A Review on Modes of Failure of Rail Tracks in Railway Transportation

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What is Railway?

INTRODUCTION

- ✓ **Locomotive engine vehicle**
- ✓ **First heavy load transportation**
- ✓ **Travel in long distance**

Development

HIGH SPEED TRAIN

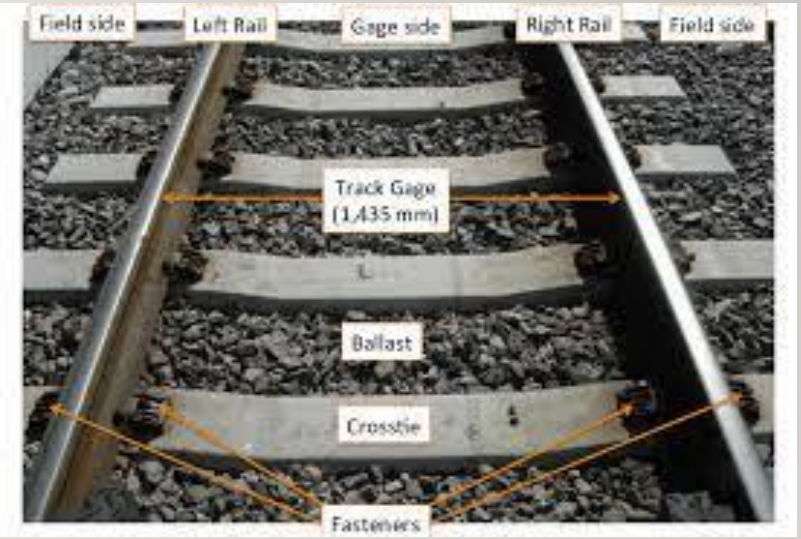
China has the largest high speed train progress

(Chen & Zhou, 2020)

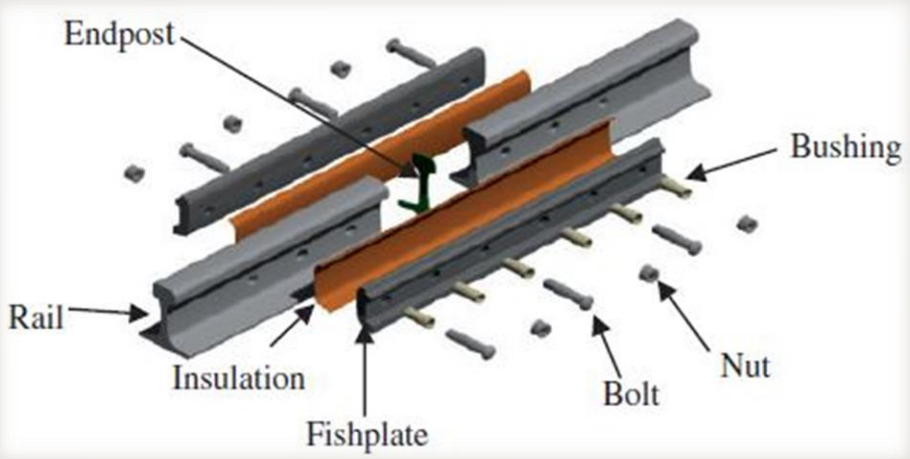
Challenges

MAINTENACE COST

Up to 40 % of the cost come from railway track (Miwa & Oyama, 2018)



Rail joint are categorized as the most vulnerable part due to its softer material and smaller in size. (Gallou et al., 2018)



History of Railway worldwide

WESTERN COUNTRY

START

In Nordic countries; Denmark, Finland, Norway & Sweden.

Reasons :

1. The growth of industrial sector in terms of transportation.
2. The exportation and exploitation of natural resources in rural areas.
3. Exploration to many more deserted areas and new opportunities

ACHIEVEMENT

- ❑ Railway track connected all the European country.
- ❑ Tourism sector grow rapidly

(En et al., 2018)

ASIA COUNTRY

START

India, China, Japan

Reasons :

1. The industry sector starts to develop in Asia country and the cost were much cheaper.
2. Moving heavy loads from rural areas.

