Heavy Trucks on the Highways: An Important Pavement Issue

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With the completion of the Interstate system, attention has shifted from building a national highway network to improving, operating, and managing the highway system. Movement has been from construction to cost-effective management of highways. Truck movements are an important issue of concern because of the damaging effects that loads from heavy trucks (five-axle and larger) contribute to pavements over time. It has been determined that heavy trucks contribute, on average, 92 percent of loads applied to rural Interstate highways. However, it has been determined that there is great variance with respect to heavy-truck traffic by route and by region of the country. Use of visual presentations such as maps to highlight the differences in levels of heavy-truck traffic by route becomes an important consideration to pavement managers concerned with maintaining existing pavements and planning for pavements in future projects. Topics also discussed include the importance and methods of predicting previous and future volumes of heavy-truck traffic in the estimation of design loadings for highways of concern, future economic trends in the heavy-truck industry, comparisons of loads imposed by truck type, and the development of load maps using load factors sensitive to roadway type and vehicle classification.

The purpose of this paper is to discuss (a) why trucks are important to pavement management, and (b) how to determine where trucks are moving on the highway system now and how much the number of trucks will grow in the future. With the completion of the Interstate system, attention has shifted from building a highway network to improving, operating, and maintaining the highway system. Thus, movement is from construction to management of highways in a cost-effective manner. Pavement management is an integral part of this overall highway management effort. Pavement management systems are being established to assist decision makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition. This systematic approach is needed to improve management of this nation's large existing investment in pavements and to help make better use of limited funds (*1*). How large an investment is there in pavements today? There are approximately 4 million mi of public highways with an annual total highway budget for all levels of governments of $63 billion. Approximately 50 percent of these funds is spent on pavements. Management of pavements is a big job, and good management will result in big savings.

Many factors affect pavement performance; these include age, environment, load, drainage, design, and construction quality (*2*). In this paper only truck-related factors are addressed. The major truck-related factor of concern is the load the trucks impose on the highway.

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A single vehicle travels down the road on a pavement structure. That structure deflects slightly with each pass of an axle load. This deflection fatigues the pavement structure, reducing its strength, thereby causing distress and roughness. Given enough repetitions of load, the pavement structure will fail.

To accurately predict the performance of new or rehabilitated pavements, an accurate prediction of future heavy-truck traffic is necessary. Without good truck information, there can be no meaningful life-cycle-cost analyses, prediction of future needs, or evaluation of alternative design loadings.

Questions facing pavement managers are how many loads

1. Can a pavement structure carry?
2. Have been applied to date?
3. Are being applied currently?
4. Will likely be applied in future years?

To answer the first question, the AASHO Road Test was carried out between 1958 and 1960 in Ottawa, Illinois. Load data collected during the Road Test were expressed in terms of 18,000-lb equivalent single-axle loads (ESALs). The ESAL concept makes it possible to represent any mix of vehicles on the highway in terms of a group of single axles, all weighing 18,000 lb. This concept provides, for any given pavement design, pavement damage caused by single or tandem axles, expressed in terms of ESALs. The Road Test Equation demonstrated that pavement performance is associated with specific axle loads and number of repetitions. The ESAL concept relates the pavement design needed for a specific level of pavement performance to a cumulative specific load level. Since the Road Test, axle loadings have increased and new pavement types have been introduced.

Questions 2, 3, and 4 concerning historical, current, and future loadings can be easily addressed if a state's traffic monitoring and forecasting programs produce good solid truck-loading information. If not, this paper supports the need to establish such programs.

CURRENT TRENDS IN TRUCKS

Figure 1 shows the relative growth in gross national product (GNP), total vehicle miles of travel (VMT) on all systems, heavy-truck VMT on all systems, and ESALs on the rural Interstate system from 1970 to 1987. These trends continue through 1989 and show that VMT and GNP have been growing at about 3.3 percent compounded yearly. Heavy-truck

VMT has been growing at about 5.4 percent per year during this period, and ESALs on the rural Interstate has been growing at about 8.9 percent per year. Truck travel on all systems is increasing at about twice the rate of growth of VMT or GNP. In addition, the high growth in ESALs indicates that there are more trucks on Interstate highways and shows that a larger portion of these trucks are 3S2 and larger, hereafter defined as "heavy trucks."

Overall the increases in heavy-truck travel and the size and weight of these trucks have resulted in more damage to pavements than anticipated. The key question is, What does the future hold?

FUTURE TRENDS IN TRUCKS

Recent forecasts by Data Resources, Inc. regarding the trucking industry indicate four major trends (*3*):

1. Truck tonnage will grow faster than industry production in most commodity markets.
2. The share of tonnage hauled by for-hire fleets will increase.
3. Shipments will be smaller as corporations try to control inventories.
4. There will be continued overcapacity and intensified competition within the trucking industry.

