Understanding the Interaction between Bike Tyres and Tram Tracks

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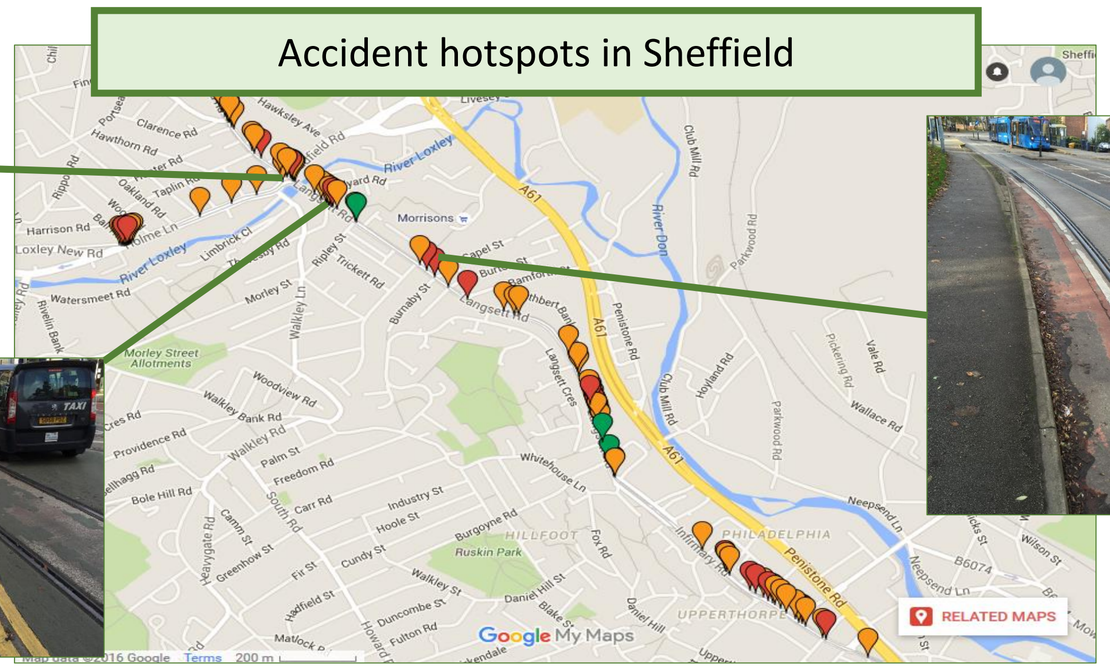
Cyclists often have accidents when navigating tram rails. In cities like Sheffield, this not only causes damage to people and their property but is a huge cost to local government.

Incidents generally involve bike tyres slipping on rails or dropping into the groove, yet little is known about the interaction between bike tyres and rails.

To tackle the problem, the friction between tyre and track is found for different conditions and used to model the forces in the contact.

Accident hotspots in Sheffield



Experiments

A section of tyre is attached to the end of a pendulum arm. When released, the arm swings down so the tyre can interact with a section of rail.

The rail is attached to a force bed, which allows the coefficient of friction to be found.

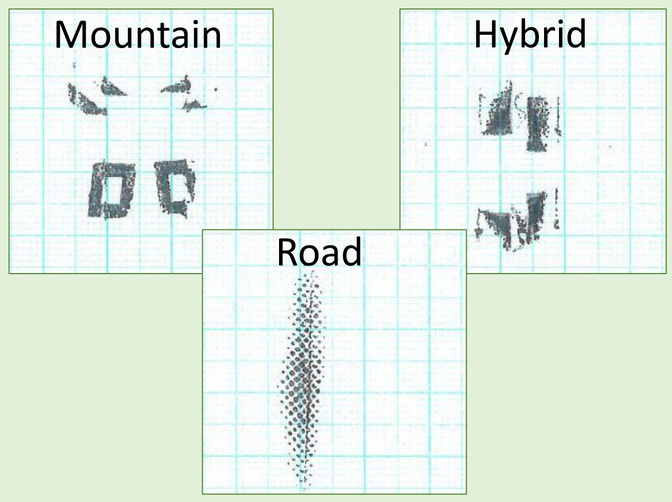
The test is done for dry, wet and oily conditions to find the worst-case scenario for a cyclist.

These conditions can simulate wet weather or traffic emissions on the rail in a city.

The best and worst-case values are used to model forces in the contact.