ACHIEVEMENT

- India : The route-milage of Indian railways reach up to 9000 miles which same as one-fourth of current mileage. (Premkumar & Kumar, 2019)
- China : One of the best technology and modern locomotive transportation (Manuel et al., 2020).
- Japan : In 2017, 440 million passenger-kilometres were recorded using railways transportation that makes Japan ranks the third in the world ranking (Lam & Tai, 2020).

DESSERT COUNTRY

START

Arab, Africa & Asia

From late 19th century

Challenges :

1. Sand deposition (Moyan et al., 2020).

ACHIEVEMENT

- The Arab countries plan to build a large railway network across all Arab League Countries with high-speed and high possible capacity modern trains (Bruno et al., 2018).

MALAYSIA

START

From late 19th century

Reasons :

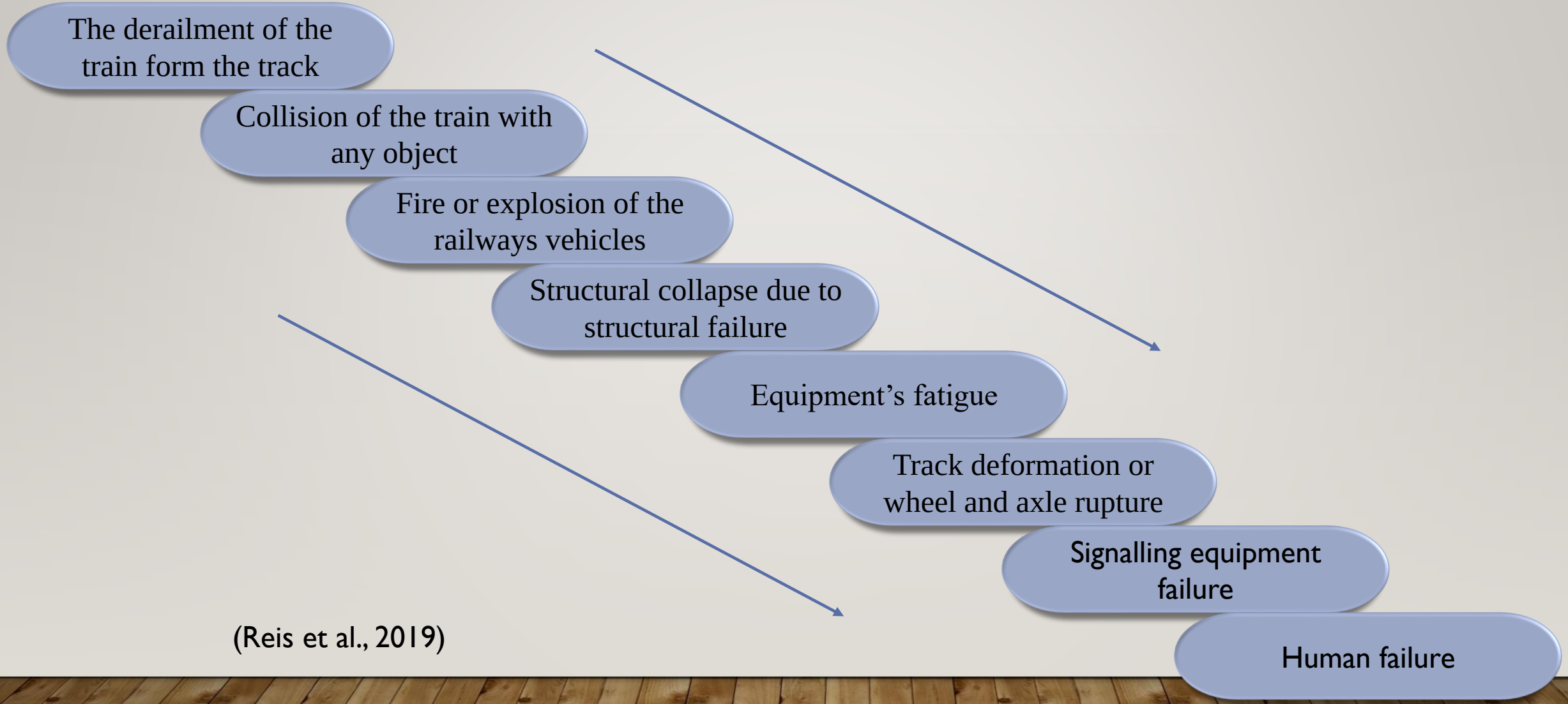
1. Due to mining industry and agriculture sector.

