BRAKING AND OTHER THINGS

R.L. REYNOLDS
CONTROLLER, VEHICLE STANDARDS
MINISTRY OF TRANSPORT

Comments on Some Aspects of Road Transport for Presentation at the Institute of Road Transport Engineers Seminar, Christchurch

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INSTITUTE OF ROAD TRANSPORT ENGINEERS

1. Introduction

Although this session is on braking, the bulk of this paper in fact will present a general view of the regulatory side of vehicle construction and equipment. The present organisation of Vehicle Standards and Vehicle Testing, and their roles will be described, as well as the general philosophy and the relationship with the transport industry. Recent events and lessons will be reviewed and some messages delivered. All of these points are relevant to braking.

2. Format of Role of the Ministry of Transport

The Ministry has recently been through a period of upheaval, and is in the process of settling down into a new format. As far as inspection of vehicles is concerned, the organisation was as shown in Figure 1 for many years.

There were Automotive Surveyors in district and subsequently in regional offices, and in testing stations. In Head Office were one or two Automotive Surveyors and a group of Automotive Engineers. With any organisation, the success or failure depends on the structure, communications and personalities. These factors are all, obviously, at the root of criticisms levelled at the Ministry, such as lack of consistency from one testing station to another. Furthermore, Vehicle Testing Stations and their staff have, for years, been an easily identifiable target for economists, management consultants and other review teams. With all the reviews they have had, and the several times they have been restructured, it really is a wonder that they are not extinct.

As a result of the latest restructuring, the organisation now looks as shown in Figure 2.

Apart from "downsizing", which is the current buzz-word for reducing staff numbers, some significant things have happened. One level of top management and two levels of lower management have been removed, to shorten the lines of communication. Also, the function of setting standards has been separated from that of checking vehicles for compliance. In the Vehicle Standards Section of the Safety Policy Branch, the standards are determined which vehicles must meet when new or modified, and which they must meet in operation. The checking of individual vehicles for compliance with those standards is the responsibility of the Vehicle Testing Section of the Customer Services Branch.

This distinction makes quite a difference within the Ministry and may be even more significant in future. However, it is possible that many in the industry will not even have noticed the change, and will have been more affected by some of the recent policy statements, which are discussed later.

3. The Role of the Vehicle Standards Section

Over the last three years or so, there has been an almost complete change in the staff concerned with vehicles in Head Office. It is this, as much as anything else, that has resulted in so many changes recently. It is in fact

convenient that the change in staff has more or less coincided with the restructuring mentioned; because the review of the Ministry's role will fit in neatly with a review of the requirements for vehicle equipment and construction, that is long overdue.

What has happened in some cases is that a rule was formulated many years ago, and the circumstances that led to its introduction have been forgotten. The result is that the rule is being implemented and interpreted under very different conditions, and this can lead to illogical results. On the other hand, changed circumstances (social, political and economic) have given rise to practices not covered by any rules but which are absurd or even dangerous by normal engineering standards.

Therefore, when a query is raised on the implementation or interpretation of regulations or policy, the response should be to go back to square one and ask:

"What is the objective of this requirement?"

"Is this rule, or some modification of it, going to achieve that objective?"

One of the key factors will be publication of a Vehicle Manual in the preparation of which this approach will be taken. This Manual will supersede the Automotive Surveyors Manual, but will have some important differences. It will eventually be a complete, up-to-date, plain language guide to every aspect of vehicle construction and operation. This ideal will not be met in one attempt. Annual amendments will be necessary and it is likely to take two or three years to fix all the errors and omissions in the first edition. Along with the planned rationalising of the Regulations it should make things easier for everyone. One essential feature of the Vehicle Manual is that it will be available to everyone, at a cost of course.

4. The Ministry of Transport View of the Transport Industry

The reason for the existence of the Ministry of Transport is almost self-evident, but some of the downstream ramifications are worth discussing.

In essence, the Ministry is there to enforce a reasonable code of behaviour on road users, with safety being the primary concern. It is interesting that nobody ever disagrees with that general statement as a description of the Ministry's role, but this agreement is frequently followed by "but is this really necessary". "This" usually offends the speakers conservatism or financial interest. Remember the seatbelt arguments of ten years ago? All sorts of spurious arguments were put up, including the "personal freedom" one. Now there is general (though not 100 percent) acceptance, and the current resistance is from the importers of second-hand cars who, of course, have a financial interest. Similarly, any mention of improved braking implies a cost, and is strongly resisted, especially by those with only a superficial technical background. On one occasion the representative of an importer (of American trucks) even queried the basic ideal of brake effort being proportional to the contact force between the tyre and the road. That ideal is of course difficult to achieve, but it is disheartening when the concept is not accepted.

Similar situations are commonly experienced by regulatory authorities. A cynic would conclude that all companies with an enviable safety record have been forced into that position.

Here are some more examples in the transport field:

Seatbelts

Despite their known advantages, it is only compulsion that has resulted in cars being fitted with seatbelts and wearing rates up to 80-90 percent.

Drawbars

Despite a series of fatalities it took coercion from the Ministry of Transport to bring about an improvement in the standard of design and manufacture.

Motorcycle Crash Helmets

Wearing rates in New Zealand (where it is compulsory) are much higher than those in the United States of America (where it is not compulsory).

