ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

INFLUENCE OF OVERLOADED FREIGHT TRANSPORTATION ON PAVEMENT LIFE

A thesis submitted to the School of Graduate Studies of
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In partial fulfilment of the requirements for the Degree of
Master of Science in Civil Engineering
(Road and Transport Engineering)

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As members of the examining board of the final M.Sc. Open Defence, we verify that we have read and evaluated the thesis prepared by **Addis Mehari,** entitled: ***Influence of Overloaded Freight Transportation on Pavement Life*** and recommend for acceptance as a fulfilment of the requirement for the degree of **Master of Science in Civil Engineering (Road and Transport Engineering).**

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Abstract

In Ethiopia; rules and regulations on highway traffic signs speculate different restrictions (like load limit posts) but still one of the existing problem affecting pavements design period is from the effect of the heavily loaded freight transportation that uses pavements / roads for circulating goods that it transports. Overloading also contributes for the aggravation of the pavement deterioration problem that is seen within the country. Therefore, this paper tries to show the influence of overloading by analyzing which percentage of overloading contributes much for the influence plus how the pavement fatigue life gets reduced is also discussed.

Analysis includes the application of the famous theories "fourth power law" as well as "AASHTO remaining fatigue life analysis" were the results gave good figure of the negative influence of overloading. The investigation was done by assessing primary and secondary data collected at Awash size and weight control station (were awash station is chosen from assessment based on the most heavily loaded vehicle count from the secondary data collected for different control stations in Ethiopia).

In conclusion, about 48% of the examined axles were overloaded and among these 56% of the axles were on the margins from the specified legal load (i.e. in between 10.1 – 12ton) were tolerance of these loads was also observed at the control station. An overlay thickness was also estimated to show that the considered pavement after some years of service will require unexpected maintenance in order to carry the additional loads due to overloading. Therefore from the results of the analysis, it is seen that the effect of overloading on the life of pavements as well as on rehabilitation expenses will be severe and needs strict awareness so that road defects / distresses due to overloading will be minimized.

Chapter 1

Introduction

In Ethiopia, roads transport was the means of movement for about 93% of freight and 95% of all passengers. In 1991, in addition to the 13,000kms of all-weather roads, about 4,000 were asphalted and 8,900 were all-weather gravel roads. There were also 4,900kms of rural dirt roads, making a total of nearly 18,000kms of all types of roads. Centering Addis Ababa, the road system radiated in all directions in a spoke-like pattern. Whereas, substantial parts of the country, notably in the west, south west, and south east, still lacked all weather connections to this network. Generally only about 12% of the population had ready access to roads and most roads in the national network were concentrated in the central, eastern & northern highlands [1]. And in recent years after the completion of Road Sector Development Program – III (RSDP-III), scheduled for 2012, the main road network was expected to become as shown in *Figure 1* below [2].