Consequently, the amount of freight hauled by trucks will continue to increase, more of this freight will be hauled by for-hire fleets, and competition within the trucking industry will intensify. In the future, more trucks can be expected on the highway system. Most of these additional trucks will be heavy trucks (i.e., those with five or more axles) loaded to legal limits. The end result will be continued growth in ESALs at a rate higher than GNP or VMT.

At the federal level, a variety of changes is possible with regard to size and weight restrictions. Changes are being explored concerning vehicle length, trailer configuration, gross axle weight, and tire pressure limits (*4*).

The potential for change in the types of trucks on the highways, especially on the Interstates, is high. These changes must be carefully monitored to be able to accurately predict future loadings on the pavements.

On the basis of an FHWA study of travel growth between now and the year 2020, it is estimated that truck VMT for two-axle, six-tire and greater trucks will grow at approximately the same rate as the GNP, the compound growth rate being 3.4 percent per year through 2005 and 2.7 percent per year from 2005 to 2020. Truck travel will continue to grow faster than automobile travel, continuing the historical trend shown in Figure 1 for the faster-growing heavy-truck travel. If these projected trends apply to heavy-truck growth, extensive growth in the loads applied to highways will continue.

IMPACT OF SPECIFIC TRUCK TYPES

The predominant heavy truck in use is the conventional 3S2. Approximately 60 to 70 percent of all five-or-more axle trucks are 3S2s. However, the double-bottom truck is also emerging as a major cargo carrier. These different trucks will have very different effects on pavement performance, depending on weight carried and number of axles. For example, Table 1 shows the ESALs produced in carrying 1,000 tons of load on flexible pavements by five different types of heavy trucks. The conventional 3S2 generates 134 ESALs. The western double (2S1-2), carrying the same weight as the 3S2, results in 175 ESALs, or a 30 percent increase in ESALs over the conventional 3S2. The Rocky Mountain double, with a grandfathered weight limit of 112,000 lb, does much more damage per vehicle but produces only slightly more ESALs in moving 1,000 tons of goods.

Francis Turner, retired Federal Highway Administrator, has proposed a double-bottom truck with a gross vehicle weight of 100,000 lb and tandem axles. With the Turner truck pro-

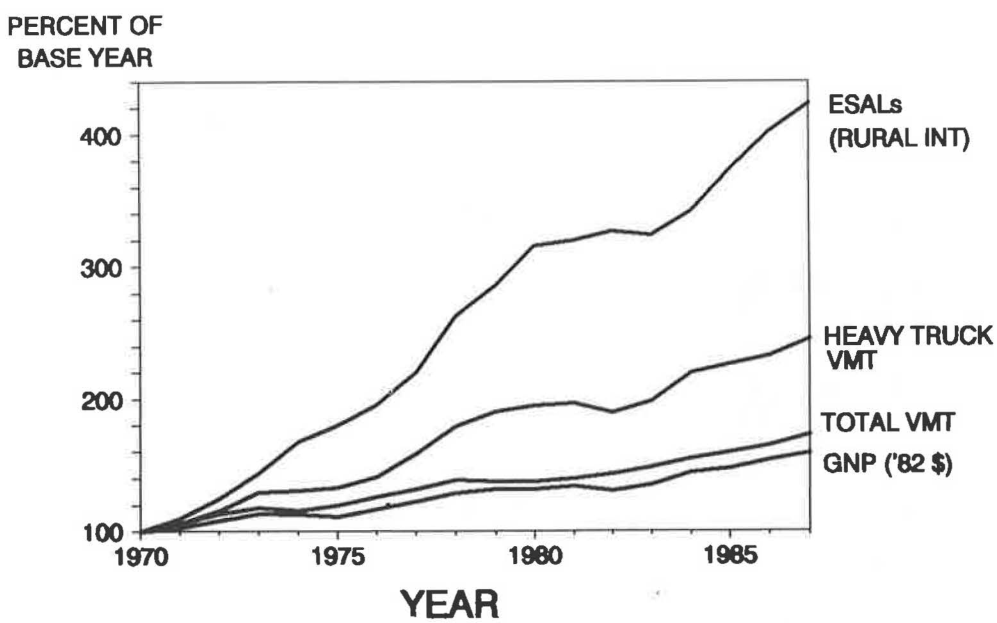


FIGURE 1 Relative growth.

posal (3S2-4), the addition of four extra axles and an increase in gross vehicle weight of 20,000 lb results in a 70 percent decrease in ESALs per 1,000 tons of load. Such a vehicle would only generate 1.23 ESALs fully loaded and would only produce 40 ESALs in moving 1,000 tons of cargo. The Turner truck greatly decreases pavement damage, with a slight increase in operating cost and bridge deterioration.