Truck Brakes

American trucks are notorious for having front axles that are under-braked or have no brakes at all. NHTSA is having an uphill battle trying to change American truckers' attitudes. In New Zealand it looks as though it will take some sort of coercion to get American-sourced trucks fitted with decent front brakes.

Interim Braking Specifications

Anecdotes plus personal experience indicate that some operators do not have the first idea on braking theory, and what the objectives are.

These examples illustrate the relationship between regulatory bodies, and those suffering under the regulations. From the Ministry of Transport viewpoint it can best be summarised by saying "We are requiring you to do the things you should be doing of your own accord".

Additionally, it is quite clear that the transport industry includes all types from the charlatan to the competent. Our primary goal is to establish a screening process that will eliminate the charlatans, and this is discussed further under item (8).

One of our common experiences is to have people approach us seeking an exemption from the regulations. In one way or another these applicants claim to have special circumstances that merit a different set of rules. It is no secret that the regulations are not perfect, and some of the cases put to us are quite valid. On the other hand there are so many people claiming to be special that there must be very few normal people in the transport industry.

5. Interaction Between Ministry of Transport and Industry

There are some basic truths that must be recognised:

(a) Legislation cannot lead technology, but can only adapt to it. The Ministry can (for example) quietly encourage the adoption of anti-lock brake systems but cannot effectively legislate for or against them until the technological and economic problems have been solved.

(b) People can only be led in directions they wish to be led. Alternatively, people can only be made to do what they are ready to do. As far as braking is concerned, this has a number of results that have been observed:

(i) Amongst those with any sort of technical background there is an overwhelming majority in favour of reform. The problems are essentially those of detail.

(iii) Amongst those with very little technical training, the present attitude seems to be one of "how to get round the rules".

The moral of this, of course, is that real progress cannot be made until there are enough people agreeing to the objectives and the route to achieve them.

6. Review of Recent Policy Changes

Most of the industry has been affected by the changes introduced over the last few years, particularly by way of policy statements.

As mentioned previously these are largely attributable to the change in staff in the Ministry of Transport Head Office - the new brooms trying to sweep clean overnight.

Policy Statements No. 3 (on vehicle modifications) and No. 5 (on towing connections) are the ones of most interest to IRTE members. The details of both those policies are still being refined, and some of our initial assumptions were clearly ill-founded. There is not time now to go into great detail, but some of the results are worth discussion.

The most important conclusion is that the transport industry must come to terms with the relative standing of the practical man and the professional engineer. The long-established operators, whether they be truckies, manufacturers or repair shops have evinced some resentment at our insistence on engineering certification. On the other hand some engineers appear to have taken advantage of the requirements and have treated the industry as a captive market. There seems to be blame on both sides and the Ministry must take some of the blame as well for not seeing what would happen.

The Ministry has a message for each group, the first part of which is that engineering, especially in the transport industry, is a combination of art and science; or, alternatively, a combination of practice and theory.

To the "practical" people the second part of the message is that you do not know all the answers just because you have been in the industry for years.

You have reached your present position by a process of trial and error, as did the first mechanical engineers. There is, however, an important difference. The engineering pioneers such as Brunel and Stephenson, were able to analyse their successes and failures scientifically and to extrapolate the results. In other words they developed the theories from their experiences and experiments. In your defence it must be admitted that professional engineers have had far too little involvement in transport, and you are to be applauded for what you have achieved.

To professional engineers the second part of the message is that some of you are an embarrassment. At the very least you have a PR problem in that you have allowed this dichotomy to persist. You have a contribution to make to the transport industry, by adding your theoretical knowledge to the practical experience that already exists. At the same time you must build on the successes of the established "practical man", and work in much more closely with him so that he knows what you are doing and why it is necessary. Unless you can do this you will do a disservice to the industry, the Ministry, and yourselves.

7. Variety vs Standardisation

New Zealand is a small market by world standards, but we seem to have an amazing appetite for non-standard vehicles and equipment.

It is hard to believe that legal and operational requirements necessitate the extension or reduction of a track wheelbase by 800 mm, yet this sort of modification is being done frequently. It sometimes seems to the Ministry, that every truck put on the road is modified in some manner before use. If this is anywhere near the truth, then the importers and assemblers need to re-examine the range they have available.

Similarly it is absurd for a country the size of ours to have custom-built drawbars and drawbeams.

The possibility of national standard designs has been discussed on and off within the trailer fraternity for years, but nothing has yet come of it. One of the current projects of the industry should be to make progress in this regard.

There are other areas in which there is similar scope for progress. It will probably be said that such areas are the concern of the industry only, and that the Ministry of Transport should be concerned only with safety. Such a view is too narrow. The Ministry's primary concern is safety, but it is also concerned with other aspects - comfort in passenger service vehicles being a convenient example.

8. Quality Assurance

One of the main problems facing the Ministry at present as mentioned previously is the fact that there is a wide range of competence in the transport industry; and it is necessary for a way to be found to distinguish between the competent and the incompetent. Two methods have been tried over the last two years, namely, the establishment of a list of "approved engineers" under the Ministry's Modification Policy, and the criteria established by NZ 5446. Both of these have had their deficiencies, and we are now working towards a third system that could provide a universal answer. This is the establishment of Registered Quality Assurance Systems.

