-distance between 100 km to 1000 km [1]. It can move a lot of weight at once and is very resistant to all kinds of weather [2]. Still, this vehicle only can travel with the visible track on the ground. As a result, railway track is regarded as a critical component of railway transportation [3]. With upgraded new and modern technologies, railways have become one of the most convenient transportation to travel either long or short distances [4]. The railway movement's scheduled and systematic timetable makes it easier for passengers to either plan their journey ahead of time or arrive at their desired destination within an estimated amount of time. People love the high-speed train as the travel time becomes much shorter [5]. Yet, the increasing number of high-speed trains increased the railway track's demand to

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have great integrity, high stiffness, and strong durability. At the moment, China has the most significant number of high-speed trains progress and by 2030, targeted 45 000 km millage of the high-speed railway [6], [7], [8].

As the demand for railways transportation keeps increasing to achieve excellent service performances, many aspects need to be taken care of—specifically, the railway track's safety precautions. Scheduling and planning of railway track maintenance must be efficient. It is essential to include the factor of increasing rail traffic, maintenance needs, and technological development for effective railway track maintenance planning and scheduling (RTMP&S) [9], [10]. Almost 80% of rail track accidents occur due to maintenance failure. Although railway maintenance is costly, the consequences of failure and poor maintenance are far more expensive [11]. Railway track maintenance costs should balance with other expenses required to be economically and environmentally friendly. Almost 40% of the maintenance cost for railway transportation comes from the railways track. For instance, the Japanese have difficulty maximising the cost to maintain the ballasted track since the structure of the track frequently develops defects as a result of vibrations caused by the passage of trains [12]. To raise awareness about the possibility of railways running rail failure, the possible mechanical failure on the structure of the railway track was reviewed in this paper. Several railway accidents were highlighted. The causes for mechanical failure on the railway running rail structure will be discussed.

2. Background of Railway Track

2.1 History of Railway tracks worldwide

The first railway to be built in every country has different years and times. The development of railway transportation mainly depends on the need of each country. Primarily because of the development of the industry, which resulted in the establishment of railway systems in every country. The market is for the exploitation of goods and the transfer of goods over long distances. One of the earliest countries to have a railway system and station is the western country. In the early years of railways transportation in Nordic countries, which are Denmark, Finland, Norway, and Sweden, was built due to three reasons: the growth of the industrial sector in terms of transportation, the exportation and exploitation of natural resources in rural areas, and exploration to many more deserted areas and new opportunities[13]. The railway track connected through all European countries in today's world. Therefore, the tourism sector is overgrowing as people feel convenient to move by using railway transportation either going on a trip or business.

When British countries started colonizing Asia to expand their empire, the industry needs also increased. The industry sector began to develop in Asia countries. The cost was much cheaper because Asia's countries are so big that railway transportation was the best solution for moving heavy loads from rural areas. Among Asia's countries with extensive rail networks is India. The Indian railway network is the largest in Asia and the second-largest in the world, according to the official record. It all began in 1843. Railways have become the main transportation for Indian countries to connect the suburbs of the country. The route milage of Indian railways reaches up to 9000 miles which is the same as one-fourth of the current mileage[14]. The biggest country in Asia, China, is very proud of its locomotive transportation system. Locomotive transportation is one of the earliest in this world. Moreover, today China has one of the best technology and modern locomotive transportation[15]. Not just China but Japan also actively uses railway transportation. In Japan, railways have become the primary mode of transportation for passengers commuting to work or school, making deliveries, or traveling for business. In 2017, Japan's railways transported 440 million passenger kilometres, placing it third in the world [16].

In the desert country, railway transportation has become a tourist attraction as the development of the railway system in the desert was unique and modern. In the 19th century, the west built railways in a middle eastern country. These railways are no longer used and are now covered by sand blown by the wind. The challenge in the past day in middle east railways track is how to mitigate the sand from covering the railway's tracks. Engineers come out with solutions by using the same method as snow mitigation. The properties of the sand and snow are total opposites, but the techniques still can be done to overcome the problem. Windblown sand has reduced the effective speed of the train in recent years, but it has become a tourist attraction as some desert trains in Africa use this opportunity to attract tourists to their country. In the near future, the Arab countries plan to build an extensive railway network across all Arab League Countries with high-speed and high possible capacity modern trains[17]. In Asia, you can also see the railroad track in the desert. The challenge in this matter is the sand deposition in those places. Sometimes the railway needs to be stopped as the track cover with sand and not suitable or dangerous for the railway to move. Sand deposition occur on the railway track will damage the mechanical train structure properties such as ballast bed drainage and track elasticity[18]. The only challenges in the dessert place are the dunes. Although the properties of snow and sand differ, similar method is used to overcome these obstacles.

