An ADR should be introduced to specify the requirements for DYNAMIC LOAD SHARING HEAVY vehicle suspensions

Introduction

The majority of existing heavy vehicle multi axle suspensions exhibit deficient dynamic load sharing. In particular most standard multi axle air suspensions exhibit grossly deficient dynamic load sharing. As a consequence the National fleet of air suspended vehicles is unnecessarily inflicting considerable road, vehicle and freight damage. The excessive extent of seat pad and cabin vibrations simultaneously generates high risk of premature driver fatigue. The same is exacerbated by high levels of pitching exhibited by turntable articulated prime movers. In regard the road damage alone the same burdens National road authorities with billions of dollars of maintenance cost. Opportunity exists, by the introduction and enforcement of dynamic load sharing suspensions, to significantly reduce road maintenance cost. Furthermore both driver and other road user safety will also be enhanced. Particularly air suspensions present greatest opportunity to exhibit maximum dynamic load sharing at relatively low cost, system simplicity, tare and reliability. Numerous other benefits and improvements are associated with the utilisation of dynamic load sharing multi axle groups including:

- genuine road friendly characteristics hence vastly improved freight, vehicle and driver ride
- reduced wear and tear on the axle group, cab and driver's seat suspension
- improved tyre to pavement contact hence improved traction hence, in turn, improved acceleration and braking and, in turn, reduced tyre wear
- improved tolerance to rapidly changing pavement friction conditions
- improved tolerance to vehicle pavement exertions and recovery
- reduced :
    - prime mover pitching (in particular and significant of turntable articulated units)
    - steering effort
    - fuel consumption
    - driveline maintenance
    - vehicle maintenance (particularly that of prime movers)
    - frame rise of driven axle / groups (at least 40% for tandem axle groups) hence increased in service roll resistance
    - risk of premature driver fatigue due to the reduced level of seat pad and vehicle (e.g. steering wheel, cab floor and gear stick) vibrations
    - need to employ differential and cross lock
    - risk of vehicle involvement in an accident
    - reduced compressed air consumption

to name just a few.

Justification

Noting the importance of dynamic load sharing from extensive test work Sweatman (1983)[1]

1 Sweatman, P.F. (1983) : A Study of Dynamic Wheel Forces in Axle Group Suspensions of Heavy Vehicles, ARRB, SR No. 27. 7. Recommendations

recommended:

' ...

6. A quantified dynamic road requirement which could be based on limiting the ***dynamic load coefficient***[2] *to 0.20 or less under roughness and speed conditions given by* $VR^{0.50} = 850$ *should be considered as a Design Rule.*

7. A ***dynamic quantitative load-sharing*** *requirement based on maintaining the average wheel load within plus or minus 10 per cent of the desired wheel load share, should be considered for inclusion in the Draft Regulations. This should be tested using a method similar to that adopted in the ARRB experiments, with all suspension attachments fitted according to the suspension manufacturer's specification.*

...'

Similar recommendations were echoed again by Sweatman (1987)[3]

' *5. Conclusions*

(a) Although the safety and road damaging characteristics of heavy trucks have been widely recognized as vital to improving road freight productivity, technical progress in improving safety has been slow and the management of road damaging characteristics has been almost totally neglected.

(b) Axle group suspension systems[4] *affect the safety, road damaging and economic performance of heavy vehicles.*

(c) Research has shown that there are two major aspects of suspension performance contributing to road damage, ***dynamic load sharing*** *and road impact. There are existing major deficiencies in each aspect of performance.*

(d) A phased industry-based approach to ameliorating these suspension performance deficiencies is needed.

(e) The first phase should address ***dynamic load sharing*** *on a national basis. Financial or operational incentives should be provided to bring about an agreed performance standard, based on existing research.*

(f) The second stage should commence with internationally–co–ordinated research into road impact performance, its effect on road damage and its interactions in other key areas of suspension performance, with operational factors and with industry effects. This co-ordinated effort should be aimed at a road impact performance standard on an international basis.

(g) The consolidated results of research into impact damaging effects of heavy vehicles, including

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2 Bold emphasis by the respondent.

3 Sweatman, P.F. (1987) : Suspension Research and its Implication, Proceedings Symposium on Heavy Vehicle Suspension Characteristics, ARRB / FdoT, March, pp 19 – 41.

