CANADIAN RESEARCH
IN
HEAVY VEHICLE WEIGHTS AND DIMENSIONS

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ABSTRACT

Over the years, Canada has expended considerable effort in attempting to rationalize its heavy vehicle weights and dimensions regulations across its 10 provinces and 2 territories. These efforts led to the launching of major cooperative research program funded by industry, the provincial and territorial governments and the federal government in 1984. Completed in 1987, the study addressed technical issues relating to vehicle safety and pavement damage with a view to providing a basis for the rationalization of size and weights regulations in the future. This paper discusses the context of this project, as well as some of the broader issues which must be addressed in concert with the study. It also outlines some of the other related work currently underway in Canada.

I. INTRODUCTION

In a country with six time zones; a land territority of 9,922,330 square kilometers of which 89% has no permanent settlement; a climate that ranges from an Artic tundra to a temperature south (parts of which lie south of California's northern boundary), a geography that includes great plains, large areas of mountains and hundreds of thousands of rivers and lakes, road transportation plays a central role. Canada spends approximately $ 5 billion (1982 Canadian dollars) annually on a road infrastructure of more than 5,000 kms. of federal highways, 270,000 kms. of provincial highways and more than 660,000 kms. of municipal roads and streets.

A sharp division of jurisdictional powers exists between Canada's ten provincial governments and the federal governments. Each level of government is virtually sovereign with respect to the powers it exercises. Road transportation jurisdiction of weights and dimensions regulatory practice falls largely under the ten provincial governments. Each province or its municipalities is largely responsible for financing, building and operating the nation's road and highway system. Road and highway funding is raised through direct or indirect taxation. The level of taxation is determined by overall fiscal policy and not specifically by transportation funding requirements or revenues generated by road users.

In the context of this highway transportation system, the role of the motor carrier within the Canadian economy is a major one. It has been estimated that for-hire motor carriers accounted for 47% of total operating revenues for all Canadian freight carriers in 1980. (1) In contrast, rail accounted for 38%. Estimates of goods moved by both private and for-hire motor truck carrier indicate that in 1980, these groups moved some 80 billion tonne km of freight. (2) Operating costs for both these groups in 1983 were in the range of 15 to 18 billion dollars (1).

This significant role is not new to the industry since it has in fact been playing a substantial part in the transportation of goods in Canada for over fifty years. It has succeeded in providing a unique type and level of service which offers both flexibility and efficiency as well as adaptability to the changing needs of the market place. The industry's desire to provide more efficient service, coupled with the continual pursuit of new markets and commodities has brought with it relatively rapid growth in the size and weight of commercial vehicles in our country, especially over the past decade.

As a consequence, the Canadian trucking industry currently operates some of the longest, heaviest and widest heavy commercial vehicles in regular use anywhere in the world. This distinction brings with it a fleet of trucks and equipment which is to a large degree, unique to Canada, reflecting the heavy loads carried across a wide variety of highways in a demanding range of geographic and climate conditions.

2. BACKGROUND

In an effort to assess the character of the interprovincial truck fleet in Canada, a cross-country survey was carried out in 1984 under the Vehicle Weights and Dimensions Study (VWD) by the University of Michigan Transportation Research Institute (UMTRI). While the findings of that work are based on a relatively small sample of interviews, and not on a statistical assessment of motor-vehicle registration records, they do provide an interesting insight into the relative popularity of various configurations used in interprovincial trucking operations across the country. The details of the survey have been published, (3) however some of the highlights merit mention here.