This means of transportation is relatively late to Southeast Asian nations compared to others. It is the late nineteenth century. The growth of railway transportation in Malaysia is a result of the mining and agricultural industries. Railway transport in Malaysia aims to save time and energy in transporting heavy mining to the coast. After the colonization of the British end in Malaysia, rail transport becomes more than transfer goods. Rail transport has become one of the main modes of transportation for people to move or go places. Examples of railways in Malaysia are heavy rail, light rapid transit (LRT), monorail, airport rail link, and funicular railway line. Moreover, there are many future projects and ongoing projects for railway transportation in Malaysia, such as the Urban railway project, High-Speed Railway (HSR) project, and East Coast Rail Line (ECLR) project. The planning to improve and advance railway transportation in Malaysia for better economic growth and excellent convenience services to the people is still ongoing[19].

Anyway, the development of railway transportation until today has become much more than just transferring goods or passengers. When internet and wireless communication become worldwide, all the railway systems have either become automatic or Internet of Things (IoT) were included. The reasons of the IoT is to meet people's needs for quick services while also saving the environment. The development of modern railways starts to rise in the early 2000s. The Evolution of the Global System for Mobile Communications-Railways (GSM-R) was the starting step to building smart railways. Smart railway technology consists of wireless communication technologies from the palling of railways trips, the maintenance and inspection safety of the railways, and customer services. The major revolution in the railways' industry started to develop after 2005, when the Internet of Things (IoT) was well known. Customers' needs vary as people depend on the internet for communication and services. The railways improved their performance with only small electronic devices, became more powerful, carried more passengers, and traveled faster. However, extra work are needed for safety precautions of the smart railways technologies[20]. In addition, the invention of smart services on railway transportation for the customer has become hot demand. Still, the early stage of railway transportation, like designing the track, engine and body of the railway, also use software and modern app to save cost, time, and energy. Mainly due to the pandemic, the design of the railway track has become much easier and cheaper by just using software such as Google Eart, AutoCAD, and SketchUp[21].

2.2 Component of Railway Track.

A train's tracks aren't only made up of a single piece of straight rail; they also include other components that help to support the railway track. The railway track components consist of rails, rail fastening, and pads, sleepers, ballast, joints, switches, and crossings [22]. These components have varying strengths to withstand the possibility of the railway track failing due to their varying sizes and shapes. Railway tracks are composed of superstructure, which is visible on the surface track, and substructure, which is the base that supports the rail construction. Examples of the superstructure are rails, fastening systems, cribs, and sleepers or ties. While, substructure includes top ballast, bottom ballast, sub-ballast, blanket, placed soil or fill, and formation or natural soil [23][24].