Heavy trucks contribute 80 percent of ESALs imparted to pavements for all highways and 92 percent of the ESALs on rural Interstates. The high amount of ESALs imparted by these vehicles and their relatively high contribution to overall ESALs applied to roadways makes knowledge of the number of these vehicles present on highways and their weights an important issue.

CURRENT TRAFFIC DATA NEEDED FOR PAVEMENT MANAGEMENT AND DESIGN

In the discussion of traffic data needed for managing and designing pavements, it must be kept in mind that the final product is the total number of ESALs during the design period for a specific location. Current traffic data provide a solid base for forecasting future usage. To support the calculation of cumulative ESALs, the traffic-counting program provides the following current-year data for each section:

- Average annual daily traffic (AADT): traffic volumes are a basic variable in the calculation of cumulative ESALs.
- Vehicle classification: breakdown of AADT by types of vehicles.
- Average ESALs per truck type: ESALs are determined from knowledge of truck weights by vehicle classification. These values are highly dependent upon gross vehicle weight and weights by axle grouping.
- Directional distribution factor: distribution of truck loads by direction during an average day for any given roadway.
- Lane distribution factor: distribution of truck loads by travel lane during an average day.

A traffic-counting and weighing program based on FHWA's *Traffic Monitoring Guide* (*5*) (TMG) or a similar statistically based traffic program will provide the capability to estimate current AADTs, vehicle classifications, and truck weights for functional highway systems.

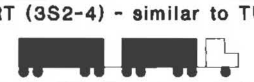
Good vehicle classification data are the key to estimation of current truck volumes. Vehicle classification data are highly variable by location. For example, in a recent study of the percent of two-axle, six-tire or greater trucks present in traffic as determined by the Highway Performance Monitoring System (HPMS), values varied on rural Interstate from 0 to 46 percent, with an average value of 22 percent. This percentage of two-axle, six-tire or greater trucks was highly variable, with a standard deviation of 8 percent. With the heavier vehicles (five axles and more) responsible for most of the ESALs on pavements, efforts should be concentrated on accurately estimating heavy-truck movements.

FHWA's TMG recommends that approximately 300 sites per state be counted during a 3-year period to obtain representative vehicle classification data of functional systems, with an approximate precision of 10 percent and a 95 percent confidence level. The best source of vehicle classification information is automatic vehicle classifiers.

Truck weight data, along with vehicle classification data, are used to calculate ESALs for specific pavement types and vehicles. To obtain accurate weight data, enough random locations are needed to provide the accuracy level desired. The TMG recommends that approximately 90 truck weighing sites per state be counted during a 3-year period to obtain truck weight estimates representative of the highway network for three-axle tractor and two-axle semitrailer (3S2) trucks, with an approximate precision of 10 percent (20 percent for non-Interstate) and a 95 percent confidence level. The best way to obtain large volumes of accurate weight data is with weigh-in-motion (WIM) data collection equipment.

Truck weight data for given vehicle classes are likely to be less variable than vehicle classification data. The emphasis in obtaining truck weight data should be placed on heavy trucks.

TABLE 1 SELECTED COMBINATION TRUCK LOADINGS

TWINS	WEIGHT	ESALs	ESALs/1000 TONS OF CARGO
SHORT (3S2-4) - similar to TURNER 	100K	1.23	40
TURNPIKE (3S2-4) 	131K	3.44	80
ROCKY MOUNTAIN (3S2-2) 	112K	5.05	144
WESTERN (2S1-2) 	80K	4.03	175
CONVENTIONAL (3S2) 	80K	3.21	134

CURRENT HEAVY-TRUCK VOLUMES

With heavy trucks accounting for 80 percent of all ESALs on all highways and 92 percent of all ESALs on rural Interstates, pavement managers must know where these vehicles are moving on the highway system. One way to do this is to develop a heavy-truck flow map. If such a map is not already available from the state planning or traffic section, it can be developed from a statistically based traffic-counting program that provides traffic and vehicle classification data.

To develop a heavy-truck flow map, one begins by getting either a traffic flow map or an estimate of traffic volumes on each roadway segment from the planning or traffic section. The next step is to estimate the proportion of heavy trucks on each roadway section by using the vehicle classification data available from the planning or traffic section. Heavy-truck volumes are then plotted to better define these movements on the highway system. A few states have begun to publish heavy-truck flow maps for either 3S2s or other heavy-truck combinations.

FHWA has compiled a national Interstate flow map for heavy trucks using 1987 vehicle classification data obtained from state highway agencies (SHAs) (see Figure 2). Separate enlarged maps have been prepared for each FHWA region. (See Figures 3 and 4 for examples.) The maps strongly suggest that Interstate heavy-truck volumes remain relatively constant over significant Interstate segments between major urban areas. Trends by FHWA region of the country can also be observed; generally the major heavy-truck routes are located east of the Mississippi, in the Southwest, and on the far western coast.