2.1. Canada's Interprovincial Truck Fleet

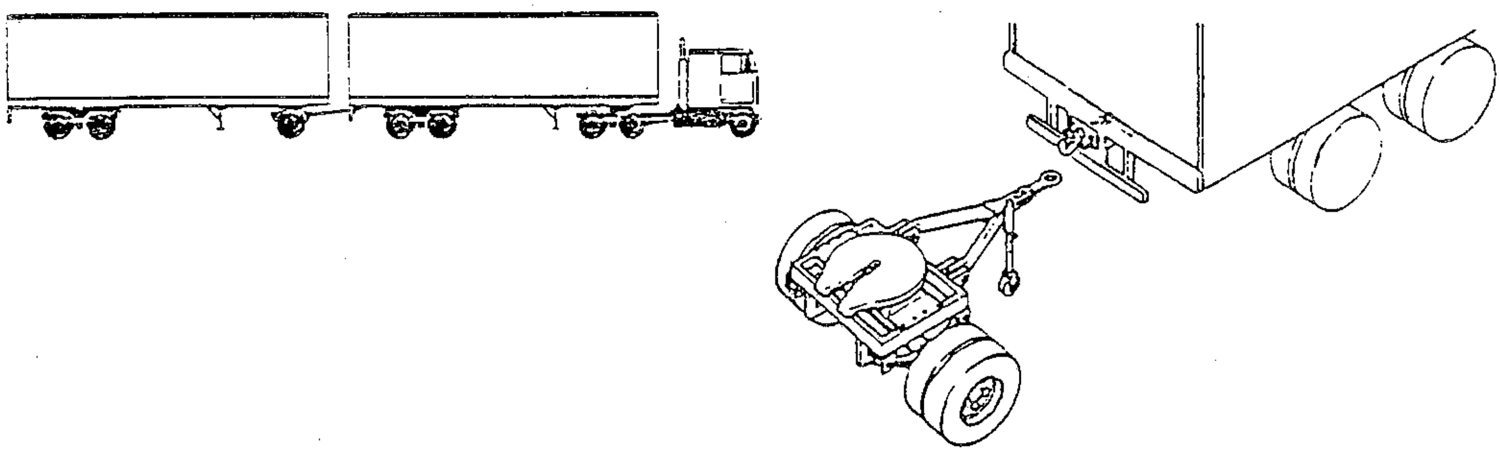
On an overall basis about 77% of the heavy combination vehicles were found to be tractor semi-trailers, 17% were A-doubles, 5% B-doubles and the remainder (1%) are C-doubles and triples. The percentage breakdowns varied across the country in the six centers where interviews were performed as can be seen from Table 1. Quebec and Atlatic region carriers had substantially higher percentages of tractor-semitrailer combinations than other centers. British Columbia, Manitoba and Ontario however were found to have substantial percentages of A-double configurations (25 to 32%) compared to the others (1 to 8%).

Within the tractor-semitrailer group, the conventional arrangement of a 3-axle tractor with a 2-axle semi-trailer dominated; ranging between 75% to 95% of the group population. Two-axle tractors were virtually non-existent for interprovincial highway trucking and their use seems to be mainly in urban area delivery operations.

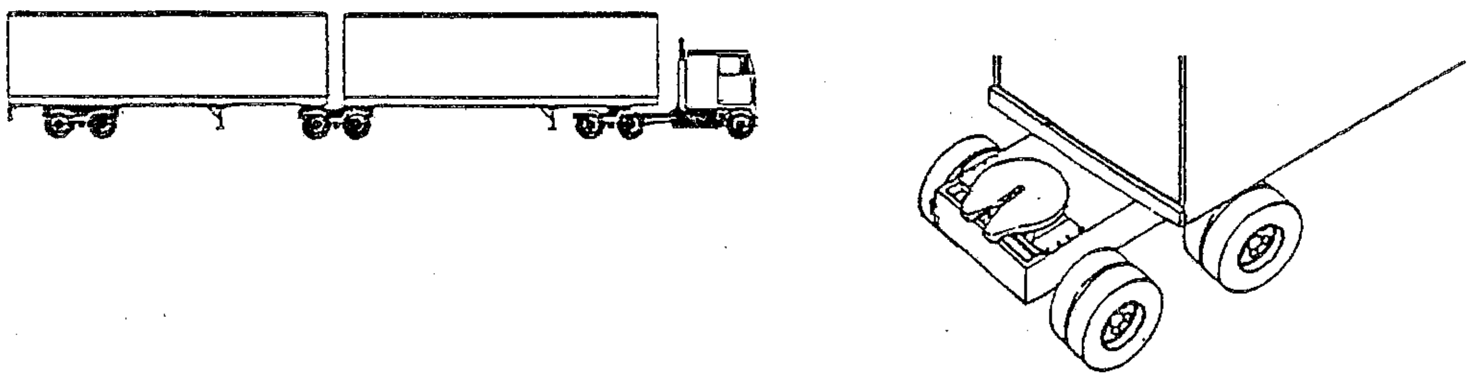
The range of typical Gross Combination Weights (GCW) carried by these types of configurations identified for the survey varied widely. The responses to this question are summarized in Table 2. Regional differences across the country become immediately apparent and a review of detailed dimensional information revealed that " ... great distinctions in vehicle configuration are seen across the various provinces .. ". (3) The differences are attributed to differences in local regulating and, to some degree the operational preferences of the carriers. The difficulties encountered by a carrier in attempting to optimize a vehicle configuration to travel between provinces can be readily