4 It must also be noted the majority of European turntable articulated primed movers are single drive units. This configuration is vastly different to that locally and in North America.

vehicle configuration, axle spacing, suspensions and tyres, should be communicated to manufacturers in the form of design guidelines on a national basis.'

In the same publication Sweatman (1987) subsequently recommended:

'*6. Recommendations*

(a) A working group ... should be formed under the ATAC structure to

(i) propose a ***dynamic load sharing performance standard*** *and*
(ii) report on operational and financial incentives to bring about its implementation

(b) A research group should be proposed under the OECD Transport Road Research Program to

(i) co-ordinate research in various countries into road impact performance of suspensions and its effects on road damage,
(ii) develop a road impact performance standard (having regard to other safety-related and economic areas of suspension performance),
(iii) consider the effects of such a standard on operators and manufacturers and
(iv) propose a means of implementation

(c) NAASRA should consider producing a vehicle manufacturers' guide to vehicle design to reduce road damage. This should include the effects of axle groups and spacings, suspensions and tyres. The guide should draw on the outcomes of (a) and (b) above plus on-going research into the effects of axle spacings and tyres. '

The importance and significance of dynamic load sharing to the National road transport industry is vividly apparent from the foregoing quotations. Noting this importance one would expect to find reference to a dynamic load sharing performance requirement for multi axle groups in VSB 11[5].

However, VSB 11 only specifies the following performance requirements:

'...

(ii) Static load share between axles in the axle group must be within 5% (multiple axle groups only).

Further VSB 11 defines a load sharing suspension system as an axle group suspension system that:
(a) is built to divide the load between the tyres on the group so that no tyre carries a mass more than 5% greater than the mass it would carry if the load were divided equally; and

(b) has effective damping characteristics on all axles of the group. '

Interestingly in comparison to the crude VSB 1 and VSB6-F '*a load sharing suspension is only one in which all axles in a group be interconnected by a load sharing suspension*'.

Returning now to the blatant dynamic load sharing performance characteristic deficiencies specified

5 VSB 11 Road Friendly Suspension Certification Requirements.

in VSB 11. These include:

- Non specification of whether the requirements apply to new, in service or both new and in service suspension systems.
- Absence of a definition of the phrase '*effective damping characteristics of the group*'.
- There is absolutely **no equivalence** between a static load sharing specification and a dynamic load sharing specification.
- A dynamic load sharing performance coefficient of say 20% is considerably more onerous relative to a static load sharing coefficient of say 5%.
- The extent of instantaneous road damage inflicted by an axle group is largely that inflicted by the instantaneous maximum axle or tyre load acting within the axle group.
- The majority of 'in service' axle groups are non load sharing as the majority of 'in service' dampers are grossly out of specification.
- The majority of standard air suspensions exhibit deficient inherent damping.
- Crude assessment of the dynamic load sharing characteristics, of driven axle groups, can be readily evaluated by conducting low speed drive tests across formed driveways.
- Relative assessment of dynamic load sharing characteristics of both driven and undriven axle groups, can be readily and reliably quantified at very low cost using a benchmark testing procedure. Notably a 'characteristic' (i.e. chassis, cab or seat pad) vibrations exhibited by a test vehicle vehicle or axle group can be compared to that exhibited by a benchmark vehicle or axle group (i.e. that installed with optimal dynamic load sharing).
- Accurate assessment of dynamic load sharing characteristics, of both driven and undriven axle groups, can now be readily and reliably quantified at relatively low cost using state of the art instrumentation.

Recommendation

An ADR should be introduced to specify the requirements for DYNAMIC LOAD SHARING HEAVY vehicle suspensions.

As an initial specification the extent of dynamic load sharing, tested up to 100 km/h, should be

The quantified dynamic road requirement should limit the dynamic load coefficient to 0.20 or less under roughness and speed conditions given by $VR^{0.50} = 850$.

The dynamic quantitative load-sharing requirement should maintain the average wheel load within plus or minus 10 per cent of the desired wheel load share . This should be tested using a method similar to that adopted in the ARRB SR 27 experiments, with all suspension attachments fitted according to the suspension manufacturer's specification. Testing should be conducted on the axle group in both the 'as new' and 'in service' conditions. To simulate 'in service' conditions testing should be conducted with 50% of the axle group's mechanical shock absorbers removed.

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