PERFORMANCE-BASED STANDARDS (PBS) VEHICLES FOR TRANSPORT IN THE AGRICULTURAL SECTOR

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Abstract

The South African sugar industry spends in the order of R750 million per annum on sugarcane transport. Although rationalisation processes are in progress, innovative systems are needed to reduce these costs even further. The current fleet of haulage vehicles in South Africa complies with a set of prescriptive regulations which specify a number of parameters. However, it has been recognised that these regulations do not address a vehicle's dynamic performance, and place a constraint on the innovative use of technology to develop new transport vehicles. The objectives of the Performance-Based Standards (PBS) philosophy are to utilise technology to reduce road damage, improve safety, increase payloads and reduce costs.

To overcome the limitations of prescriptive legislation, is has been proposed that PBS regulations be introduced. With this system the criteria for design is that the vehicle should conform to a set of performance standards that will achieve the above objectives.

This paper will discuss the standards proposed for use in South Africa, the demonstration projects to test these standards, and the way forward to introduce PBS to the sugar industry.

Keywords: PBS, sugarcane transport, vehicle safety, road damage, payloads, RTMS

Introduction

The South African sugar industry spends in the order of R750 million per annum on road transport, which accounts for between 20 and 30% of individual grower production costs. In the light of ever-increasing input costs, innovative systems are needed to reduce these costs substantially. The current fleet of haulage vehicles in South Africa complies with a set of prescriptive regulations which specify a number of parameters, such as the vehicle's dimensions and its configuration. However, these regulations do not address the vehicle's dynamic performance, such as its tracking ability, its roll-over threshold and its behaviour when a sudden directional change is made. Legislation on vehicle loading focuses on axle and axle unit loadings, the maximum permissible vehicle and combination masses, and the so-called 'bridge formula'. While the current standards address a range of safety issues, there are some aspects of heavy vehicle safety performance that are not adequately controlled by these regulations.

Legislation also places a constraint on the innovative use of new technology such as steering axles to develop new transport vehicles with high performance characteristics. The objectives of the PBS philosophy are to utilise technology to reduce road damage, improve safety, increase payloads and reduce costs. This is done by designing vehicles that conform to a set of performance and management standards that will achieve the above objectives.

The PBS approach addresses factors for which vehicle designers and road safety practitioners have always had a healthy respect, in particular the highly important aspect of a vehicle's stability and dynamic performance. PBS vehicles must thus comply with certain prescribed static and dynamic performance standards such as Maximum Swept Path, Acceleration Capability, Steer Tyre Friction Demand, Static Roll-over Threshold (SRT), High Speed Transient Offtracking and Rearward Amplification.

Designing vehicles to safely carry greater loads and operate more economically is only one aspect of PBS. Another important aspect is the design enhancements and features that make it possible to achieve higher levels of safety. In this regard, greater commitment and diligence are required of operators to properly maintain their vehicles. Similarly, they will also have to ensure that loads are properly positioned and, where necessary, secured.

Should PBS vehicles be introduced in South Africa, it would be essential for their owners to implement higher standards of management and loading of the vehicles. In this respect, the Road Transport Management System (RTMS) offers a solution. The introduction of PBS vehicles should also be considered against the background of the mechanisms of road wear, which is accelerated not only by heavy (overloaded) axle loads, but also by the significant changes that have been introduced in heavy vehicle tyre technology. This is particularly relevant to countries such as South Africa, where roads with light pavement structures (paved low volume roads) are common. The effect of the trend of increasing heavy vehicle tyre pressures during the past few decades has been to reduce the size of the contact patch between the tyre and the road surface, inducing far greater stresses in the upper layers of road pavements. Improving freight logistics by introducing PBS should therefore be approached with an appreciation for the additional need to introduce more effective operational management procedures, and vehicles that are 'kinder' to road pavements.

Road Transport Management System (RTMS)

RTMS is an industry-led, voluntary self-regulation scheme that encourages consignees, consignors and transport operators engaged in the road logistics value chain, to implement a vehicle management system that promotes the preservation of the road infrastructure, the improvement of road safety and an increase in the productivity of the logistics value chain (National Productivity Institute, 2006; Nordengen and Oberholzer, 2006). This scheme also supports the Department of Transport's National Freight Logistics Strategy (Department of Transport, 2005).

All players in the road logistics value chain are aware of the problems concerning road logistics that affect their industries. The road infrastructure is deteriorating rapidly due to, *inter alia*, overloading, and there is an unacceptable number of accidents attributed to heavy trucks (see Figure 1). Both road safety and road infrastructure protection are public concerns subject to strict regulation by governments, particularly when abused. Over-regulation, road deterioration and high accident rates pose a significant threat to the long term sustainability and global competitiveness of the road logistics value chain.