The heaviest concentration of heavy trucks on the Interstate in the Northeast and Midwest is generally 5,000 trucks per day or greater, examples being I-295 in New Jersey, with 10,500 trucks per day; I-70 from Indianapolis to the Ohio State line, with 6,700 trucks per day; and I-70 between Pittsburgh and Hagerstown, Maryland, with 7,500 trucks per day.

The heaviest concentration of trucks in the South and Southwest is 4,500 trucks per day or greater. Examples of heavy-truck routes in the South and Southwest are I-75 from Atlanta to Chattanooga, with 8,400 trucks per day; I-10 from Houston to San Antonio, with 5,500 trucks per day; and I-85 from Atlanta to Charlotte, with 5,500 trucks per day. The average concentration of heavy trucks in these regions is roughly 3,000 to 5,000 trucks per day.

Longer haul-to-market Interstate routes with smaller heavy-truck volumes are present between the Midwest and the Far West. Heaviest volumes in this area are 1,000 trucks per day or greater, with average truck flows of 300 to 800 trucks per day. Examples of heavy-truck flows in the West are 1,382 trucks per day between Cheyenne and Salt Lake City on I-80, 3,200 trucks per day between Albuquerque and Flagstaff on I-40, and 3,100 trucks per day between El Paso and Phoenix on I-10. Average truck volumes are in the region of approximately 450 trucks per day in North Dakota on I-94, 700 trucks per day on I-90 between Butte, Montana, and Spokane, Washington, and 600 trucks per day on I-70 in western Colorado and eastern Utah.

The heaviest concentrations of heavy trucks in the far western states are generally 5,000 or greater on the Interstate, with average concentrations of 1,000 to 4,500 trucks per day. Examples of heaviest concentrations in the Far West are 5,000 heavy trucks per day between Seattle and Portland and between Los Angeles and San Francisco. Examples of average heavy-truck volumes in the Far West are 3,500 heavy trucks per day on I-5 from Sacramento to Eugene, Oregon, and 3,300 heavy

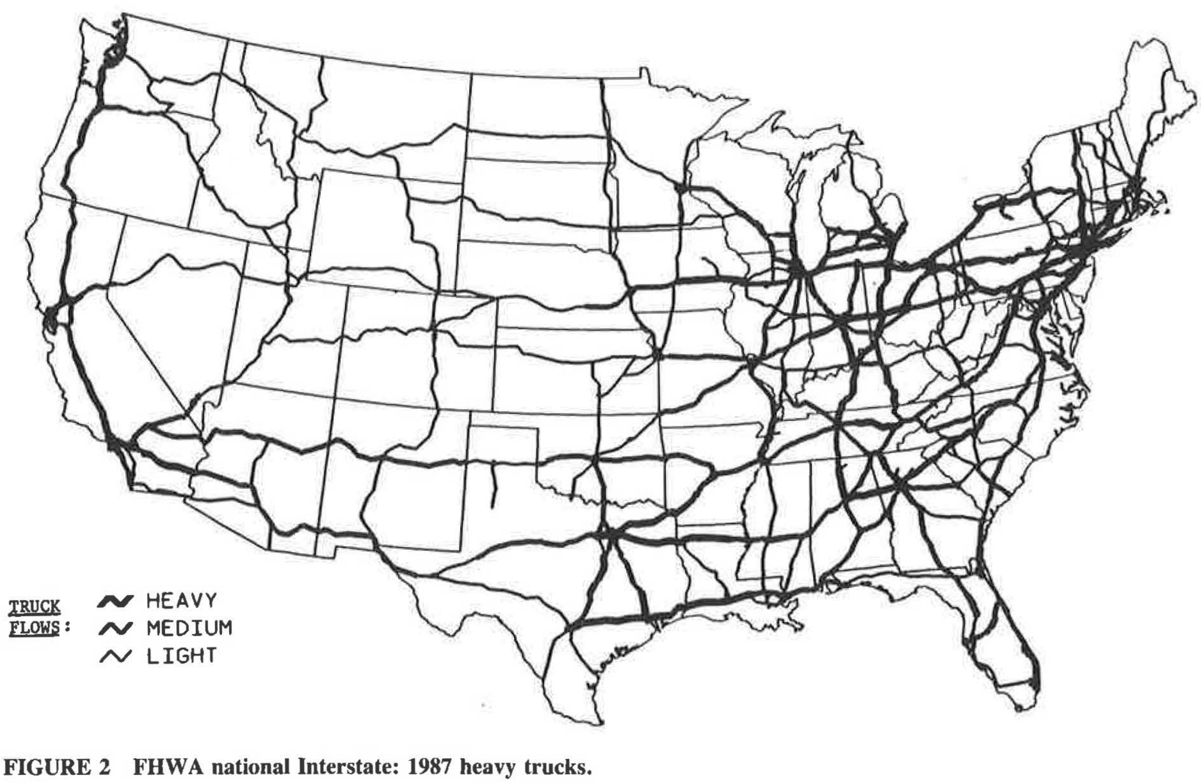


FIGURE 2 FHWA national Interstate: 1987 heavy trucks.

trucks per day between Las Vegas and Barstow, California, on I-15.