Figure 1: Configurations of Combination Vehicles

A-Train



B-Train



C-Train

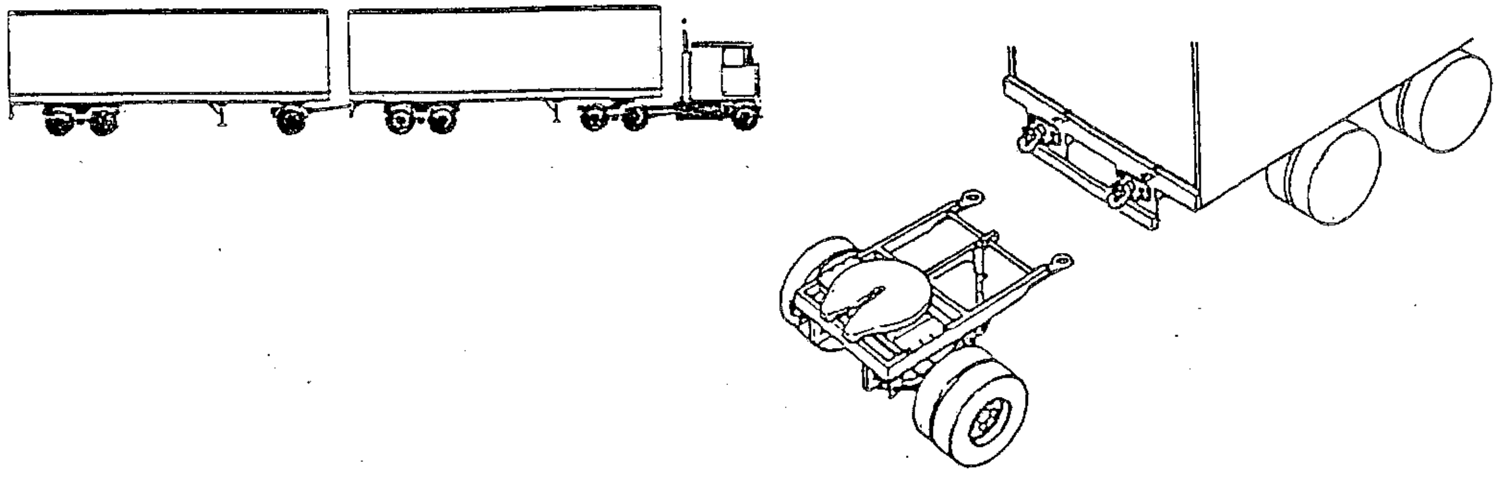


Table 2

Typical Gross Combination Weights by Configuration

(lb x 1000)

Configuration	No of Axles	Meeting Sites: Vancouver	Calgary	Winnipeg	Toronto	Montreal	Moncton
Tractor-semitrailer	5 - 6	80-107	80	80	88-118	87-118	80-108
A and C Doubles	5 - 8	95-126	102-118	103-125	100-140	127	--
B Doubles	6 - 8	125-140	115-117	115-117	114-140	124-127	--
Triples	8 - 11	--	118	125	--	--	--

Table 1

% Distribution of Long Haul Combination Vehicles in Each Region

Meeting Sites

Configuration	Vancouver	Calgary	Winnipeg	Toronto	Montreal	Moncton
Tractor-Semitrailer	60	80	60	70	90	98
A Train Double	32	8	25	25	8	1
B Train Double	8	10	14	5	2	1
C Train Double	0	2	1	1	1	0
A or C Train Triples	0	1	1	0	1	0
Total	100	100	100	100	100	100

appreciated, particularly given the wide variability of the detailed specifics of the dimensional regulations.