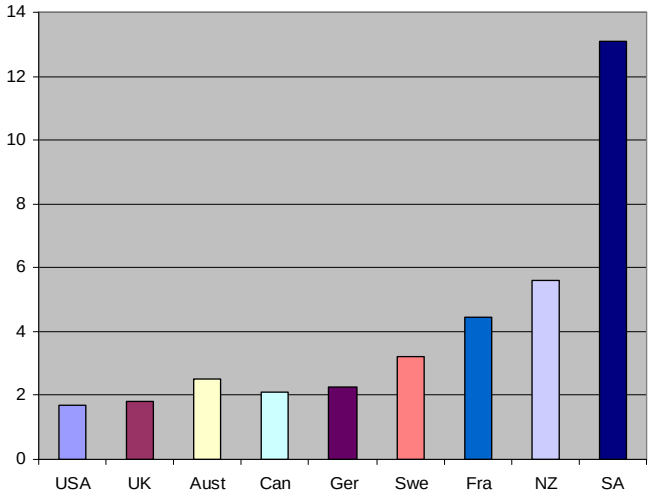

Figure 1. Benchmarking heavy vehicle safety – heavy vehicle fatalities per 100 million kilometres (2002) (Moore, 2007).

This has prompted users of road haulage (consignors and consignees) and providers of road haulage (transport operators) to jointly develop strategies aimed at protecting the road network, improving road safety and transport productivity for the benefit of the country's citizens and the industry itself.

The industry also recognises that poor compliance to transport regulations creates an unfair competitive environment. It was therefore felt that a self-regulation scheme was required to create standard rules for the industry, and that these rules should become the 'business norm', supporting the principles of good corporate governance (Standards South Africa, 2007). It is for this reason that industry is leading this initiative, to ensure its swift adoption by all businesses participating in the road logistics value chain. The RTMS is one of the key innovative and proactive initiatives that will make this possible.

PBS as a concession of the Road Transport Management System

Performance-Based Standards could play a significant role in improving productivity and safety in the transport industry, which in turn is vital for the country's competitiveness in international markets. It is essential that all PBS participants are certified in accordance with the RTMS accreditation scheme, to avoid the situation where truck and trailer manufacturers start designing vehicles on an *ad hoc* basis. It should be borne in mind that PBS vehicle designs include certain safety features, and must be loaded in the correct manner. The RTMS approach offers the most suitable way of ensuring that these requirements are met.

The idea is that the PBS vehicle design approach is not bound by the accepted prescriptive standards and that a redesigned vehicle will still conform to road infrastructure and safety conservation principles.

As an example, PBS-designed vehicles will be able to safely carry heavier loads with no additional effects on the road network apart from normal deterioration. This will have a positive effect on the productivity and safety record of the transport industry.

Support of the Department of Transport

The Department of Transport (DoT) fully supports the self-regulation approach of the RTMS because it contributes to the overall aim of improving the productivity of the transport logistics value chain, which will in turn contribute to the growth of the economy.

With reference to the specific request to support the proposed PBS initiative and demonstration projects:

- The DoT supports the initiative with the understanding that it seeks to improve system efficiency by optimising truck payloads, improving truck safety and protecting road infrastructure through innovative vehicle design and technology application.
- The DoT maintains that exceeding current dimension and load limits should be restricted to the demonstration projects for evaluation purposes, if such approval is obtained. For full scale roll-out, the heavy vehicle owners will need to demonstrate innovation in increasing payloads through vehicle design and technology within the current load and dimension limits. If Government is convinced that vehicle owners have explored this approach sufficiently, then the larger vehicle load and dimension concessions could be considered for vehicle owners that have a proven track record of self-regulation (e.g. those within the RTMS or those complying with the national standards in this regard).
- Government acknowledges the RTMS to be an industry-led process, and will support it as such in accordance with the recommendations of the National Overload Control Strategy (Department of Transport, 2004). Industry will, however, have to ensure sustainability of the initiative beyond the pilot stage.
- Government will continue to implement its regulatory interventions and ensure compliance with legislation through intensified law enforcement, while acknowledging any specific concessions that may be granted to the self-regulation initiatives.

Objectives

The over-arching objective of PBS is to design heavy vehicle combinations that conform to road infrastructure and safety conservation principles and according to specific standards as a point of departure, but accepting that some of the constraints in the current prescriptive regulations may be relaxed to allow the PBS approach to be optimised.