Knowing routes that carry heavy-truck volumes and the fact that volumes are consistent over large segments of the highways can be a powerful tool for pavement management. Only in unique situations will section-specific data collection be necessary.

A load map can, in some cases, provide additional supportive information along with a truck flow map. To build a load map, it is first necessary to establish a load distribution table for each roadway type and for each vehicle classification category. These load distributions are converted to ESAL factors for each vehicle classification and roadway type. These load distributions, wherever possible, should be developed from WIM data.

The load map is developed by taking the volume of each vehicle type for each roadway section, multiplying the volume by the ESAL factor for the respective vehicle type, and summing the ESALs. The result is the annual cumulative ESALs for each roadway section. Heavy-truck flow-load maps are a very useful way to summarize truck data being collected by the planning and traffic section. These maps form the basis for estimating pavement deterioration rates and growth in ESALs, and forecasting future pavement performance. When produced on a periodic basis (i.e., every few years), these maps would be very useful to many parts of a highway department in areas such as pavement management, bridge management, accident analysis, traffic operations, and environmental and other topics.

FORECASTING

Pavement managers need an estimate of cumulative ESALs for a specific location (*6,7*). Current-year ESALs can be estimated in an accurate manner; the greater challenge is to accurately predict ESALs over a 10-, 20-, or 30-year period. States use the following methods of forecasting most frequently:

1. Trend forecasts with little or no site-specific data,
2. Trend forecasts with site-specific data, and
3. Multiple regression forecasts.

Florida has evaluated the effects of making trend forecasts where little or no site-specific data on trucks are available. The Florida procedure depends upon the level of site-specific data available.

1. Traffic volume is the single most important variable, without which loadings cannot be forecast.
2. Next most important is the volume of heavy trucks. If it is not available, classification data from the same or similar area and similar type of highway facility can be used.
3. Site-specific truck weights provide the best estimate of 18-kip ESALs. Truck ESAL factors should be stratified as rural or urban and by functional classification.

The Iowa Rural Traffic Forecasting Model (RTFM) uses very detailed count, classification, and truck weight data within the statewide framework to make forecasts.

1. The RTFM includes past population trends for counties and cities. The traffic log is computerized so that past volumes and trends are available for all count locations. Vehicle classification and truck weight counts and trends are available by area and highway classification. If data are not available for the specific site, there are usually data available for adjacent sections.