In reality, the greatest differences in loading allowances under the current regulatory regimes in Canada result from two main points :

(a) Certain provinces grant additional load on a tandem group when axle spread is increased beyond 48".

(b) Certain provinces allow additional load for additional axles in the combination (i.e. : the Triaxle question).

2.2. Size and Weights Issues in Canada

Changes in size and weight regulations in Canada over the years have been traditionally brought about through pressure from the trucking industry. The implications on vehicle stability and control of such changes have not always been fully understood, in many cases simply because little information has been available to make a proper assessment. Due to the fractured nature of regulatory responsibility in Canada, a considerable degree of non-uniformity has come about which renders the efficient operations of a motor carrier fleet across multiple provinces difficult.

The Canadian Vehicle Weights and Dimensions Study was launched largely due to a desire to achieve a greater degree of uniformity in size and weight regulations affecting interprovincial motor carriers across the country. A number of agencies however were extremely concerned of the impact of changes of highway safety. Uniformity and productivity increases were viewed as essential but these had to be based on sound, proven, rational performance criteria and infrastructure impacts. Bridges and bridge capacities were originally thought to be the limiting factor, however, a cooperative study carried out from 1975 to 1979 (4) indicated that bridges could withstand significantly higher loads than originally expected and suggested further research be conducted into pavement structures and limitations they might impose.

Work in defining the research needed resulted in the launching of the VWD Study in Canada which is described in more detail in the next section of this paper. Vehicle stability and pavement response issues were seen to be the critical areas requiring immediate attention if a sound technical basis was to be provided for bringing weights and dimensions uniformity to Canadian regulatory practice.

Other issues had also been identified as requiring consideration but were not incorporated into the study.

regulations have not been well known in the past. Both regulators and operators have had to use considerable judgment in predicting the implications of regulatory change.

Increasing allowable vehicle and/or axle weights without increasing dimensions can cause the centre of gravity of the vehicle to rise, potentially to obtain maximum permissible loadings while complying with bridge formula or other regulatory constraints, thereby producing a potentially wide range of behaviour for trailers with the same physical dimensions.

Achieving uniform weights and dimensions regulations in Canada must entail developing regulatory principles which are acceptable to all jurisdictions. The consequence of changing the existing regulations will result in changes in the configurations used in the trucking fleet. To reach a rational concensus on uniform regulations, industry and government had to have sound technical knowledge of the impacts of weights and dimensions changes on the stability and control characteristics (as well as the highway infrastructure impacts) of vehicles which are likely to appear in the commercial trucking fleet.

With this in mind, the primary objective of the research program was to determine the nature and magnitude of the likely stability and control problems which could be expected from varied truck configurations meeting various size and weight contraints. Supporting objectives were :

a. To evaluate the dynamic manoeuvring characteristics of various long and heavy vehicle combinations.

b. To establish criteria for determining acceptable vehicle performance.

c. To achieve an improve level of Canadian capability for conducting research and testing into truck stability and control.

Before launching the research program, a survey was carried out to determine the types and relative popularity of vehicles currently used in interprovincial trucking. The results of this survey enabled a structural framework to be established for the investigations which describes the range of vehicles currently in service, and would accommodate variations on these configurations if changes in regulations were to occur.

The framework categorizes articulated vehicles by the number of trailers used in the configuration and the method by which they are connected. Within each of these

This was in order to keep the size of the study to manageable proportions from both a budget and a research logistics standpoint. A number of these other issues were however being examined through the coordinated efforts of different agencies in the country. Others remain to be tackled in the longer term research programs of these groups.