ACHIEVEMENT

- ❑ Heavy rail
- ❑ Light rapid transit (LRT)
- ❑ Monorail
- ❑ Airport rail link
- ❑ Funicular railway line
- ❑ Urban railway project
- ❑ High Speed Railway (HSR) project
- ❑ East Coast Rail Line (ECLR) project

(Sahrir Abd Aziz et al., 2018)

Railway tracks accident and disaster



(Reis et al., 2019)

Real-life accidents

Viareggio (Italy) railways disaster

- In 2009
- Due to the rupture of the axle on the first wagon

(Iorio, 2019)

Railway bridge in Poland

- Age more than 100 years
- Unable to operate at its best efficiency as the structure of the railways bridge corroded due to lack of maintenance services

(Kowal & Szala, 2020)

Indian railway

- Failure of suspension springs used in fiat bogie of Indian railways occurred faster than the springs' actual life.

(Nehete Pradip Patil Tushar Jangam, 2021)

Fatigue Failure accident

- The Versailles accident of 1842 : due to unusual fracture surface on the railway's axle
- the Pensitone accident of 1884 : axle suddenly breaks and the trail derail from its track

(Smith & Hillmansen, 2004).

Mechanical failure on running rail structure

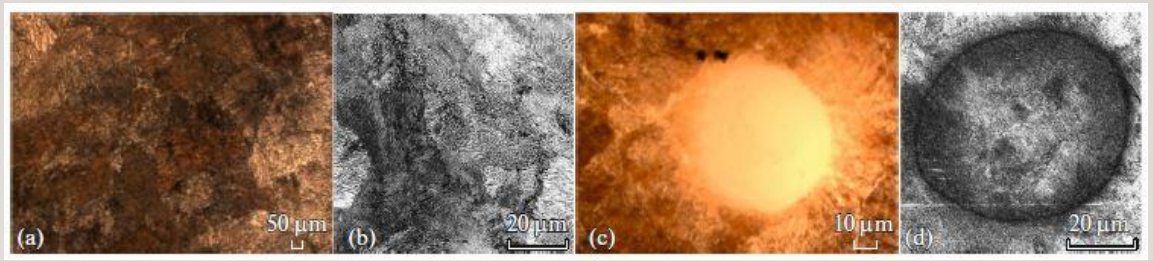
FATIGUE FAILURE
(continuous cyclic load acting on the railway track)

FACTOR
Weld defect during the fabrication process
Load stress on the low fatigue strength structural component
The deformation and distortion of the railway track
Vibration from the environment

(Alencar et al., 2019)