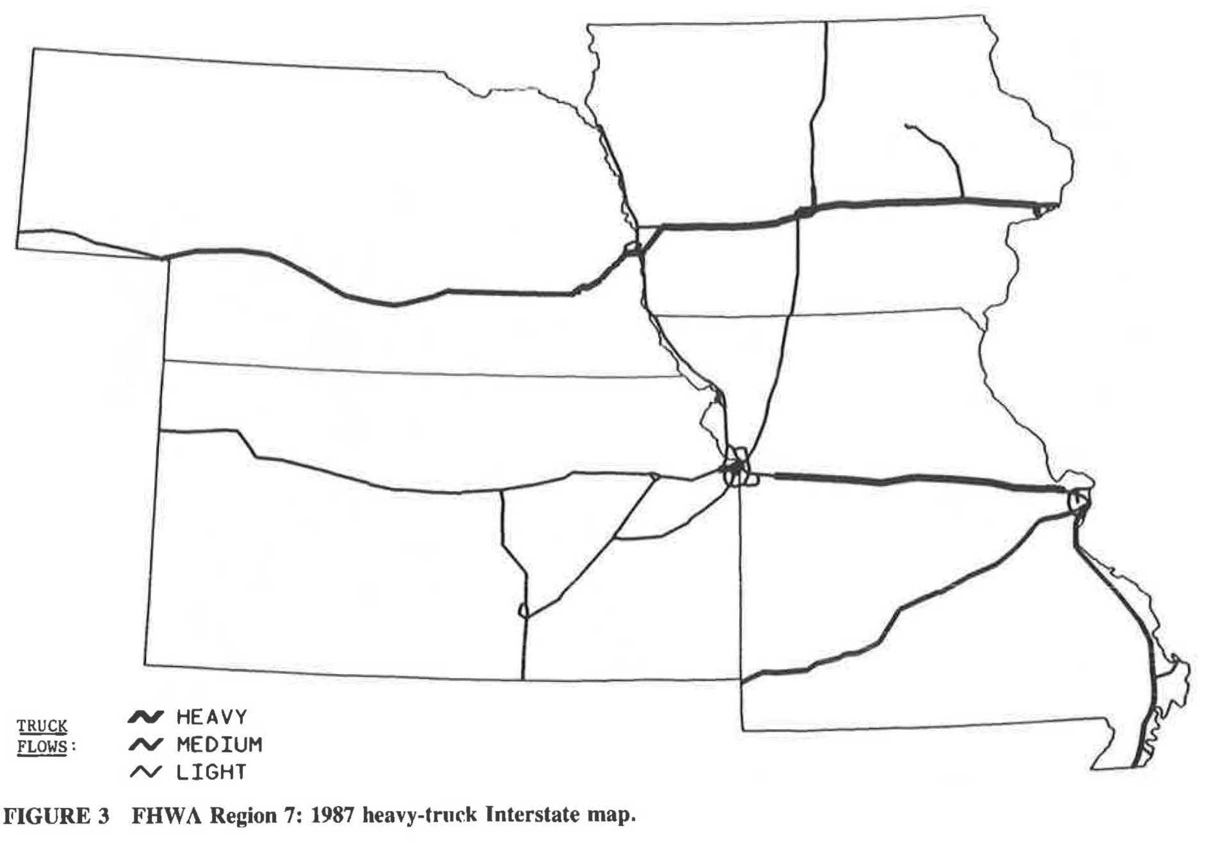


FIGURE 3 FHWA Region 7: 1987 heavy-truck Interstate map.

2. Traffic data and trends are separated by passenger vehicles, single-unit trucks, and combination trucks. The forecasts for combination trucks can be much more accurate as a result.

3. The model assumes that linear growth rates apply throughout the 20- or 30-year period and is best used on lower-volume roadways in Iowa with predictable population and traffic growth rates. A separate procedure is used for new, high-volume roadways.

Idaho has developed a method of estimating vehicle weights that relies on the load distribution factor (LDF) approach.

1. Meaningful LDFs may be calculated by selecting typical sections of roadway and weighing a random sample of trucks to determine single- and tandem-axle weight groups. A single representative LDF for that highway section can then be calculated on the basis of the weighted average of all types of trucks and weights using the road.

2. LDFs were developed from W-4 tabulations made in truck weight studies from 1971 to 1983. Rather than use Federal-Aid or functional classification designations, Idaho relied on the proportion of different vehicles in the truck traffic stream. The designations developed included light-, medium-, and heavy-density truck routes. The higher the proportion of five-axle tractor semitrailer combinations, the heavier the classification of the roadway.

3. Mathematical models were developed for roadways of each classification. These linear models described the growth of load distribution factors over time. The impact, or LDF, was determined to be increasing each year for both medium- and heavy-truck routes and declining slightly for light-truck routes. LDFs can be projected into the future with this process.

New Mexico developed truck travel growth models using multiple regression techniques (*8*). Truck forecasts are improved when they reflect changes in truck fleets, GNP, local economic, and other indicators. Travel forecasts should be based on the relationships between truck travel and population, employment, income, GNP, and other factors.

1. The New Mexico State Highway and Transportation Department identified four factors as the best indicators of heavy commercial traffic growth: U.S. average gasoline cost per gallon, U.S. disposable personal income, New Mexico population, and New Mexico residential building permits (dollar value).

2. Fourteen separate models for forecasting heavy commercial traffic along various sections of the New Mexico Interstate system were developed. Linear regressions were conducted by New Mexico by using heavy commercial average daily traffic (ADT) and ADT as dependent variables. Six years of historical data were used. Best-fit equations were then used to predict heavy commercial ADT and ADT from 1985 to 2005.

East-West routes are the prime carriers of trucks in New Mexico, as well as in the rest of the Southwest. North-South