Firstly, from the superstructure of the railway track, the most important component is rail. Rail is formed of steel and must meet the following specifications: high wear resistance, high deform resistance, high fatigue strength, high yield strength, good weldability, good texture, profile evenness and dimensions correctness, and low residual stresses after production. [25]. The rail grades different name is based on the hardness and the rail type. EN 13674-1+Al 2017 is the most recent accepted rail specification, which divides steel rail grades into two categories and introduces new steel grades. There are two types of steel: non-heated steel, whose strength depends on how hard it is, and heat-treated steel, whose strength depends on its composition and how it was heated. The three types of rail grade are non-heat treated (R200, R220, R260, R260Mn, R320Cr), heat-treated (R350HT, R350LHT, R370CrHT, R400HT), and new steel grades (HP335, B320, B360, DOBAIN) [26]. Next, Rail pads are an important component of the railway track fastening system. The rail pads' function is to tighten the rail to the ground and act as a cushion to absorb shock and vibrations caused by the repetitive loads of train wheels passing through the track [27] [28]. Furthermore, the rail pad channels serve as a drainage and cooling system. The purpose of this functionality is to prevent the temperature of the railway track from rising, as this can change the mechanical properties of the material [29]. In modern railways, the fastening system of the rail track becomes complex with various additional components such as rail, pad, insulator, rail clip, and base plate [30]. Aside from that, one of the main components of the superstructure is railway sleepers. Railways sleepers are placed between rail and ballast. The railway sleepers' function is to absorb the repetitive impact load from the rail distributed by the train wheel as it passes through the track [31]. Commonly the sleepers are timber, cast-iron, steel, concrete, and prestressed concrete. The advantages and disadvantages of the material that is used are different. The demand for new railway sleeper materials is necessary because the common materials currently in use do not meet modern performance standards. Most available materials necessitate frequent maintenance and are prone to failure, such as steel and cast iron, which can corrode in less than a decade. Although prestressed concrete sleepers outperform other materials, their service life is limited to five years. This problem is costly in replacement and maintenance services [32]. Today's composite sleeper material outperforms the commonly used material of performance. HDPE, waste rubber, and glass fiber are some examples of composite materials. These materials exhibit high resistance to climate influence, support the green environment, and have the proper track stiffness to overcome the vibration problem experienced by railway sleepers [33]. Besides that, the other component of superstructure railway track is rail joints. To create a single, lengthy railway track, rail joints are placed between the individual rails. There are three types of railway joints: fish-plated rail joints, rail welding, and rail expansion devices. [34]. Rail joints are the most vulnerable part of a railway track because the material is softer, and the size is smaller when compared to the rail [35].

Then, ballast is part of the substructure for the railway track. The substructure of a railroad track must have good drainage, great soil qualities, and strong ballast resistance to deformation and failure from dynamic wheel load [36]. When the railroad passes through the track, the substructure will bear the load.. Safety of the track can be attributed to the substructure performance of the railway [37]. There are two types of railway track substructure which are ballast track and concrete track (ballastless track) [23], [38].

It is safer to design a railway track structure using a dynamic design method because it is frequently subjected to dynamic loading conditions. Maximum forces for dynamic wheel load are five times higher than static wheel load. When the train track is designed with static conditions in mind, it's not clear if it can be used in real life when the train goes fast [39].

3. Railways Track Accident and Disaster

Accidents and mishaps are unavoidable in everyday life. The only precaution is to learn from previous mistakes or to study and analyze the problem that has arisen to maintain and overcome any catastrophic incident in the future. There are seven types of accidents in the railway system, including the derailment of the train from the track, collision of the train with any object, fire or explosion of the railway's vehicles, structural collapse due to structural failure either on the train or in the environment, Equipment's fatigue such as broken rails, track deformation, or wheel and axle rupture, signalling equipment failure, and lastly, human error in terms of operability [40]. Apart from that, the cause of an accident on railways also comes from the mechanical components of trains. The train bogie components are responsible for 45% of the accidents, while other components such as brakes, couplers, and the body are responsible for 37% of the accidents[41].

Train accidents are mainly caused by the derailment. The train goes off the track because there are cracks and bends in the track [42]. According to an assessment of track derailment incidents in Canada from 2001 to 2014, rail integrity accounted for up to forty percent of the causes [43]. Based on an analysis of rolling stock derailment at PJSC Ukrzakinznytsya over the past five years, a number of types have been identified, including those caused by track disassembly, rolling off a wheel ridge on the railhead, unacceptable horizontal transverse curvature of a rail-sleeper, rolling of a cut ridge of a defective bogie, arrow cut, rolling stock collision, and rail breakage [44]. Hua et al. also investigate the factors contributing to railway accidents in China. By frequency of occurrence, most railway accidents in China occur due to human rule violations and mechanical equipment failure. The person in charge did not follow the rules and regulations, and the testing and maintenance was inadequate. As a result of improper maintenance, the railway track suffers sudden damage and detachment [45], [46].