Among area of particular concern are :

- o methodologies for the evaluation of the economic impacts of regulatory rationalization.
- o the interaction of heavy vehicles with other elements of the traffic stream on highways. o issues relating to the sensitivity of bridges to variations in axle spacings and loading's which might occur with new configurations.
- o the need to simplify or improve the accessibility to and understanding of necessarily complex regulatory regimes.
- o issues relating to equipment compatibility for intermodal operations.
- o enforcement equipment procedures and practice.
- o driver related issues.

A number of these are discussed in more detail in a subsequent section of this paper.

3. THE CANADIAN RESEARCH PROGRAM

3.1. Organization

Launched in the spring of 1984, the Vehicle Weights and Dimensions Study represents a landmark undertaking in Canada. Valued at nearly $ 3 million and spanning three years, it constitutes the largest single highway related research program ever undertaken. It also represents a truly cooperative venture between both public and private sectors, with 25% of the total costs being provided by the trucking and truck and trailer manufacturing industries. The committee structure used to design, steer and approve the technical program also includes representatives from both government and industry, as well as observers from AASHTO, TRB and the U.S. Federal Highway Administration.

3.2. Vehicle Stability and Control Research

The multitude of vehicle configurations, with their regional concentrations, currently in use in the Canadian trucking fleet directly reflects the range of weights and dimensions regulations in place across the country. It is evident that regulations do drive commercial vehicle design, and as a consequence, changes in regulations bring changes in vehicle configurations. Unfortunately, the stability and control characteristics of new vehicles spawned by changing

Table 3

Vehicle Classification Framework

CATEGORY	BASELINE CONFIGURATION
Tractor-Semitrailer	Three axle tractor with 45' tandem axle semitrailer
A Train Double	Three axle tractor with twin 26' tandem axle semitrailers and single axle A Dolly
B Train Double	Three axle tractor with twin 26' B train; triaxle lead trailer with tandem axle pup
C Train Double	Three axle tractor with twin 26' tandem axle semitrailers and single axle au steer B Dolly
A Train Triple	Three axle tractor with three 28' single axle trailers and single axle A Dollies
C Train Triple	Three axle tractor with three 28' single axle trailers and single axle auto steer B Dollies

categories a baseline, or dimensionally specific. configuration was chosen to provide a reference level of performance against which the effects of variations in parameters, equipment and dimensions could be presented. The baseline configurations provides a focus for the research needs of the category, recognizing that the principal factors affecting stability and control will vary from one generic category to another.

Recognizing that analysis or testing of vehicle performance provides data which is best understood by vehicle dynamics experts, the performance of particular configurations is related, whenever possible, to that of the best known and most common configuration, the five axle tractor semitrailer. The common use of this vehicle indicates that this vehicle's level of risk has been accepted by society.

Vehicle stability and control research has traditionally been explored through actual testing of vehicles under controlled conditions. However over the past decade the capabilities of computer simulation models have advanced tremendously, to the point of now being reliable and efficient tools for assessing vehicle behaviour. One important advantage provided by computer simulation is the ability to predict the bahaviour of vehicles which do not currently exist, and therefore could not be tested. The testing and simulation capabilities were both used to full advantage within the study, enabling a broad based assessment of the stability and control characteristics of existing and hypothetical vehicle configurations to be carried out. It summary there are three main elements to the research program being carried out in pursuit of the vehicle stability and control objectives stated previously.

3.3. Computer Simulation of Heavy Vehicle Dynamic Behaviour

The University of Michigan Transportation Research Institute was retained to undertake an analysis of the stability and control characteristics of vehicles within the framework established for the study. UMTRI has established a world leading reputation for its expertise in vehicle simulation and employ a series of computer models to explore and document the performance of the heavy vehicles in the areas of :

1. Straight Line Braking Behaviour.
2. Low Speed Offtracking
3. High Speed Offtracking
4. Yaw and Roll Stability
5. Rearward Amplification
6. Static Roll Threshold.
7. Braking in Turning Manoeuvers.