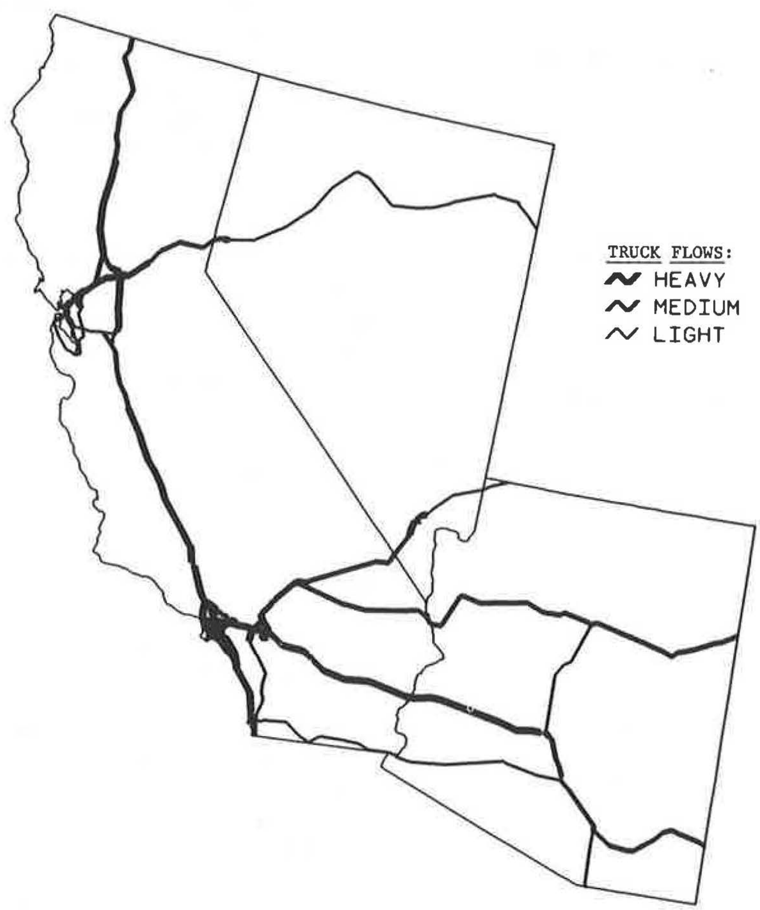


FIGURE 4 FHWA Region 9: 1987 heavy-truck Interstate map.

routes have less traffic, because there are smaller economic markets in these directions.

State forecasts of heavy-truck volumes for various rural and urban conditions are an important component in the understanding of where potential pavement needs may be greatest in the future.

In general, when traffic data are analyzed for forecasting trends, it is best to divide the data into those for light vehicles, medium vehicles, and heavy vehicles. Forecasting procedures should be developed for each of the three groups. By using separate groups, future growth in heavy trucks will be more accurately predicted. As historical trend data have shown, the volume of heavy trucks is growing faster than traffic in general.

The three groupings are

1. Light vehicles: motorcycles, cars, pickups, and other two-axle, four-tire vehicles;
2. Medium vehicles: two-axle, six-tire, single-unit; three-or-more-axle, single-unit; and three-or-four-axle, single trailer; and
3. Heavy vehicles: five-or-more-axle, single trailer and five-or-more-axle combination.

Average ESAL factors determined for these groups are as follows:

Vehicle Group	*ESALs/Vehicle*
Light	0.001
Medium	0.35
Heavy	1.00

From these ESAL factors it is evident that light vehicles, even in high volumes, contribute little to the total ESALs for any given roadway segment.

Future Changes in ESAL Factors

ESALs vary from year to year, mostly because of changes in size and weight laws. In the calculation of cumulative ESALs, careful consideration should be given to expected changes in truck types during the analysis period. Emphasis should be placed on developing trends for heavier, larger vehicles because these vehicles affect pavements more than other vehicle types. If no trend data are available, a 1 percent average growth rate for heavy-vehicle ESAL factors and no change for other vehicle types is a good rule of thumb.

Directional Distribution

For pavement design purposes, the distribution of daily load should be characterized by direction, not by the types of vehicles. Changes in distribution factors will occur with changes in economic development, such as in availability of port or rail facilities. Large manufacturing plants may cause an imbalance of loaded and empty trucks. Very little change in directional distribution would normally be expected during the forecast period.

Lane Distribution

Lane distribution, as with directional distribution, should reflect the distribution of load, not traffic. In urban areas, more truck lane management strategies are being implemented that will change lane distributions. Therefore, in urban areas, lanes should be designed to carry 100 percent of the anticipated loads. In rural areas where little change is expected in the future, the initial value should be used.

Results of Forecasts

No matter what method of forecasting is used, the desired result is the same. Cumulative ESALs in the design lane need to be accounted for in a given analysis period. To determine total cumulative ESALs, the following values must be forecast:

1. Light-vehicle volumes,
2. Medium-vehicle volumes,
3. Heavy-vehicle volumes,
4. ESAL load factors by vehicle type,
5. Directional distribution factor, and
6. Lane distribution factor.

The importance of forecasting cannot be overstated. Estimates of future volumes of traffic are the basis for highway design and are used in estimates of future funding for the highway program. Errors in forecasting have resulted in expensive mistakes, such as premature failure of facilities or reconstruction of facilities soon after initial construction is completed. A well-developed accurate traffic forecasting procedure will result in significant future cost savings.