Individual role players, however, have their own objectives that should be borne in mind:

Government (National and Provincial)
Reducing infrastructure damage
Improving road safety
Reducing the burden of law enforcement
Improving freight logistics – cost and time
Supporting transport efficiency and productivity
Improving South Africa's global competitiveness
Improving awareness
Improving compliance with the Road Traffic Act.

Industry
Improving efficiency, productivity and profit
Supporting competitiveness
Creating a level playing field – promoting fair competition

Complying with best practice standards
Improving road safety – reducing cost of accidents
Promoting professionalism
Complying with corporate governance standards.

Demonstration projects

Because the RTMS self-regulation scheme was initiated in the forestry industry, it was identified as the logical industry to commence with PBS demonstration projects. Both Sappi Forests (Pty) Ltd (Sappi) and Mondi Business Paper (Mondi), the two major timber growers and pulp and paper companies in South Africa, decided to initiate PBS demonstration projects, and both companies set up project teams consisting of various manufacturers, suppliers and consultants. Sappi approached and subsequently appointed Mechanical System Dynamics Pty Ltd (MSD) in Australia to assist with the development and analysis of the PBS vehicle.

Two concept vehicle designs, a rigid/trailer and an interlink (B-double), were initially developed and considered by the project team. The team comprised representatives from Sappi, truck (DaimlerChrysler South Africa (Pty) Ltd), trailer (Afrit) and suspension (BPW Axles (Pty) Ltd) manufacturers, a transport operator (Timber24), CSIR Built Environment and MSD. At the outset a number of important design parameters were decided on and set; some were outside the direct control of the project team, while others – set by Sappi – were directly related to the timber product (e.g. log lengths) and the requirements of the current and expected future log transport task. For example, maximum overall length was controlled by the regulators, maximum axle loads and spacing was consistent with the prevailing pavement and bridge load requirements, and safety items linked to the current regulations were retained. While there was a clear focus on productivity, in view of the number of roll-overs and crashes reported by operators, safety performance was given a high priority, so much so that a loss of productivity was considered acceptable if it meant that a higher level of safety could be achieved. Therefore, it was a primary design goal and requirement that the vehicle should have acceptable safety performance and meet all of the applicable PBS safety standards.

State-of-the-art numerical modelling was used to establish benchmark performance levels (baseline vehicle, see Figure 2) and to guide and assess the new designs to achieve performance levels that would satisfy the PBS performance requirements and the transport task.

Figure 2. Example baseline vehicle comprising a rigid truck towing a 4-axle drawbar trailer.

The rigid/trailer concept vehicle, comprising a three-axle rigid truck towing a five-axle drawbar trailer, was selected in favour of the interlink, and after a number of iterations a satisfactory vehicle design was achieved. At an overall length of 26.4 m and 27.0 m for the 4- and 5-bundle trailer log-loads, respectively, and a gross weight of 67.5 t, the truck/trailer combination satisfies the PBS performance standards considered and delivers an increase in payload capacity of 15%. By contrast, the baseline vehicle with both a lower gross weight (58.8 t) and payload capacity was not able to satisfy several PBS performance requirements, as described in the following section (Nordengen *et al*., 2008).

Side view drawings that highlight and contrast the key aspects of the baseline and proposal PBS vehicles are shown in Figure 3.

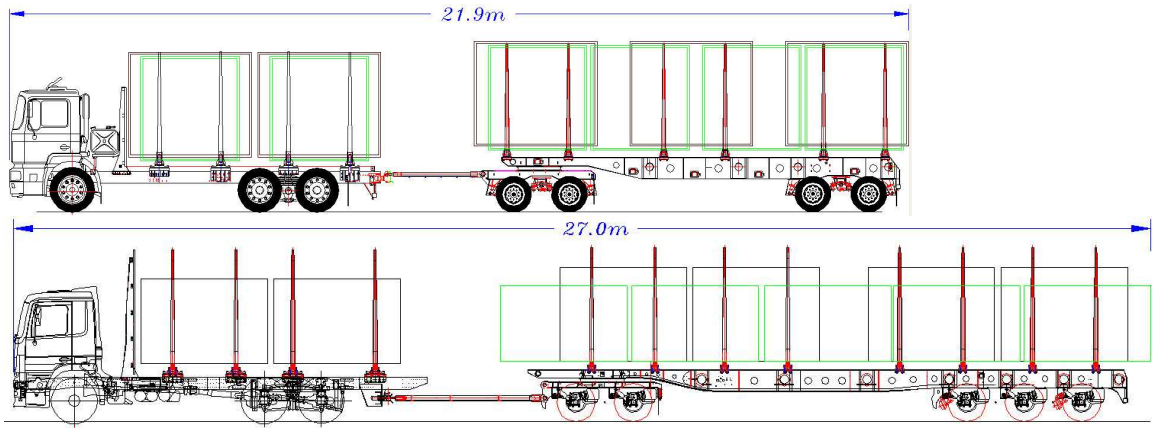

Figure 3. Baseline (top) and Performance-Based Standards (PBS) (bottom) vehicles at 58.8 t and 67.5 t combination masses respectively (Nordengen *et al*., 2008).