The computer simulation tools were used firstly, to document the behaviour of the baseline configuration and secondly, to explore the sensitivity of each of the six basic configurations of vehicles to changes in :

- Gross Combination Weight
- Centre of Mass Height
- Tractor and Trailer Axle Spacings.
- Tractor and Trailer Track Widths
- Tire Selection
- Dolly Selection
- Dolly Drawbar Lengths
- Loading Arrangements and Bias.

In addition, parameter and equipment variations of specific interest to each of these configurations were also explored.

3.4. Field Testing of Heavy Vehicle Dynamic Behaviour

Major vehicle testing testing programs were carried out under the study by the Ontario Ministry of Transportation and Communications and UMTRI at three test facilities: Centralia, Ontario; Blainville, Quebec; and Chelsea, Michigan.

Four distinct elements of the program were carried out for the following purposes :

1. To obtain test data necessary to prove the validity of the computer simulation models.

2. To provide technical and visual evidence of the behaviour of each of the baseline vehicle configurations, through the full range of performance and in pursuit of performance indices.

3. To illustrate the performance of specially selected vehicle configurations, relative to the baseline configurations.

4. To conduct research into vehicles and stability and control phenomina which could not be adequately simulated.

3.5. Testing of Vehicle Roll Stability on a Tilt Table Device.

An 80 long tilt table device was constructed for the research program which enabled combination vehicles to be staticly titled to the point of rollover. The angle at which rollover occurred can be related to the amount of lateral acceleration which the vehicle could be capable of sustaining while negotiating a curve, thereby providing insight to the vehicle's operational roll stability.

The test program on the tilt table included examination of the effects of variations on equipment and parameters on the rollover threshold of the tractor semitrailer combination as follows :

- tractor and trailer suspension selection.
- tire selection; bias ply, radial, low profile, super single .
- overall width; 96" versus 102"
- vertical slack in fifth wheel.

In addition, each of the single and double trailer baseline vehicles employed in the field test program was tilted to rollover to correlate the static roll test results with the test data obtained in dynamic testing.

3.6. Visiting Researcher Program.

In pursuit of the objective of enhancing Canadian research capabilities in the vehicle dynamic field, individuals were supported to undertake the following tasks:

1. Development of a graphic animation package to enhance the utility of the UMTRI computer simulation model output data.

2. Development of simplified procedure for assessing vehicle rollover threshold.

3. Undertaking an assessment of, and developing a users guide for, the UMTRI computer simulation models.

4. Undertaking a review and assessment of heavy vehicle braking hardware and systems.

5. Undertaking a review and assessment of regulations in Canada and abroad governing heavy vehicle braking.

3.7. Pavement Response to Heavy Vehicles Research

The second major thrust of the Vehicle Weights and Dimensions Study was an investigation of issues related to the impact of heavy vehicles on pavement structures. The variety of vehicle configurations and suspension systems used in Canada defined the structure required for the vehicle stability and control investigations. Similarly, the wide range of pavement designs, constructions, geography and climate in twelve jurisdictions across Canada dictated the research needs in this field.

Over the years the AASHO Road Test results have constituted the principal basis for pavement design in most highway agencies in Canada. However, changes in axle loads, suspension systems, speeds and gross vehicle weights have moved the utility of data from the AASHO Road Test from the realm of interpolation to that of extrapolation. Pavement impacts attributable to heavy vehicles are critical in assessing transportation costs and include consideration of the effects of specific suspensions or vehicle configurations where differences are clearly apparent. New design techniques, and the use of new construction materials has resulted in several new types of pavement structures whose response characteristics merit further investigation.

The research in this field comprised two programs of testing:

3.8. Pavement Test Site Research Program

The primary objective of this program was to obtain concensus among pavement engineers from each jurisdiction in Canada on the impact factors for a variety of loading conditions on pavement structures used on the interprovincial highway system.

Using procedures and instrumentation developed by the Alberta Research Council, thirteen test sites at locations across Canada on the interprovincial highway system were instrumented to measure pavement strain and deflection under vehicle loading. The site selection was made by a committee of pavement engineers representing each jurisdiction. Each site is representative of the designs of pavements which will be used in the 1990s in the five geographic regions of Canada and each reflects a unique construction and design practice using local materials.