It is important to obtain accurate traffic growth forecasts by vehicle type for pavement design purposes. If one assumes an equivalent growth rate of the trucks, as with the rest of the traffic, some serious underestimation of total ESALs accumulated by the pavement through the design life could result. For example, with an initial AADT of 3,800 vehicles per day and 26 percent trucks in the traffic, if a growth rate of 3.5 percent is applied over 20 years with the assumption that the vehicle type percentages of traffic will remain the same, approximately 7.1 million ESALs would accumulate over a 20-year period. However, if there is in actuality a heavy-truck growth rate of 9.7 percent, with smaller trucks growing at about 7 percent per year and the remaining traffic growth at 3 percent, the total accumulated ESALs in a 20-year design period would actually be 19.7 million, or 12.6 million more ESALs than projected. The pavement thickness would be underdesigned to meet future loads and significant rehabilitation costs could ensue as a result (see Figure 5).

Past Truck Traffic

Estimation of past traffic is a straightforward process (*8*). There are eight basic steps:

1. Gather historic data on: (a) traffic volumes, (b) vehicle classifications, (c) truck weights, and (d) legal load limits;
2. Divide the highway system into functional classes or other groupings;
3. Establish vehicle types (a minimum of two types should be used);
4. Establish analysis period—group the backcasting period into years with similar ESAL factors (similar legal load limits) for the vehicle groupings;

5. Develop table of historic ESAL factors by pavement type, years, and vehicle type;
6. Determine best estimate of vehicle distribution by vehicle type and analysis period;
7. Determine best estimate of vehicle volumes by classification by analysis period; and
8. Calculate cumulative ESALs for each analysis period.

FUTURE NEEDS

Because of the importance of knowing heavy-truck volumes, and hence ESALs for pavement management purposes, state programs should provide representative information on the number of trucks using specific routes and the loads these trucks carry. The work reported in this paper indicates great consistency among heavy-truck volumes over significant portions of specific routes.

The ability of state traffic programs to provide truck volumes, truck weight data, and lane, directional, and seasonal adjustment factors representative of specific truck routes or groups of truck routes should be assessed. Procedures for assessing the current traffic program and for making necessary modifications to establish annual representative truck volumes and weights for pavement-roadway management purposes should be developed.

Much more effort should be given to developing some forecasting procedures for truck volumes that can more accurately estimate future volumes of heavy trucks and can be used in planning future needs of pavements.

CONCLUSION

This paper has shown that a pavement manager must know what heavy trucks are moving over the highway system in order to manage pavements. A pavement manager needs to know

- Past loading history,
- Current heavy-vehicle volumes by route,
- Future heavy-vehicle volumes by route, and
- ESAL factors by pavement types and vehicle types.

With good methods to estimate current heavy-truck volumes, forecast future heavy-truck volumes, and calculate ESAL factors, a pavement manager can accurately predict future pavement performance. To obtain this information, the pavement manager needs to work with his or her respective planning or traffic section to obtain access to accurate data on the current heavy-truck population from an integrated traffic-counting, vehicle classification, and weighing program. The planning or traffic section should also be encouraged to have forecasting procedures that take into account past trends and the effect of future changes, both in economic activity and in changes in truck fleets.

The use of graphical aids in the determination of which routes are generally receiving higher heavy-truck loadings can be an important tool in discerning which routes may be in need of more scrutiny for signs of pavement damage. Monitoring truck volumes and ESAL applications using graphical aids will become an important consideration in planning sound pavement management strategies. The pavement manager, working with the planning or traffic section to obtain accurate estimates of current and future truck loadings, can have confidence that he is doing the best possible job in predicting the future performance of his pavements.

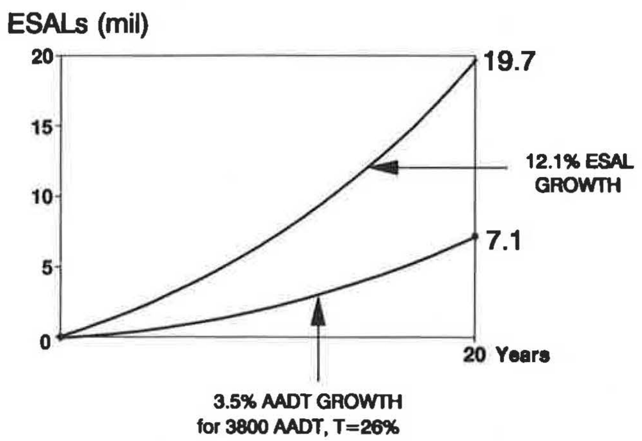


FIGURE 5 Example of ESAL growth tied to AADT growth.

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Publication of this paper sponsored by Committee on Vehicle Counting, Classification, and Weigh-In-Motion Systems.