Such systems would be relevant to the activities of the person or firm, and would ensure (in theory at least) that the person or firm was competent to carry out those activities. The TTMF has already made some progress in this area, and the Ministry intends to apply the principle to consultants as well.

9. Braking

(a) The New Approach to Truck Braking

The present campaign on truck braking started a few years ago but already the origins are surrounded by myth. Apparently, a survey showed that braking was one of the major concerns in the industry. One theory holds that this was the result of pulling old trailers with new trucks; with consequent problems of mismatched air valves and relays. According to that theory the problem has already been largely solved by fitting modern valves and relays for the old trailers. The DSIR tests and recent Ministry testing with full loads have shown that the problem has not been solved.

(b) Regulatory vs Operator Requirements

The traditional regulatory approach has been to require a minimum deceleration, i.e., has concentrated on the "panic" stop. On the other hand the operator's main concerns are normal braking, (which of course, results in decelerations of less than 20 percent) and maintenance (usually meaning lining life). These two criteria can be mutually exclusive.

An extreme example was seen in Australia, where the introduction of ADR 35 led to all sorts of problems, because the regulatory requirements focused primarily on the panic stop. The truck suppliers, in turn, set their brakes with insufficient regard to normal brake usage. The European Code (ECE 13) attempts to compromise between the requirements for light and heavy braking; and the New Zealand Code will follow the same lines as far as possible.

(c) Recent Experiences

During the lead-up to the introduction of the Interim Braking Specification, a series of trials were held around the country, which were intended primarily as training sessions for the Ministry's Automotive Surveyors.

As an aside, it should be noted that the present Regulations require the specified braking performance to be achieved at all states of loading.

The trials took place in:

Wellington (Seaview)	2
New Plymouth	1
Te Awamutu	1
Napier	1
Dunedin	1
Christchurch	2

and a total of eight combinations were put through their paces. Of those eight, two could not achieve all of the requirements for a Certificate of Fitness.

The most interesting test was at Te Awamutu with a truck and trailer combination. During the tests using the service brake, there was some

lock-up on one of the wheels on the rear-most bogie. This in itself was cause for some concern. Then with the emergency brake application the whole bogie locked up. Under the terms of the specification the combination had failed. As an experiment, the brakes on the rear-most bogie were adjusted by moving the actuator connection down one hole on the slack adjusters; and the tests were repeated. The result was that the deceleration figures were achieved easily with no sign of lock-up at all.

If this sort of improvement could be done on a national scale, worthwhile progress will have been made.

(d) Braking Fundamentals

One of the advantages of the NZIRTE is that people from all levels in the transport industry get together. This means that my audience contains people who are more or less expert on the practicalities of compressed air circuits and perhaps also some who are experts on the theory of braking.

At the risk of boring those people, some of the basic theory is relevant, and here full-air brakes are assumed.

(i) **Brake Torque and Power**

$$\text{Torque} = P \times A \times L \times BF \times U.$$

P = air pressure.
A = chamber area.
L = slack adjuster length.
BF = brake factor.
U = lining coefficient of friction.

The brake factor includes things like S-cam geometry, drum diameter and shoe pivot location. These attributes are determined by the design and construction of the brake, and are usually beyond the control of the operator.

On the other hand:

(a) The air pressure is varied by means of the treadle valve, and may also be varied by proportioning and other valves. Losses through the air system must be minimised by using large-bore piping, and valving with minimum pressure differential. Ideally the pressure at each actuator should be the same, unless a deliberate and rational decision has been made to vary it, for example, by using load-sensing equipment.

(b) The chamber area can be varied by changing chambers. It should also be noted that in a normal air chamber the force output varies significantly with stroke, which is why brakes should be kept properly adjusted.

(c) In the course of applying the shoes, the output from the actuator must also overcome the shoe return springs, plus any friction in the S-cam, followers, and pivots.

The friction can be minimised by good maintenance, but at any time there will still be some resistive effort. With correctly

adjusted brakes this resistance will be a small proportion of the actuator output. As the linings wear, that proportion will increase because the actuator stroke increases, and its output is reduced.

(d) The slack adjuster effective length can be changed quite readily, as already mentioned.

(e) The lining friction factor is the most difficult area to resolve. The coefficient will differ from one set of linings to another, and our aim can only be to minimise this difference. On top of that the coefficient will vary with temperature, usually decreasing (resulting in brake fade).

Note that the shoe <u>width</u> does not enter this equation.

The <u>power</u> absorption of a brake <u>does</u> depend on its width because power is converted into heat. The temperature rise depends on the power input and the area of the shoes. Therefore, a 15" brake 1" wide can have the torque capacity, but will heat up rapidly and fade. It will not have the power absorption capacity to stop a big truck.

(ii) **Retarding Effect and Brake Balance**

The retarding force at any wheel is:

Brake torque ÷ effective tyre radius

and this is independent of tyre/road friction and vertical wheel load until a limiting condition is reached. At that limiting condition, of course, the wheel locks up and skids, and the loss of rubber becomes noticeable as black marks on the road.

The main variable is the coefficient of friction between the tyre and the road. Under favourable conditions this can exceed 0.8. It is generally appreciated that wet, oily or icy roads can sharply reduce the coefficient and experiments have clearly shown that friction can decrease:

(a) with less tread depth;

(b) at higher speeds.