A test loading program was carried out at each site to determine the relative potential damaging effects (in terms of Equivalent Single Axle Loads) of :

- single axle loadings from 9,000 kg to 11,000kg
- tandem axle loading from 14,000 kg to 22,000 kg
- tandem axle spacings from 1.2 m to 1.8 m
- triaxle loadings from 20,000 kg to 32,000 kg
- triaxle spacing from 2.4 m to 4.9 m

The effect of vehicle speed on pavement response was also examined for each loading condition. Pavement response variables caused by an 18000 lb single axle-dual tire load of a standard Benkelman Beam vehicle were recorded immediately following each test series. Employing this procedure, comparisons between the magnitude of response variables recorded under each loading being investigated to those caused by standard load were made at comparable vehicle velocities and pavement temperatures. These comparisons, which are in the form of interfacial tensile strain and surface deflection ratios, allow the influence of axle load and loading configurations on the magnitude of the response variables (relative to the standard load) to be readily identified. Combining the pavement response ratios with asphaltic concrete fatigue life and limiting pavement surface deflection criteria, destructive effects of traffic loads are expressed in terms of an equivalent number of applications of the standard load, or load equivalency factors.(5)

3.9. Suspension Dynamic Response Investigations

The primary objective of this program was to examine the ability of different heavy vehicle suspension types to share loading between all axles in a group under the variety of conditions encountered in trucking operations.

An axle instrumentation procedure was developed by the National Research Council, based on the installation of strain gauges and accelerometers. This technique provided a continuous profile of the wheel forces being transmitted to the pavement on both sides of each axle on the vehicle. The Instrumentation was calibrated both statically and dynamically using static scales, weigh in motion scales, and electro-hydraulic shaker installations.

Two different tandem tractor drive axle suspensions and three different trailer suspensions (in both tandem and triaxle configurations) were fitted with these instrumented axles and loading profile data collected as the vehicle was driven over a standard highway course which included varying pavement conditions from smooth to rough. Using this technique the issues being investigated by the National Research Council for the study included :

1. An examination of the load equalization capability of different multiple axle truck suspensions under smooth and rough road conditions, and over single and multiple bumps.

2. An examination of the influence of mismatched tractor-trailer deck heights and vehicle braking on the load equalization capabilities of suspensions.

3. A correlation of the dynamic axle loadings obtained from the instrumented axles with the readings obtained from a weigh in motion scale.

4. An examination of the response of a pavement structure (in terms of strain and deflection) to dynamic and loadings of known magnitude and duration.

3.10. SUMMARY

The research investigations undertaken within the

Vehicle Weights and Dimensions Study constitute a major step forward in terms of understanding the factors which affect the stability and control of heavy commercial vehicles, and the effects these vehicle are having on the Canadian highway system. The schedule and content of the program was structured to obtain direct answers to the types of questions in these areas which had to be resolved before uniformity in weights and dimensions regulations could be achieved.

While research often raises more questions than are resolved, the net benefits of the program to regulators, the trucking community and pavement engineers will far outweight the costs of the work.

The information base assembled will retain its value for many years to come, and will continue to assist in the pursuit of improved productivity and efficiency within the highway transportation mode.

4. OTHER RELATED CANADIAN WORK

4.1. Bridge Capacity

While previous research concluded that the capacity of bridges on the interprovincial highway system would not impede the development of uniform weights and dimensions regulations, a number of issues in the field merit further, ongoing investigation. There are currently three bridge codes in use by different jurisdictions in Canada, and a variety of methods available to bridge engineers to determine bridge capacity to carry load. While the weights and dimensions research program investigated the effects to axle spacing on both the stability of vehicle combinations and on pavement response, the influence of axle spacing on the loading of bridges required further clarification and agreement by bridge engineers across Canada.

In 1985, a committee of bridge engineers was formed under RTAC to develop a program of research to investigate the sensitivity of bridges to changes in the spacing within and between multiple axle groups on heavy vehicles.