Some real-life accidents were recorded. This disastrous phenomenon affects human life, the system, and the environment. Iorio discussed the cause of the Viareggio (Italy) railways disaster in 2009. The first wagon's axle bursts, causing the derailment of four of the thirteen other wagons on the train. The tank of a heavy-load train was overturned, causing the tank to fall and leak, resulting in the dispersal of the tank's fuel across the station. [47]. Kowal and Szala study the railway bridge in Poland that has aged for more than 100 years. This study attempts to determine the mechanical qualities of this railway and suggest improvements that can be made when it is replaced by a new railway track. The old railway bridge in Poland was unable to operate at its best efficiency as the structure of the railway bridge eroded due to a lack of maintenance services. A new material for the railway bridge that is easier to maintain, suitable for current trains, and less prone to failure was developed by Kowal and Szala, and this information was used to help prevent the structure from failing [48]. The cause of the failure is not just determined by technical inspection only. Still, several methods were proposed to study the problem from the railway accidents as Nehete et al. use the *ISHIKAWA DIAGRAM* method to find the root cause for the failure of the suspension spring in the fiat bogie. Failure of suspension springs used in fiat bogie of Indian railways occurred faster than the springs' actual life. The train that goes from Solapur to Kolhapur and the Siddheshwar have springs that don't last as long as the springs used in Express trains [49]. Sometimes accidents occur out of prediction. When involved with fatigue failure, the defects on the railways seem hard to be visible to the eyes vision. Furthermore, due to people’s careless behavior about the safety precaution of railways to be operated, leads to tragedy as Smith and Hillmansen highlighted several occasions of the fatigues of railways axles. In addition to this, The Versailles accident of 1842 is the first railway accident to occur. Many speculations were being made, such as religious groups claiming that it was a punishment from God. However, the technical journals figured out the accident occurred due to an unusual fracture surface on the railway’s axle long after this incident. The “crystallized” part described as the railway axle lamellated with large crystals. The failure happens as the railway’s axle cannot support the weight and suddenly breaks into pieces. Secondly, the Penistone accident of 1884 occurred when the railway’s axle suddenly breaks, and the trail derails from its track. It turns out that the axles used for driving were either broken or banned. The author believed the failure happened due to the side thrust experienced by the railway’s axle. When a train is moving at a high speed, the oscillation caused by the movement of the train places tremendous stress on the axles [50].

4. Mechanical Failure on the Railway Running Rail Structure

Various types of defects and mechanical failures exist on the railway structure. This form of failure is complicated since it is difficult to notice with the naked eye, and extra inquiry or analysis is required to solve the real problems. The maintenance cost to control this issue is considerably high. To save money and energy, early detection and careful inspections were done. This article will only talk about a few types of mechanical failures to bring awareness to these problems.

4.1 Fatigue failure

Fatigue failure define as a failure that occurs due to continuous cyclic load acting on the railway track. Most of the time, damage to a structure caused by fatigue failure shows up below the material's stress limit. The three effects of fatigue failure are the stress range magnitude, the type of the structure material, and the number of load cycle passed through the track [51]. One of the examples done by the previous researcher was Alencar et al. did review of the mechanical failure of welded railway bridges. The mechanical failure that focused on is the fatigue cracking visible on the welded railway bridges. The welded part of the railway tracks becomes one of the main concerns as the track deteriorates faster. Four factors are were highlighted as the cause of the fatigue cracking on the railway bridge. Firstly, fatigue cracking due to weld defects during the fabrication process. Second, load stress on the structural component with a low fatigue strength. Thirdly, the displacement and distortion of the railroad bridge track cause the emergence of fatigue cracks. Lastly, environmental vibrations might contribute to the development of cracks on railway bridge tracks [52]. On the thermite weld rail, the stress intensity factor was higher in the out-of-plane loading case as the fatigue crack grew much faster than in-plane loading cases. The direction of the crack propagates to the width direction of the rail. The fatigue life of the rail becomes shorter as the fatigue growth behavior increase rapidly[53]. Fatigue crack length does not just depend on the service time of the rail running track, but fatigue cracks initiate or grow faster on the rail surface that is closer to the wheel of the railways. Usually, this crack propagates in the transverse crack as in the width direction of the track[54]. Mechanical properties of materials are significantly altered when they are subjected to repetitive cyclic loading, as demonstrated by Parvez and Foster. Permanent strain and deformation on the rail structure will continue to increase while the structure's stiffness decreases. The fatigue of railway tracks begins with the formation of a micro-crack. It progresses to the formation of a macro-crack, which eventually leads to the material's sudden fracture or failure[55]. Atroshenko et al. have performed fractographic investigation of the microstructure of rail steel fatigue failure. There are three fracture zones that have been classified into three distinct stages. Figure 1 shows that the first zone fracture was near the surface of the fracture area. Dynamic recrystallization took place here for all the microstructures. The surface crack had a noticeable grit at this point in the fracturing process. The second zone fracture is called the intermediate fracture stage. The crack form as a longitudinal line and continue to elongate inside the rail steel. The last stage is the initial fracture stage in the third zone. The crack line was closer to the fracture surface[56].