Design criteria

Drawing on the PBS developed in Australia jointly by the National Transport Commission (NTC) and Austroads, the following performance measures were chosen and considered in the performance analysis. These are a subset of the complete set of PBS standards (National Transport Commission, 2007a) and relate specifically to safety performance relevant to this assessment:

Tracking Ability on a Straight Path – the vehicle's total swept width while travelling on a straight path, including the influence of variations due to crossfall, road surface unevenness and driver steering activity.

Low-Speed Swept Path – the maximum width of the vehicle's swept path in a prescribed 90° low-speed turn.

Steer Tyre Friction Demand – the maximum friction level demanded of the prime mover steer tyres in a prescribed 90° low-speed turn.

Static Roll-over Threshold – the steady state level of lateral acceleration during a constant-radius steady-speed turn that the entire vehicle can sustain without rolling over.

Rearward Amplification – the degree to which the trailers in a combination amplify the lateral acceleration of the prime mover in a prescribed lane change manoeuvre.

High-Speed Transient Offtracking – the maximum lateral distance, or sideways distance, that the last axle on the rearmost trailer tracks outside the path of the steer axle in a prescribed lane change manoeuvre.

Yaw Damping Coefficient – the rate at which 'sway' or yaw oscillations of the trailers 'settle down'.

PBS assessments and results

For PBS assessment of the two concept vehicles and baseline (benchmark) vehicle, three numerical models were created using the ADAMS multi-body dynamics simulation software package (MSC.Software, 2007) and MSD's Atruck™ toolbox. The first model represented the truck/trailer combination, the second represented the B-double combination, and the third the baseline vehicle. Only the truck/trailer design was taken through to manufacture (Prem *et al*, 2002).

A range of simulations were performed using the numerical models and the precisely defined test conditions specified under PBS. The simulations comprised a low-speed 90° turn, high-speed travel over a 1.0 km long section of uneven surface in the presence of representative driver steering activity, a steady turn, a lane change manoeuvre, and a pulse-steer test. At the conclusion of the simulations, the specified vehicle responses were analysed and the performance values calculated.

Under PBS in Australia, access to road class Levels 1 to 4 (L1 to L4), respectively, denote 'General Access', 'Significant Freight Routes', 'Major Freight Routes' and 'Remote Areas'. Further information on the road classification system can be found in National Transport Commission (2007b). Further, a vehicle can only be granted access to a particular route if it meets all the performance requirements specific to that route.

The results showed that the baseline vehicle (current truck-trailer) failed to achieve the required PBS performance level on two of the safety standards. These are Static Roll-over Threshold (performance=0.305g, performance requirement=>0.35g) and Rearward Amplification (performance=1.990, performance requirement=<1.738). By contrast, the proposal truck-trailer (4- and 5-bundle variants) satisfies the PBS performance requirements at PBS L2. In addition, the baseline vehicle has a significantly higher value for high-speed transient offtracking, achieving a performance outcome consistent with PBS L3 road network access. In Australia, vehicles assigned PBS L3 status are generally restricted to road train routes. The results showed that the only area where the proposal vehicle performs significantly worse than the baseline vehicle is in low-speed turns, where, due to its overall length and, in particular, much longer trailer, the Low-Speed Swept Path width is greater.

Operation and driver feedback

The PBS vehicle commenced operations on 29 October 2007 and, by the end of February 2008, had completed 200 trips with an average payload of 47.2 tons and an average fuel consumption of 61.7 litres/100 km (Figure 4). Detailed monitoring of the vehicle and comparison with the control vehicle are ongoing. Monitoring parameters include payload, trip times, fuel efficiency, average speed (empty and laden), drive train maintenance costs, tyres, accidents or incidents and feedback from other road users.

Figure 4. The as-built PBS truck-trailer (supplied courtesy Sappi Forests (Pty) Ltd, Afrit and Timber24).

Initial feedback from drivers has been very positive in terms of stability and manoeuvrability, which supports the improved performance features evidenced in the PBS vehicle compared with the baseline vehicle.

The vehicle was recently shown at a Sugar industry RTMS workshop on 21 February 2008.

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