4.2. Economic Evaluation

The pursuit of uniform weights and dimensions regulations is predicated on improving the efficiency of goods movement operations on the highway system while protecting the monumental public investment in the infrastructure. As any changes in regulations will produce benefits and costs for both public and private sectors, it is essential that the financial implications of regulatory change be well understood.

In 1985, Transport Canada sponsored an investigation by a consulting firm into the economic impacts of changes which have occurred in the weights and dimensions regulations in the past. The research focuses on developing a detailed understanding of how weights and dimensions regulations affect truck types, the trucking industry, shippers and the public. Included in the study is an assessment of the productivity and operational characteristics of various truck types.

4.3. Safety Issues

The effects of long and heavy vehicles on the level of service provided by the highway system to the general public have long been studied by traffic engineers and are a major consideration in highway planning, design and maintenance. However, the continued growth of heavy vehicle weights and dimensions has brought about renewed discussions of the safety implications of extremely long and heavy vehicles in traffic streams composed of passenger cars which have been continually reduced in size, weight and horsepower. The time and distance required by passenger cars to pass long combination vehicles, the potential increased severity in car/truck accidents and the accelerated rate of pavement degradation due to heavier vehicle are examples of emerging research priorities to engineers in Canada.

4.4. Regulation and Enforcement

The economic recession of the late 1970s and early 1980s resulted in limited resources to provide services by government at all levels. As a consequence, truck inspection stations were not manned as often as in the past and enforcement of weight and dimensions regulations was reduced. Concern for the safety of the trucking fleet and protection of the highway system infrastructure has caused government agencies to look for new and more efficient methods of enforcing regulations in a time of reduced availability of manpower and resources.

As a consequence, research continues in Canada into automated weight and dimension enforcement systems, including the weight-in-motion scale, automated overheight dectectors and "smart" systems incorporating weigh-in-motion scale technology, traffic monitors (for axle spacings) and microcomputer-based regulatory databases to automatically detect vehicles which are in violation of regulations.

4.5. Applied Knowledge-based Systems

The factors which must be considered by an operator in purchasing a combination vehicle are numerous: regulatory constraints on axle loading and spacings, constraints imposed by the quantity and nature of the commodity to be carried, the stability and control characteristics of the vehicle once assembled and loaded, plus the comfort of the driver. Each of these factors brings with it advice on how a vehicle should be configured, how the vehicle should be loaded, and so on.

In 1985, a study was launched in Canada by the Council on Highway and Transportation Research and Development into the application of expert systems technology to the optimizations of heavy vehicle configurations. The study is examining, as a pilot project, the feasibility of developing a working model expert system which incorporates the existing weights and dimensions regulations in Canada and would serve to optimize vehicle configurations for interprovincial carriage. If successful, this model system will be further developed to include the other factors described previously.

4.6. 1986 International Symposium on Heavy Vehicle Weights and Dimensions

In recognition of the completion of the technical research under the weights and dimensions study, and in conjunction with the World Exposition on Transportation and Communications (EXPO 86), a symposium was held in Kelowna, British Columbia in June 1986 on heavy vehicle weights and dimensions. This symposium brought together industry and an international group of researchers to present and exchange information on the most current research activities and findings in the field. In particular, the subject areas addressed included vehicle dynamics, impacts of heavy vehicles on highway infrastructure and the technoeconomic impact of regulatory measures.

5. CONCLUSIONS

In Canada, the highway system and the trucking industry which uses it are both vital to the economic base of the nation. Governments have striven to provide truck operators with a regulatory environment which provides the greatest opportunities for efficient movement of goods, while protecting the massive public investments in highway infrastructure. As this paper has shown, the presence of heavy commercial vehicles on the public highway system raises a multitude of issues related to vehicle safety, economics, regulations, enforcement, pavement degradation and bridge capacity.

The pursuit of efficiency brings with it the need for change, and changes in any aspect of this highly dynamic system must be considered carefully. While the vehicle weights and dimensions study constitutes a major step forward towards obtaining a better understanding of the safety of heavy vehicles and their effects on pavements, there will continue to be a need for further research in many areas before the implications of size and weight controls will be fully appreciated.

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