Do We Need Heavyweight Track?

The cost of implementing British tramways has escalated over the years. It has become established that street track has to be laid on substantial concrete foundations, and that all utilities have to be diverted, often at enormous cost to the tramway promoter, and the utilities get new assets free!

Is all this really necessary? Is it done everywhere else in the world? The answer to both is no. Why then has this happened? Largely I believe because Britain lost the ability to design tramways, and contractors only had experience of heavy rail. In a typical insular British way, they started from scratch, and took little notice of practice elsewhere. The privatised utilities saw this as an opportunity, and encouraged unnecessary standards to be created, to their benefit. Not only utilities though, also the fragmented rail industry, where tram tracks were in close proximity to rail lines. This all caused another over-specification, on leakage currents, and a requirement that track needs to be insulated.

Conventional tram track uses girder rail, which by definition transfers vertical load, so that it does not need supporting on all its length. It is therefore unnecessary to have a massive continuous support foundation. If such a foundation is used, the rail only really needs to be a running surface. Such principles were used in Eastern Europe, and indeed have also been used by Tram Power with their LR55 rail. So far, this has only been used on a short trial section on Sheffield Supertram on a crossing at Tinsley; but seems to be successful; but a larger installation has not been done.

In The Netherlands, a very simple support of girder rail is used, see picture, in which concrete blocks support the rail, which themselves lie on larger area concrete slabs to take the load into the sub-soil, largely sandy in Holland. The void is in-filled, and the road surface brought up to railhead.

Simple track in Den Haag.

This simple system has worked for decades, and produces a good, quiet ride; with less transmission of vibration than with massive concrete foundations.

Massive track foundations in Nottingham (line 1)

Another view of Nottingham track

We now come to utilities, and whether or not to divert them. They have statuary rights to put equipment in the roads, and to be able to access it; but they don't have the right to stop others also putting equipment in the road, and this includes tram track. The ground is designated "common user".

If massive concrete foundations are used, they will largely preclude access, and utility diversions will be required. However, open "simple" track allows access, so total utility diversion is not required, see picture. However, it would obviously be undesirable to have track over a longitudinal large pipe or sewer. In some countries, temporary surface–laid tracks are used round major works.

Bielefeld Utility Work. It can be seen that the track is supported by a beam across an open trench.

Using simple track saves in two ways; reduced construction cost, and reduced utility diversions. It may require more maintenance, but this is relatively simple, whilst if there is a failure of concrete foundations, it will be very difficult to correct. Both Manchester and Croydon have had to rebuild such track.

We now come to the supposed problem of leakage currents, and track insulation. Leakage is caused by voltage drop in the rails causing currents to flow in the ground, which could cause corrosion of metal underground equipment. There has become a requirement for an earthing mesh to be located under the track to divert such currents to earth at the substation, and to insulate the rails from their local earth. Again, this is a largely British obsession, and not common practice elsewhere. It must be remembered that this voltage drop, up to about 60Volts, represents an appreciable energy loss, and should really be corrected by better electrical design. If the current demand of trams were to be reduced, so would the voltage drop. Modern trams are heavy, and use relatively inefficient induction motors, the use of permanent magnet motors would reduce currents, especially the high starting currents, where induction motors are particularly inefficient, see note. Some induction motor-fitted trams use about 100KW BEFORE the tram moves. Ideally, no power should be expended until the vehicle actually moves, producing mechanical energy. This again would be greatly improved if an energy store was incorporated in the vehicle. This would smooth out current demand, reducing peaks about ten-fold; and also allowing much greater recovery of regenerated energy on braking. As well as reducing track loss, it will also greatly reduce current in the overhead, so simpler, lighter construction could be used, reducing visual intrusion. Energy storage would be by Super-capacitors, a growing technology; which offer large amounts of energy storage at high power levels. Research has now produced examples that rival batteries in energy density, but will have a long life, unlike batteries.

Lighter trams would help in all respects; does a tram have to weigh about twice as much as a bus per metre length? More should be done to reduce weight and cost, which is presently about seven times bus cost per metre. Both, I believe, can be reduced by making the topology of a tram more similar to that of a bus; this can be achieved by using steerable wheels. To see this in action, look on YouTube for “Steerable Wheel-motors”.

If we can simplify track, reduce utility diversions and get lighter, more energy efficient trams at reduced cost, the tram’s inherent advantage of low rolling resistance will come to the fore as the “greenest” form of transport.

Note. Induction, or asynchronous, motors produce their mechanical output in a somewhat indirect way. Electric motors produce a torque due to the forces acting on a current carrying conductor in a magnetic field, and the force is the product of current, conductor length and field strength. In a permanent magnet motor, the field is produced by the magnet, and no energy is used in providing it (apart from the initial magnetisation). In the case of the induction motor, the field is produced by the stator, which has to magnetise the system, including the air gap between rotor and stator. This requires quite a high current, and whilst this itself is a quadrature or “Wattless” current, it causes resistive losses in the winding. This magnetising alternating current then acts on the rotor winding like a transformer, inducing a current in the rotor, which acting with the magnetising field, causes torque. As in a transformer, this tends to de-magnetise the stator, so more current has to be applied to create balance. There are thus three main causes of losses, stator magnetising current, stator load current, and rotor load current. In a permanent magnet motor there is only stator load current. (At higher speeds there are also iron losses in both motor types, again more with an induction motor.) The efficiency of permanent magnet motors can be up to 97% over a large load/speed range. Wheel-motors are available which incorporate such a motor as an integral part, and offer such efficiency, direct to the rail with no gears or transmission. This should allow over 60% recovery of traction energy during regeneration in urban duty. The high efficiency gives energy recovery down to about 1 mph. Run as synchronous motors, they also offer full braking down to standstill.

David Gibson,

16 Lockwood Road,

Allestree,

Derby DE22 2JD.