Even at the New Zealand legal minimum tread depth and maximum speed, the coefficient could be less than 0.2 (reference 1), and this is without assuming an icy road surface.

The value of the coefficient of friction is identical with the maximum retardation that can be achieved, and if friction is 0.2, retardation cannot exceed 20 percent.

This is simplistic statement, but it is only modified in practice by details such as variations in the road surface and tyre tread compounds, and the difference between static and sliding friction.

There is therefore ample justification for the Ministry to be concerned with brake balance at low decelerations.

Most people in the industry have some grasp of these fundamentals. Unfortunately not all of them understand the implications.

(e) Weight Transfer

It might also be instructive to run through a very basic exercise on weight transfer. This may help some of you to understand what the new braking code is trying to do.

Consider a simple two-axle truck (Figure 3) with 5 tonnes on the front axle and 8 tonnes on the rear with two different brake settings. Leading dimensions are, wheelbase 4.5 m, height of centre of gravity 2.5 m.

The first case assumes the braking proportion according to the static load, i.e., 5 units of braking on the front axle, 8 units on the rear axle. The effect of weight transfer on the braking is shown in the table and graph of figures 4 and 5. A limiting value of 0.8 has been assumed for the coefficient of friction. For the second case, the braking is proportioned approximately according to the dynamic loads at 0.5 g. The effects are shown in the table and graph of figures 6 and 7.

The discrepancy between braking effect on front and rear axles is thus markedly reduced by proportioning the braking according to the dynamic load rather than the static load.

(f) Practical vs Theoretical Considerations

The fundamental and theoretical points in the previous two sub-sections are modified by a number of factors.

(i) Brakes not properly adjusted - as mentioned previously, the chamber output force varies considerably with stroke, and must still overcome the same resistive forces within the brake. Brakes which have not been adjusted will be capable of a much lower torque.

(ii) Lack of maintenance may result in higher friction in any of the moving parts of a foundation brake.

(iii) Brakes designed for overseas conditions (as most of our trucks are) will probably be unbalanced for New Zealand axle loadings.

(iv) Buying spares on price alone can lead to problems with mismatched linings.

(v) Incompetent adjustment has resulted in slack adjusters losing their locking features.

Each of these is really an example of incompetence. There is the importer who sells a truck with unbalanced brakes to an operator who couldn't care less. There is the driver who forgets about his brakes until he needs them, and the mechanic who lacks either the training or the brains to know what he is doing. All of these people should be putting more thought into what they are doing, but it seems as though the Ministry must coerce them into doing so.

(g) **Light vs Panic Braking**

Light braking applications tend to be of short duration and result in low decelerations. If road conditions are favourable, then the required deceleration can be achieved with grossly unbalanced brakes; however, this will probably show up as differential lining wear. In this context, lack of balance includes timing and threshold pressures.

If we take threshold pressure to mean the pressure at the treadle valve at which a particular brake starts to become effective, then it follows that the brake with the lowest threshold pressure will be the first one to act, and will therefore suffer the most lining wear. Therefore, for light braking, the threshold pressures for every brake on a vehicle or combination of vehicles should be as nearly equal as possible. Threshold pressure is less significant for heavy braking, provided that there is not too much variation. Similarly, timing is significant only if the variation is large. Experiments in Australia have proved that artificially long delays are of little consequence in heavy braking; but a time delay of one second would obviously become significant if a typical light brake application lasted less than one second.

Therefore, in addition to balancing the brakes according to the dynamic load, they should be set so that threshold pressures and timing as as close as possible.

(h) **The New Zealand Brake Code**

The New Zealand Brake Code in its present form is almost a straight copy of ECE 13 with the exception that we have to allow for the fact that load sensing is not a viable norm in New Zealand at present. ECE 13 addresses all of the problem areas that have been touched on in this paper. The New Zealand Brake Code will be a compromise between ECE 13 and our present circumstances, but should, nevertheless, represent a "great leap forward" in braking in New Zealand. It will be up to the industry to take up the Code with a positive attitude when it is finalised.

(j) **Miscellaneous Items**

There are some items that do not directly follow from previous items, but which are still worth mentioning.

(i) **Cardan Shaft Handbrake**

As a parking brake, the cardan shaft brake complies with the New Zealand regulations. As an emergency brake it is a dismal failure. In the long term, the future for cardan shaft handbrakes is either non-existent, or as a third braking systems to complement the service and emergency brakes.

(ii) **Trailer Brake Hand Controls**

This is a contentious subject, and time will not allow a full examination of the subject.

The only real justification for these controls that the Ministry is aware of is that the braking balance between truck and trailer can be raised according to the load that each is carrying. This presupposes that the driver has sufficient expertise to make the appropriate adjustments correctly. This aspect has not yet been properly investigated by the Ministry.

Protagonists also claim that a separate trailer brake control is necessary when using any form of engine brake on the truck. This argument is undermined by the fact that the temperatures of the trailer brakes and the truck brakes will then be different, leading immediately to an imbalance.

One other popular argument in favour, is the ability to "straighten-up" a combination when the trailer has drifted sideways. This, however, seems to rely on the truck being accelerated; and this disguises the fact that it is the truck acceleration that solves the problem, rather than the trailer braking.