Tyre	Condition	Mean Coefficient of Friction μ
Mountain	Dry	1.361
	Wet	0.520
	Oil	0.319
Hybrid	Dry	1.334
	Wet	0.518
	Oil	0.275
Road	Dry	1.502
	Wet	0.393
	Oil	0.371

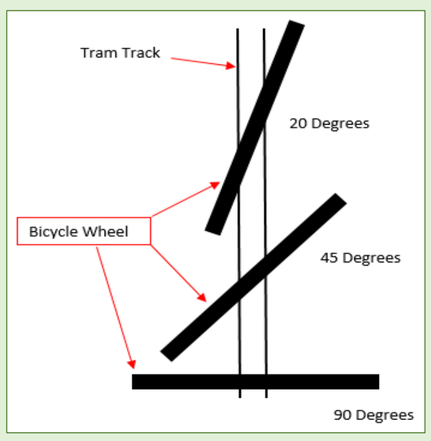
Tyre contact area:



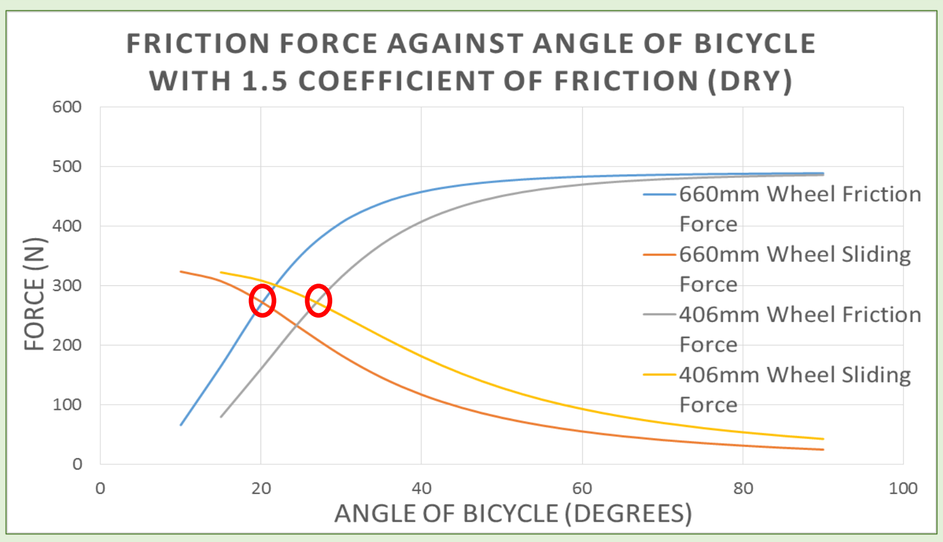
The results align with anecdotal evidence: that the track becomes more slippery with water or oil.

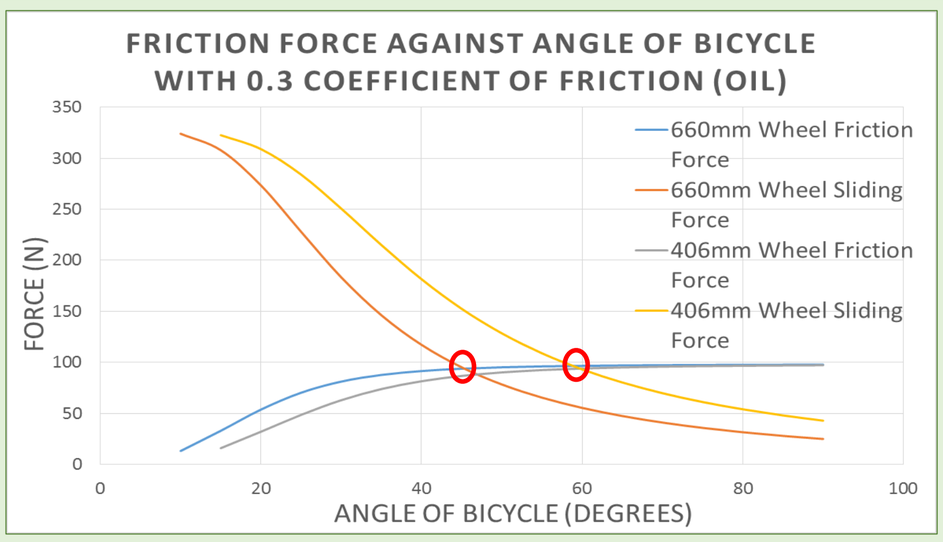
Road tyres have the most grip, likely due to their larger apparent contact area.

Modelling



The approach angle of the bike as it crosses the track affects the likelihood of the tyre slipping or getting stuck.





Friction and sliding forces are calculated for different sized wheels. A smaller approach angle reduces the friction force.

The bike can cross the tram track safely until a critical point marked in red, at the angle where the sliding force becomes bigger than the friction force – this is when the bike will slip into the groove of the track.

Conclusions

The pendulum tests show that oil on the track hugely reduces the friction between the track and tyre. This means that the minimum safe angle is reduced even more and slipping is much more likely.

Further tests can be done with real cyclists in a controlled environment to confirm that a bike will slip into the groove at the expected angle. This is more complicated as there are many other factors at work, such as the rider's confidence and the influence of traffic conditions.

What this study can confirm is that cyclists must take extra care in wet or oil conditions, regardless of their bike or tyre type.

Map courtesy of Cycle Sheffield Tramcrash