

Appendix 6

Washboarding of Roads



A typically washboarded road

After reading the non scientific literature on washboard formation it is apparent that there is a load of completely unscientific baloney about how washboarding forms in gravel roads, and why.

Tarberlet *et al*, after modelling tyres rolling over various granular terrains, have established that the washboarding phenomenon is independent of wheel diameter and substrate grain size and furthermore is not influenced by the presence/absence of wheel (vehicle) suspension. In fact a wheel is unnecessary at all, as washboarding occurs even if a simple board or plough is dragged over a surface, or if the wheel is fixed ie does not rotate. Apparently washboarding can occur on steel rails and in snow.

The only relevant parameters are:

m the mass of the wheel (per unit width)

ρ the density of the bed

v the velocity of the wheel, and this speed appears to be crucial.

A dimensional analysis of the parameters yields one unique dimensionless number which characterizes the substrate instability which facilitates washboard formation:

$$F_r = \frac{v^2}{g} \sqrt{\frac{\rho}{m}}$$

Froude number is a dimensionless number used in fluid mechanics. From the above it can be inferred that $v^4 \propto m$

In this context it is suggested that a substrate (gravel, sand etc) instability resulting in a switch from highly dissipative, plastic behaviour at low speeds to weakly dissipative, dynamic supporting forces at high speed.

Indeed, there exists a critical velocity below which the road always remains flat and above which washboard bumps appear. For a car this critical velocity occurs when $V \propto \sqrt[4]{m}$, this is around 5 mph (8 km/h).

The natural length of the ripple wavelength created under these circumstances is $\frac{v^2}{g}$

As the researchers say:

*Washboard road will no doubt continue to annoy drivers
for as long as there are unpaved roads and wheels to roll over them*

Although as they highlight in their appear the wheels do not actually need to roll!!!

References

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