On the other hand there are numerous anecdotes about "owners brakes", where it is quite clear that drivers (usually owner-drivers) have been using the trailer brakes to slow a complete combination. On the whole, therefore, the Ministry is presently inclined to feel that the disadvantages of trailer brake hand controls greatly outweigh their advantages.

(iii) **Mixed Braking**

The New Zealand habit of fitting "tag axles" to trucks has been accompanied by the mixing of suspension media and brake actuation systems, e.g., air-bags with leaf springs and full air with air-hydraulic.

Mixed suspensions systems can be made to share the load by adjusting the pressure in the air-bag. However, as soon as the load is changed, the load-sharing ratio must change. Even if the load does not change, the spring rate of the two systems will be different, and dynamic load-sharing will vary with deflection. Therefore, in general terms, the Ministry does not consider mixed suspension media to be load-sharing.

Similar arguments apply to mixed media braking. Full-air and air-hydraulic brakes could be set to give the same response, but the Ministry believes that any such balance will be lost very quickly in service. No evidence to the contrary has yet been offered.

10. Summary

This paper has been a combination of information and technical discussion, and an indication of things to come. As a presentation from a regulatory agency it is appropriate to summarise the principal messages.

(a) The Ministry's role is to distil the wisdom and experience available here and overseas, and to educate or coerce the New Zealand industry to adopt the conclusions. This applies to both safety, and to good practice.

(b) It is in the industry's own interest to take up the hints offered by the Ministry, and to implement them voluntarily before coercion becomes necessary.

(c) The industry has a wealth of practical experience, but this must be allied with the academic expertise that is available and combined into a more professional approach.

(d) An improvement in heavy vehicle braking can only be achieved by a careful scientific analysis of the problems.

(e) In preparation for the advent of the Braking Code, all parties should be looking at dynamic brake balance, threshold pressures and timing; in that order of priority.

This paper has touched very briefly on a number of aspects of vehicle design and construction. The Ministry and the industry both have a part to play in further development of all those aspects, and it is hoped that the current spirit of co-operation will continue.

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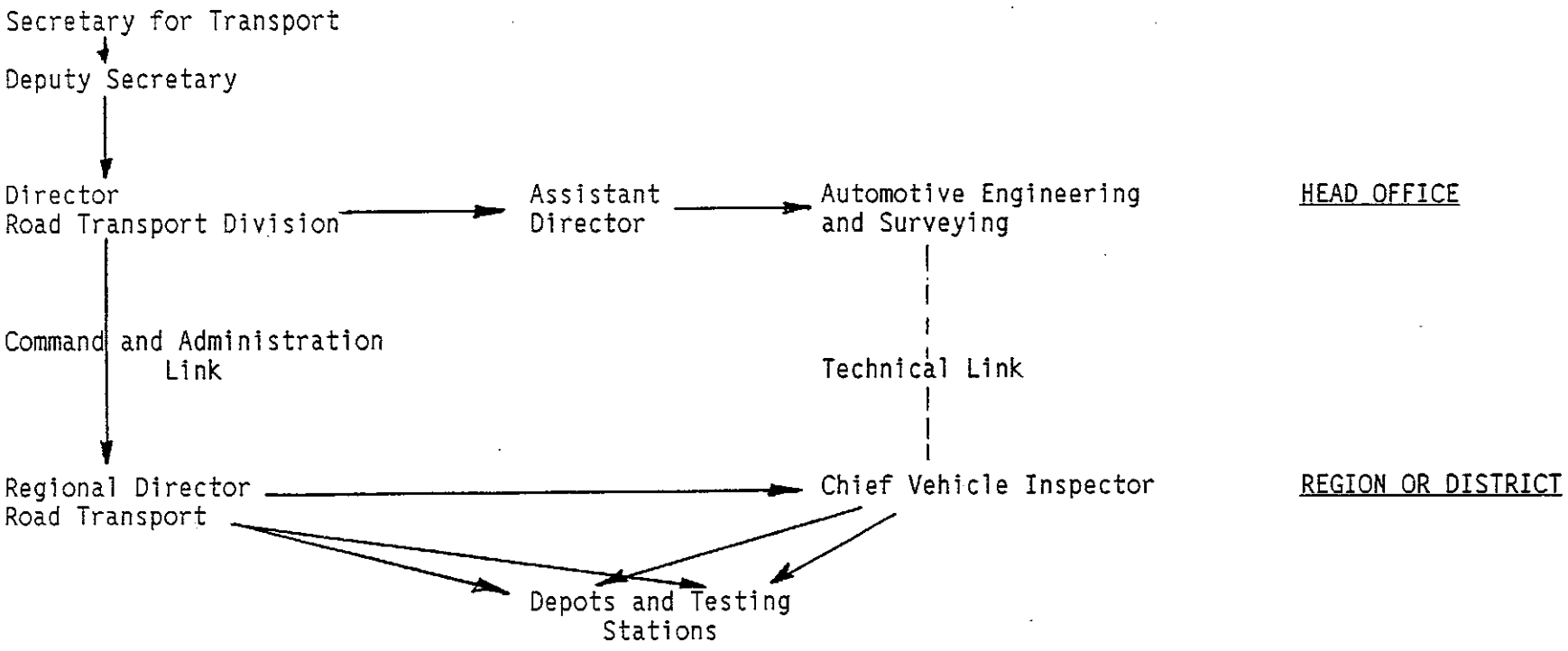