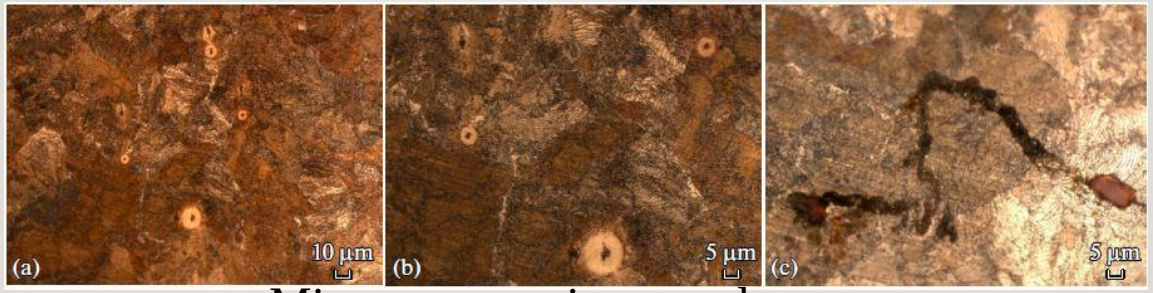
MICROSTRUCTURE ANALYZATION OF THE FATIGUE FAILURE

First Zone



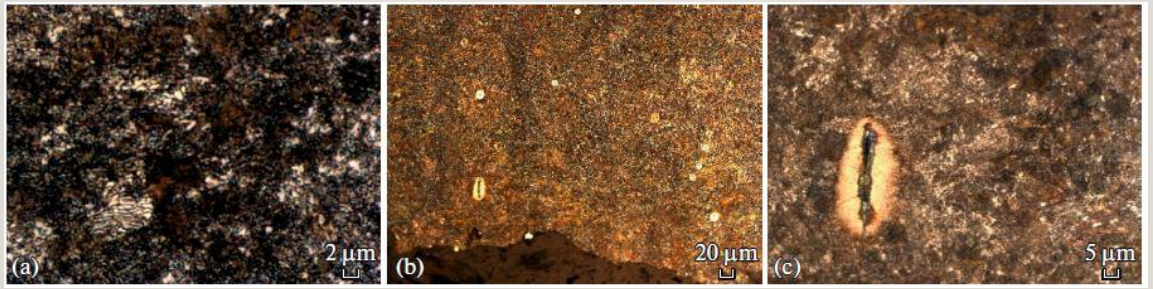
Microstructure in first zone

Second Zone



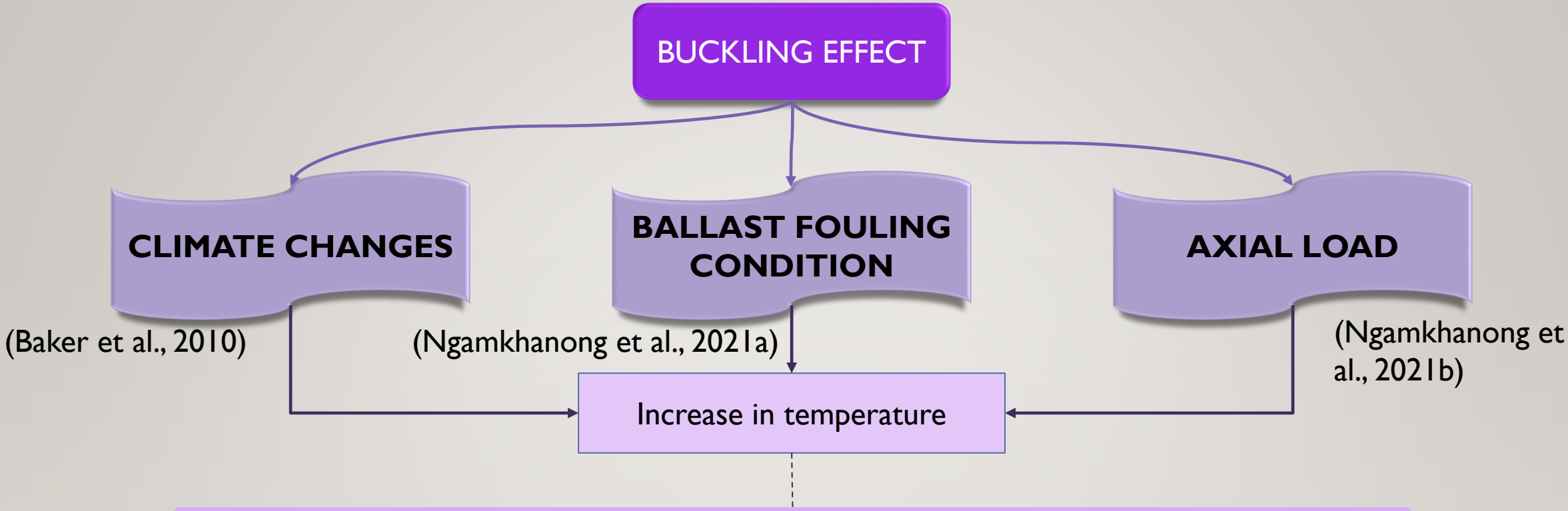
Microstructure in second zone

Third Zone



Microstructure in third zone

(Atroshenko et al., 2020).



- **When exceed the critical force, the track will buckle.**
- **Reduction of buckling temperature.**
- **The rail will buckle when the compression axial force continues to increase until reach the limit or buckling resistance.**
- **The track start to buckle when the maximum compression axial forces the same as critical buckle force which can be seen at the maximum temperature.**