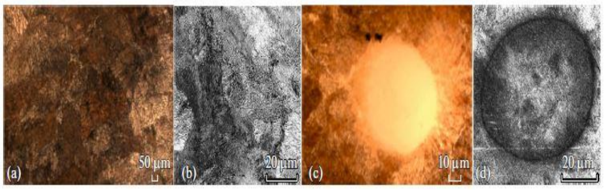

Figure 1. Microstructure in center of region 1[56].

4.2 Buckling failure

Apart from that, the buckling effect on the railway track's curvature section should be a top priority of concern for the degradation of the railway track's performance. The material's safe temperature can be affected by cyclic working conditions. When the force applied to a railway track exceeds the safe temperature limit, the track begins to buckle. As the track temperature rises and exceeds the buckling temperature limit, the track is prone to early fracture [57]. Baker et al. discussed the effect of climate changes to the railway track. During hot, dry summer, the railway track was exposed to a high frequency of temperature, and if the temperature frequency exceeds the critical level of force, the train track will buckle. The increasing buckling of the train track will change the shape or deform entirely from its original state. During this time of year, the tracks are more likely to buckle, thus trains must travel more slowly [58][59]. Other than that, Miri et al. did a study on dynamic track buckling analysis. Wheel/rail interaction, bending between wheel loads, and train braking were all regarded as train track interaction types. According to the findings of this research, the existence of wheel flaws as well as harsh braking action will bring the buckling and safe temperature limit decrease [60]. In addition, the ballast fouling condition and the length of misalignment of the track will affect the buckling temperature. In the simulation done by Ngamkhanong et al., the ballast fouling condition is described in figure 2. Ballast fouling occurs when finer particles, such as those that are smaller than the ballast materials, are combined with them. There were three different categories ; only 100 mm fouled layer from the ballast condition, which is most of the ballast condition is clean. The second category is half of the ballast condition was fouled layer which is 200 mm in height of the fouled layer. Lastly, the fully fouled layer. When the significant misalignment comes with ballast fouling conditions results in buckling temperature reduction, the low allowable temperature is no good as the buckling strength keeps decreasing. Thus, the chances that the track would buckle in the summer is increased when the temperature falls between 20 °C and 30 °C, which is the temperature range during those seasons [61]. Aside from that, Khatibi et al. investigated the effect of different ballast properties on track buckling. It was found that increasing the holes in the ballast lowers the temperature at which the track buckles and the temperature at which it is safe. The porousness of the ballast shows how much ballast fouling there is. The fouling condition becomes more severe as the ballast porosity increases [62]. The inspection method employing fibre optic sensors was utilised to gain a deeper comprehension of lateral buckling under axial load. The buckling effect on each different strain length detected by the sensor can be studied and analyzed. The parameters or the value may show slight differences still, lateral buckling under axial load happens when the amplitude of the curvature profile of axial loads approaches the buckling loads, the track will undergo lateral deformation[63]. The rise in rail temperature comes from the compression axial force acting on the rail. The rail will buckle when the compression axial force increases until it reaches the limit or buckling resistance. The buckling resistance depends on the condition and the element of the track. The track lateral resistance affects the buckling shapes. Interestingly, the more buckled region is noticeable on the higher lateral stiffness than the low lateral stiffness track. For example, the plain tracks buckling shapes region are higher than the interspersed tracks. However, the higher the unconstrained length, the earlier the track to buckled. The track starts to buckle when the maximum compression axial forces are the same as the critical buckle force, which is obvious at the maximum temperature. From this point, the track will undergo deformation and degradation[64].