FIGURE 1

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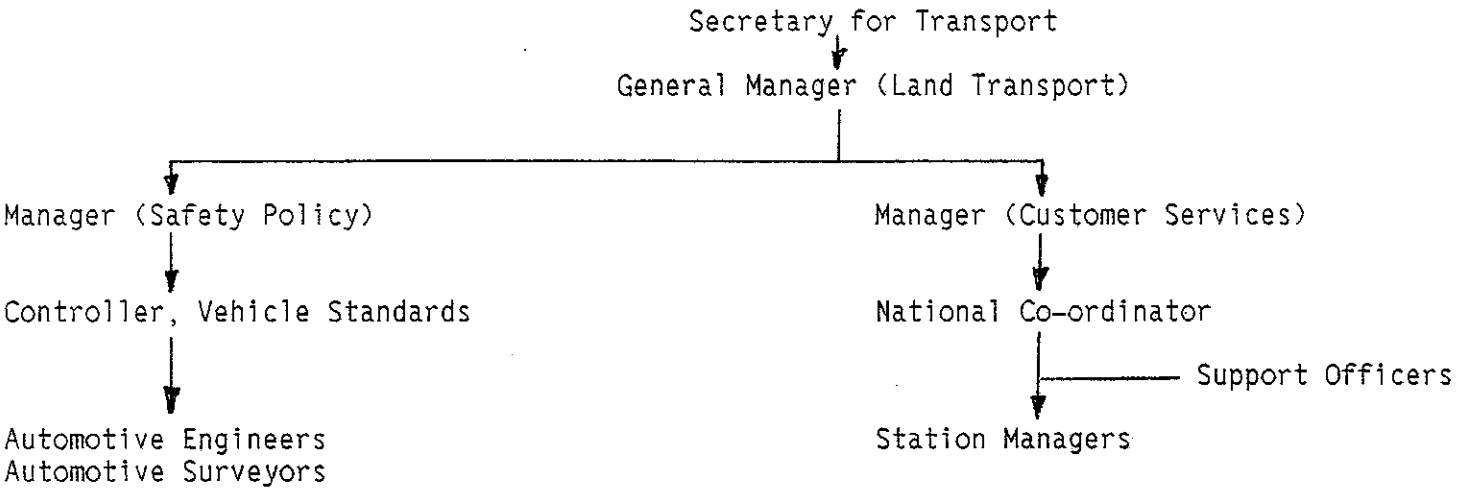
Secretary for Transport
General Manager (Land Transport)
Manager (Safety Policy)
Manager (Customer Services)
Controller, Vehicle Standards
National Co-ordinator
Support Officers
Automotive Engineers
Automotive Surveyors
Station Managers