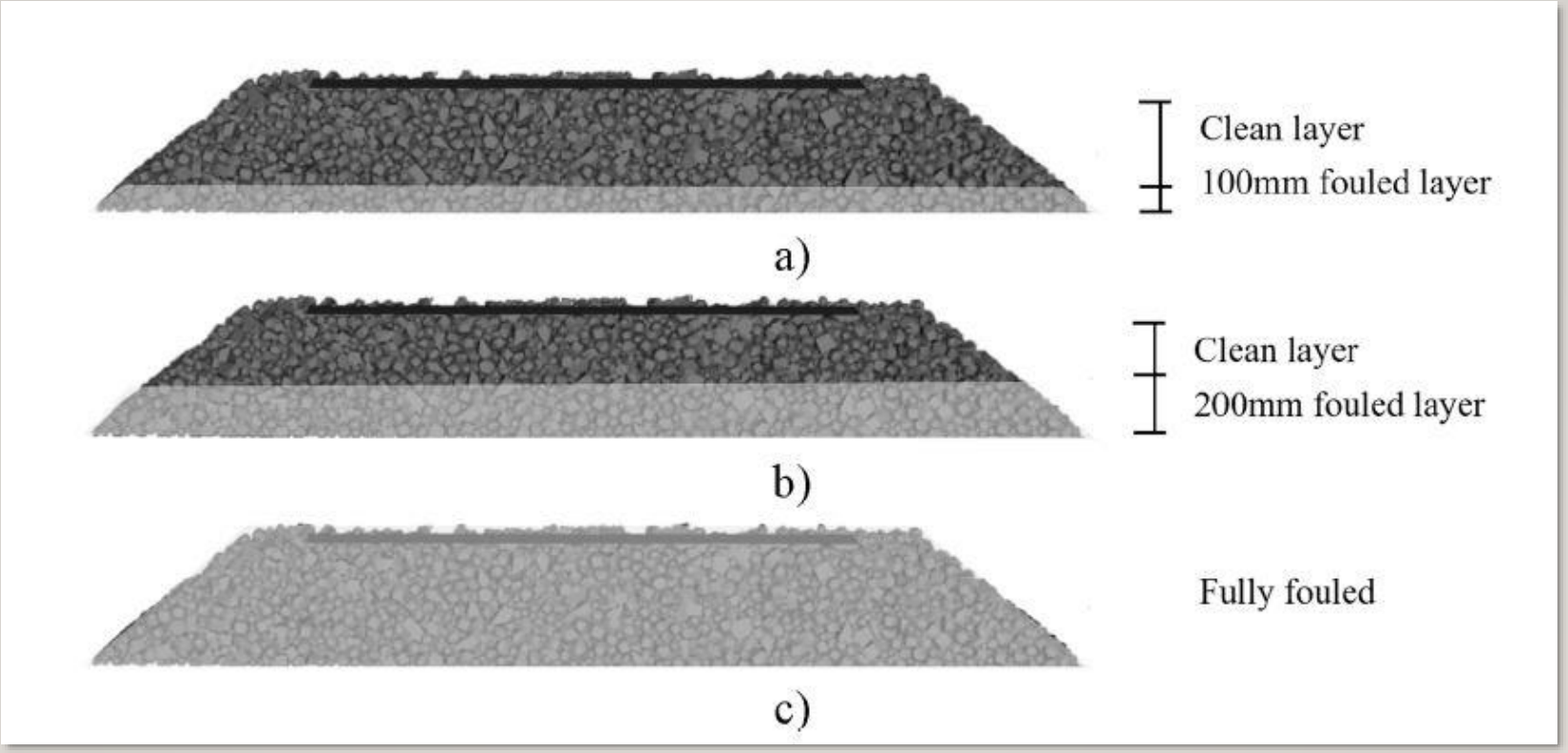


FIGURE : Ballast fouling condition a) 100 mm fouled layer b) 200 mm fouled layer c) fully fouled (Ngamkhanong et al., 2021a).

SHEAR STRESS AND FAILURE

SOIL

- Excessive amount of water being absorb by the soil on the upper part of the railway track foundation will soften the railway track.
- Lead to more shear failure on the subgrade part.

(Usman et al., 2015)