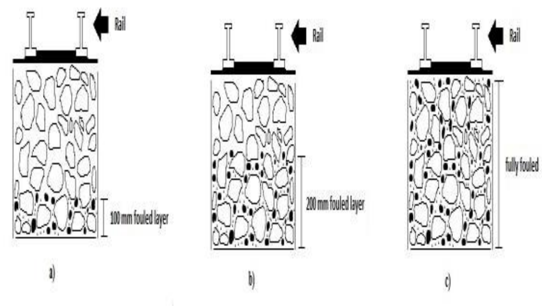

Figure 2. Ballast fouling condition a) 100 mm fouled layer b) 200 mm fouled layer c) fully fouled[61].

4.3 Shear failure

Most defections occur on the track's structure or surface due to an axial load or force acting perpendicular to the track. This force direction has a significant impact on the track structure's deformation. However, shear stress and failure should draw attention to this railway track structure failure. The ground's soil serves as the foundation for the railroad's track. The characteristic of the soil can absorb water. However, an excessive amount of water was absorbed by the soil on the upper part of the railway track foundation will soften the railway track and lead to mechanical failures. The progressive shear failure on the subgrade part becomes faster. This can occur due to the cyclic over-stressing on the soil as it will be sheared and remolded. The plastic deformation on the subgrade part becomes much softer as the ballast pocket containing water exceeds the subgrade part's region. When the railways track becomes softer, the railway track cannot withstand the heavy load as it will lead to more shear failure on the subgrade part [65]. Li and Vanapalli study progressive shear failure (PSF) and the shape of failure planes in the subgrade. Repeated stresses from soil movement upwards and sideways cause PSF to develop. Rail structure and cyclic train loads, as well as soil type, contribute to subgrade failure. Shear and stiffness of the track are reduced by poorly drained soil [66]. Apart from that, Mamou et al. look into the effect of the different conditions of the soil on the cyclic shear stress threshold. The tests were performed in two conditions: free-to-drain and undrained. There were no significant changes in the resilient stiffness of the soil when the stress cycle was below the cyclic shear stress threshold. However, once the stress cycle exceeds the cyclic shear threshold value, the soil stiffness and stability are reduced, resulting in abrupt track deterioration [67]. Lazorenko et al. also review the stability of the soil to build a railway track for heavy haul railway. By knowing the stability of the soil, the necessary control to build the foundation of the track becomes much more accurate to make the railway track that has a more substantial structure and decelerate the degradation process. It is important to do frequent surveys and appropriate maintenance to reduce the risk of railway track deterioration[68]. Besides that, ballast conditions influence the shear strength of the railway track. Dissanayake et al. have compared fresh ballast conditions and fouled ballast conditions in Sri Lanka. Fresh ballast with higher interlocking action provided by more angular particles with sharp edges exhibits higher shear resistance than fouled ballast with no sharp edges and reduced effective interlocking of grains. The degree of roundness of the material determines the effective interlocking of grain. According to Mevelase et al.'s experiment, the internal friction angle increases as the average roundness of the material increases from 0.8 to 1. The sharp edge became smooth due to repeated loading, which caused the ballast to break down, producing fines and flaking [69]. The fouled ballast condition occurs as a result of the train's weight and exposure to severe weather conditions. As a result, the track has less frictional resistance and shear strength, resulting in shear failure [70]. In other words, the failure of a rail track depends not only on the performance of the rails, but also on the performance of every component that comprised the rail track. One crucial component is the rail fastening system that holds the curvature of the rail track. The illustration of the rail fastener type has three types, as shown in figure 3. Due to significant shear stress, the possibility of a fastening grip such as a nut and bolt becoming loosened is increased [71]. Large lateral forces can lift the rails when a train passes through the curvature track. When the disk arrangement weakens the fastening strength, the friction between the washers and the base plates reduces, and the displacement of the base plates will occur. The shear stress caused by the displacement of the base plates fails the anchor bolt[72]. Shear stress is higher for tightly bolted rail join bars than for loosely bolted rail join bars. Plastic deformation occurs on the rail-end joint bar due to soaring shear stress [73].