FIGURE 2

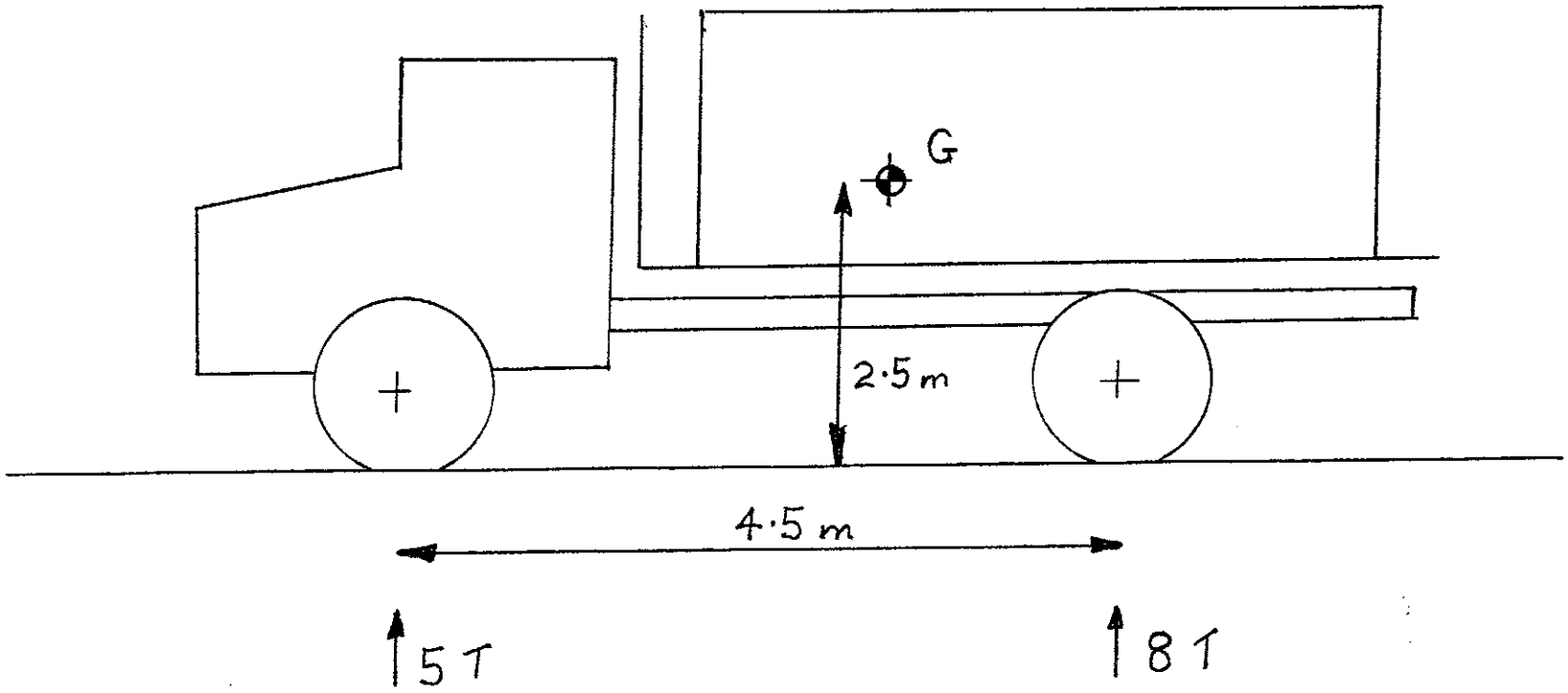

Figure 3

Case 1

Braking units	FA	5	Wheelbase	4.5 metres
	RA	8	CG height	2.5 metres
			GVM	13 tonnes
			FA	5 tonnes
			RA	8 tonnes

Weight Transfer =(GVM*g*Decel)/wheelbase

Decel. % g	Total Retarding Force N	FA Vertical Force N	FA Retarding Force N	FA R/V	RA Vertical Force N	RA Retarding Force N	RA R/V
0	0	5	0	0.00	8	0	0.00
0.001	0.01	5.03	0.01	0.00	7.77	0.02	0.00
0.1	1.30	5.72	0.50	0.09	7.28	0.80	0.11
0.15	1.95	6.08	0.75	0.12	6.92	1.20	0.17
0.2	2.60	6.44	1.00	0.16	6.56	1.60	0.24
0.25	3.25	6.81	1.25	0.18	6.19	2.00	0.32
0.3	3.90	7.17	1.50	0.21	5.83	2.40	0.41
0.35	4.55	7.53	1.75	0.23	5.47	2.80	0.51
0.4	5.20	7.89	2.00	0.25	5.11	3.20	0.63
0.45	5.85	8.25	2.25	0.27	4.75	3.60	0.76
0.5	6.50	8.61	2.50	0.29	4.39	4.00	0.80
0.55	7.15	8.97	2.75	0.31	4.03	4.40	0.80
0.6	7.80	9.33	3.00	0.32	3.67	4.80	0.80
0.65	8.45	9.69	3.25	0.34	3.31	5.20	0.80
0.7	9.10	10.06	3.50	0.35	2.94	5.60	0.80