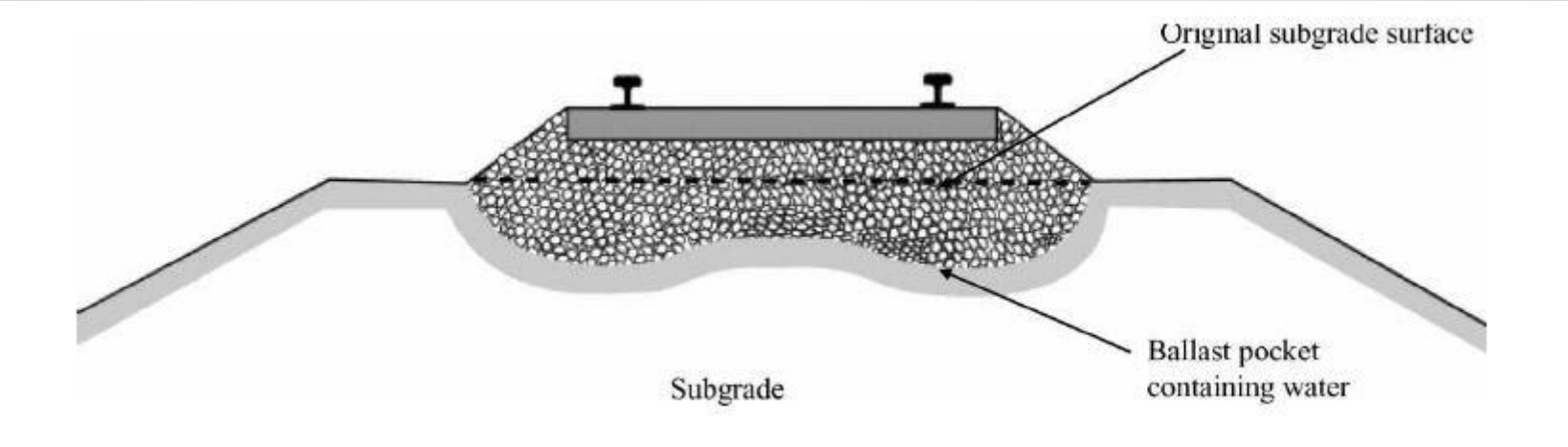
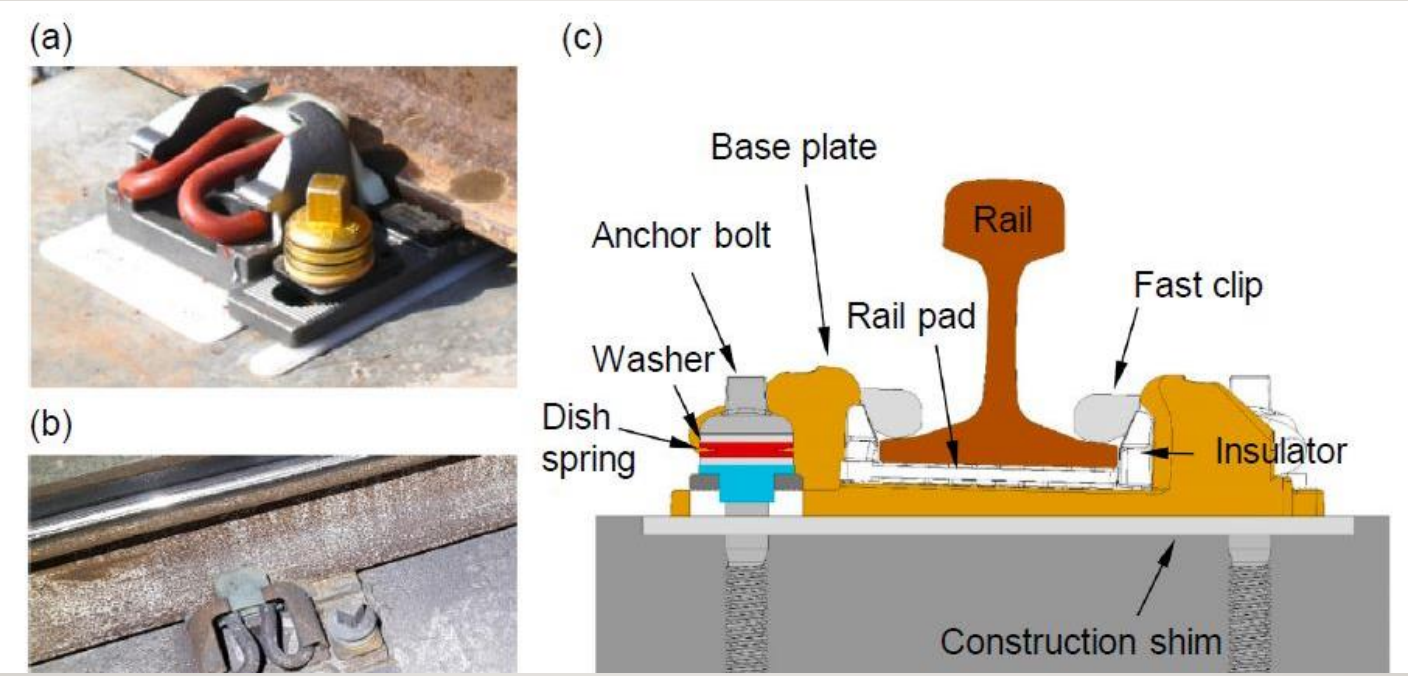


FIGURE : Excessive subgrade plastic deformation

RAIL FASTENING SYSTEM

- When the disk arrangement weakens the fastening strength, the friction between the washers and the base plates reducing and the displacement of the base plates will occur.
- The shear stress caused by the displacement of the base plates, results in the failure of the anchor bolt.

(Choi & Kim, 2020)



CORROSION

- First reason for the railway track to undergoes reducing in strength and its performance .
- Due to changing humidity of the atmosphere or due to rolling contact fatigue.
- The microstructure of the material of the railway track undergoes changes.
- Corroded area large and reach the limit stretch of the material, crack will start to form.

(Xu et al., 2021)

CONCLUSION

- ✓ Get to know the history of railway transportation around the world.
- ✓ Identifying some previous accident or damage occur on railway track.
- ✓ Mechanical failure on railways running rail structure such as fatigue failure, buckling effect, shear failure and corrosion have been discussed.
- ✓ The defects should be detected earlier to maintain a good performance of railways running rail structure.
- ✓ Thus, catastrophic incidents and serious damage to the track can be avoided.

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THANK YOU ☺