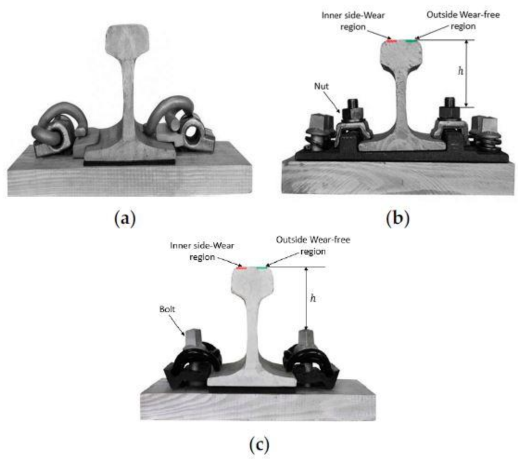

Figure 3. Rail fastener type: (a) Bolt-free fastener (b) nut-fastening fastener (c) bolt-fstening fastener[71].

4.4 Corrosion

Last but not least, the corrosion of the running rail structure must be taken seriously. Corrosion on the surface of the track at first glance may not seem crucial until the need to be replaced or maintained with the new one. This is because corrosion is not the main factor in deteriorating or failing the railway running track. Yet, form corroded surface is the first reason for the railway track to undergo a reduction in strength and its running performance. The corroded structure occurs based on two situations, either from the changing humidity of the atmosphere or due to rolling contact fatigue. The latter reason should be taken seriously as the rails can experience corrugation and cracking. The type of corrosion are classify into two different corrosion: general corrosion and localized corrosion. General corrosion covers a large or wide area of the corroded structure, mainly due to salt deposition and atmospheric corrosion. Meanwhile, localized corrosion focuses on a specific area, such as crevice corrosion and stress-induced corrosion. The new type of corrosion is stray current corrosion, corrosion of ballasted track, and galvanic corrosion[74]. Corrosion on the railway track structure starts to form when the microstructure of the material of the railway track changes. When external impurities such as rainwater change the microstructure of a railway tracks, this effect also leads to the deformation of the railway structure. If the corroded are become larger and reaches the limit stretch of the material, a crack will start to form, which is the first step that leads to dangerous mechanical failure[75]. Furthermore, it was demonstrated that a non-corroded rail structure has more fatigue life cycles than a corroded rail structure. As in figure 4 and figure 5, Mahmoodian et al. have made the comparison of maximum stress location between non-corroded and corroded rail. In the simulation result, the corroded rail experienced higher von-misses stress at the centre of the stress location. This should be taken into account when rescheduling maintenance timetables to avoid the effect of corroded rail structure, which increases the risk of crack initiation and eventual failure[76].

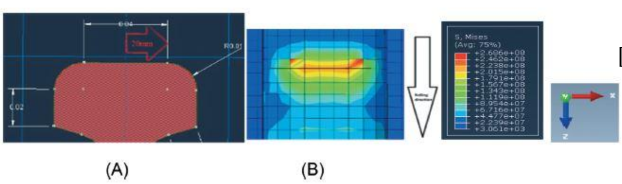

Figure 4. (a) the maximum stress location on the non-corroded rail profile (b) the distribution of Von Misses stress (non-corroded) rail[76].

5. Conclusion

Mechanical failure on railways running rail structures such as fatigue failure, buckling effect, shear failure, and corrosion were reviewed. This paper begins by identifying some previous accidents or damage on the railway track. As a result of these accidents, not only is the railway infrastructure damaged, but also human lives are jeopardised. This type of mechanical breakdown is not to be taken lightly. Further study and research on this topic offer numerous options to solve this issue in a more effective and transparent manner. The defects must be identified earlier to maintain a good performance of railways running rail structure. Therefore, it is possible to avoid catastrophic incidents and severe damage caused by mechanical failures in the running rail system of railways.

6. Acknowledgment

The author would like to express her gratitude to the Kementerian Pengajian Tinggi (KPT) Malaysia under research grant FRGS/1/2020/TK02/UKM/03/1 for supporting this research project.

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