Figure 4

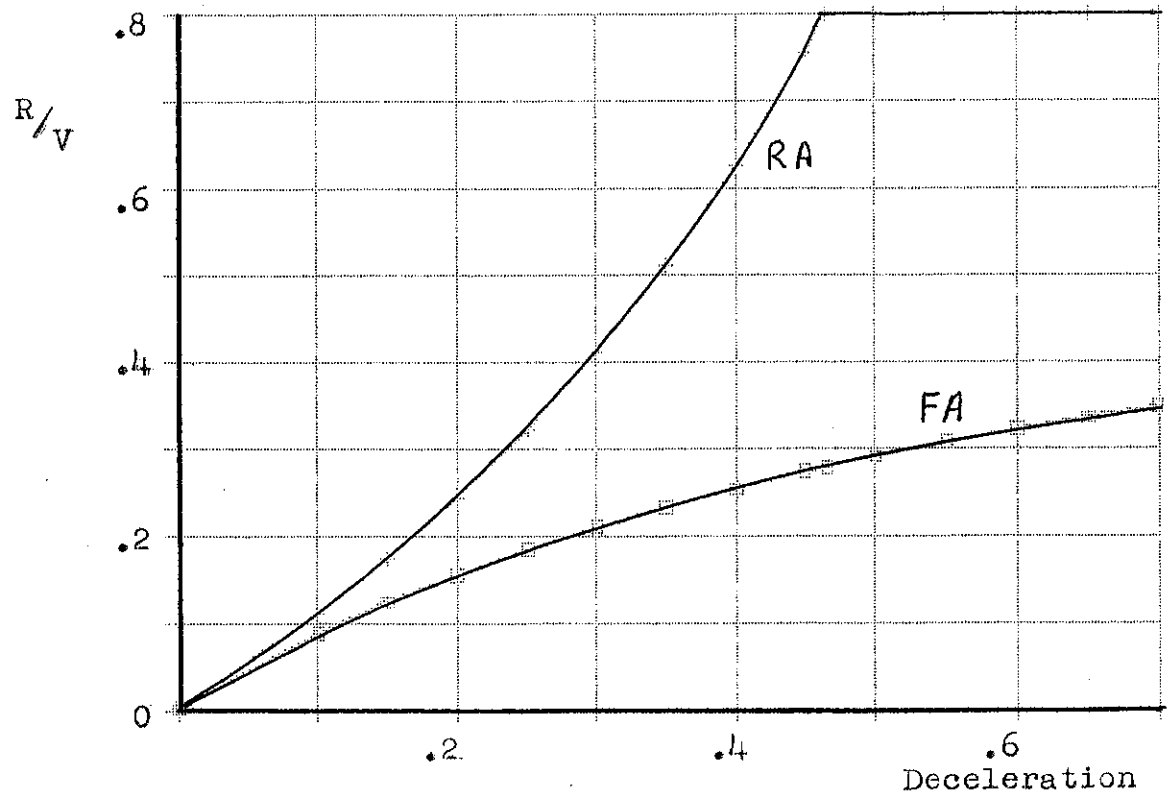

Figure 5

Case 2

Braking units	FA	8	Wheelbase	4.5 metres
	RA	5	CG height	2.5 metres
			GVM	13 tonnes
			FA	5 tonnes
			RA	8 tonnes

Weight Transfer =(GVM*g*Decel)/wheelbase

Decel. % g	Total Retarding Force N	FA Vertical Force N	FA Retarding Force N	FA R/V	RA Vertical Force N	RA Retarding Force N	RA R/V
0	0	5	0	0.00	8	0	0.00
0.001	0.01	5.03	0.02	0.00	7.41	0.01	0.00
0.1	1.30	5.72	0.80	0.14	7.28	0.50	0.07
0.15	1.95	6.08	1.20	0.20	6.92	0.75	0.11
0.2	2.60	6.44	1.60	0.25	6.56	1.00	0.15
0.25	3.25	6.81	2.00	0.29	6.19	1.25	0.20
0.3	3.90	7.17	2.40	0.33	5.83	1.50	0.26
0.35	4.55	7.53	2.80	0.37	5.47	1.75	0.32
0.4	5.20	7.89	3.20	0.41	5.11	2.00	0.39
0.45	5.85	8.25	3.60	0.44	4.75	2.25	0.47
0.5	6.50	8.61	4.00	0.46	4.39	2.50	0.57
0.55	7.15	8.97	4.40	0.49	4.03	2.75	0.68
0.6	7.80	9.33	4.80	0.51	3.67	3.00	0.80
0.65	8.45	9.69	5.20	0.54	3.31	3.25	0.80
0.7	9.10	10.06	5.60	0.56	2.94	3.50	0.80

Figure 6

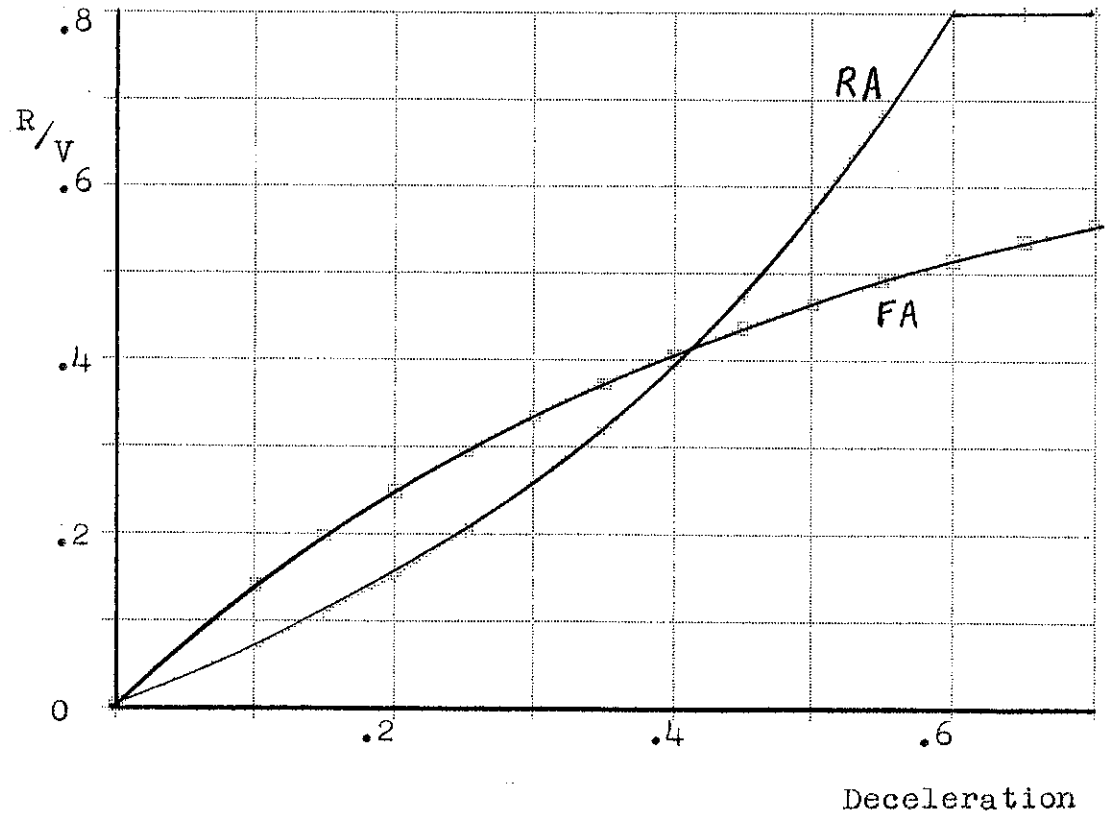

Figure 7