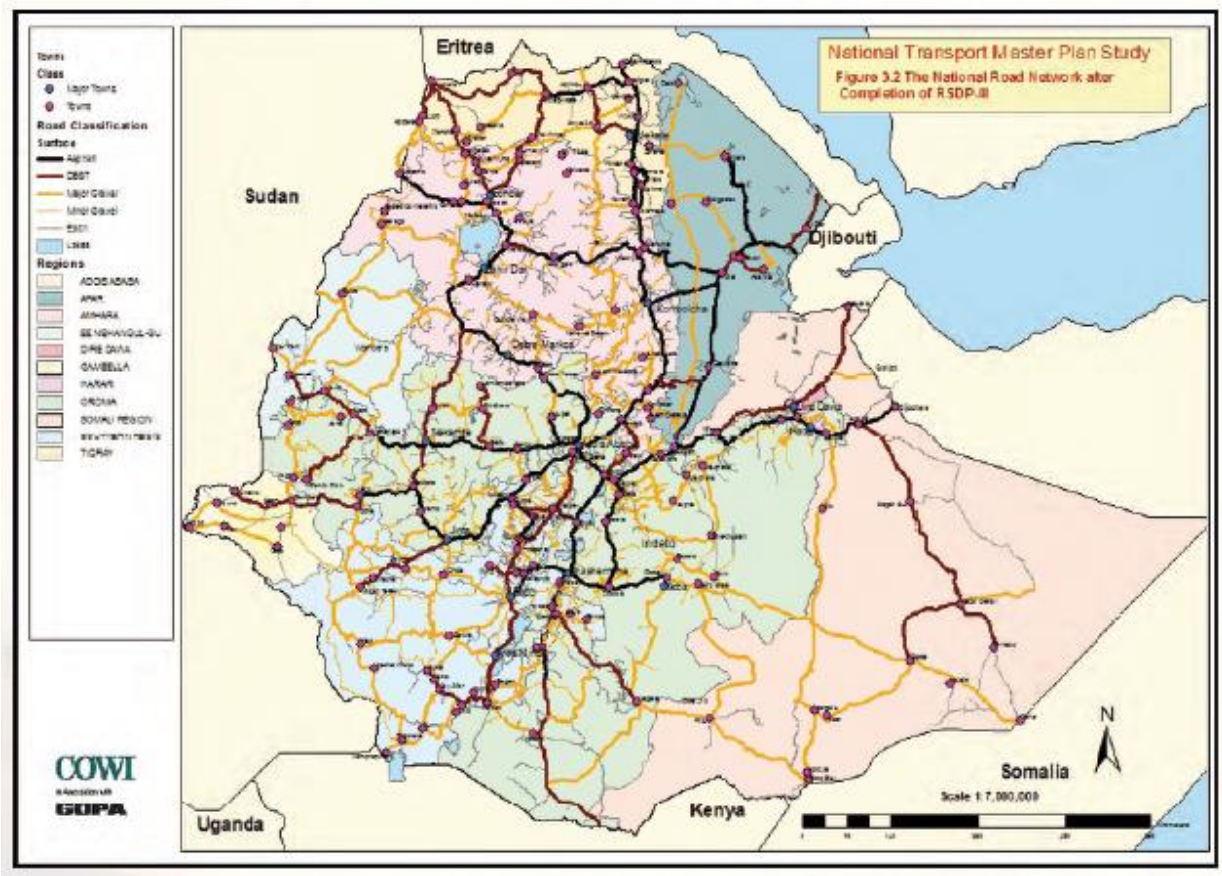


Figure 1: National Road Network after completion of RSDP-III [2]

The Road Sector Development Program is having important implications for commercial road transport in Ethiopia [2]. But as the commercial road transportation gets advanced, the amount of freight being transported should also be investigated (in an advanced way too) whether or not it is beyond the designed carrying capacity of the road (i.e. overloading control needs to be modernized as well).

For example 35% overloaded vehicles were counted in 2013 from all vehicles examined at the different size and weight control stations planted at different checkpoints of different road routes in Ethiopia [3]. And in previous works / findings, it has been known that pavement life is severely affected by the inculcation of heavy traffic loading (overloading). And pavement distresses are one of the critical problems on pavement, which will lead to maintenance & operational costs as well as time loss. These losses could be directly or indirectly results of the increasing usage of roads by the overloaded freight transporting trucks. Therefore if some work is done on this section, it will contribute a hand in the effort of minimization of pavement distresses.

1.1 Background of Overloading

Overloading is the load beyond the standard load limit. Some transporters/drivers use overloading as one of the way of maximizing profit which is by loading the vehicle beyond its acceptable limit. On doing so, these unfaithful transporters/drivers play unfair transportation competition and gains more profit while simultaneously damaging the roads. And since the overloading of the vehicles will cause severe damage in the long run, the government will incur high costs to maintain or even rehabilitate or reconstruct the roads. It is also evident that overloading causes excessive destruction of the road network. And when the condition of these roads deteriorate, vehicle operating cost increases subsequently, the travel time and commodity prices will also eventually increases and so the public will suffer. For instance, statistics of vehicle overload control from TANSROADS weighbridge stations (in Tanzania) indicate that, the total damage cost are TShs.62,369,980,360 and TShs.77,864,890,807 for financial year 2011/12 and 2012/13, respectively. The statistics show that approximately 94% of the damage for each financial year is caused by overloading within 5% of the legal limit. Also the overloading damage for 2012/13 has increased by about 25% from the previous financial year [4].

Furthermore; research by South Africa Department of Transport and Council for Scientific and Industrial Research identified the damage factors of road pavements are multi-facets, but limited to

main factors such as axle loads, spacing between axles, number of wheels, travelling speed, types of pavement, tire pressure and transport modes [5]. This paper will be focusing on the effect of axle loads from freight transporting trucks up on pavements life.

1.2 Statement of the Problem

The main problem of overloading that is going to be considered as the one that is serious is the increase in rehabilitation cost before the road serves for the design period.

It is known that a certain road is designed for the specified design/service period, where the entire budget for the construction will be allocated according to the design. But even though the design is good that different pavement problems are hardly to occur, the effect of overloading will take high credit for the damage of the roads before the it reaches the desired design life which could be caused because of the unpredicted traffic growth due to the inculcation of overloaded vehicles resulting in an increased load repetition on the roads. And as a result of this, the maintenance, rehabilitation as well as operation costs will increase accordingly because the maintenance period will be "now and then" incurring much cost.

In addition to the previous narration about the effect of overloading up on pavements, indirect problems like increase in vehicle operation costs will also occur since the vehicles will be loaded beyond their carrying capacity the fuel consumption as well as frequency of vehicle maintenance will be high. Therefore, attention needs to be given on how to alleviate the said problems due to overloading.

1.3 Objective of the Study

The aim of this paper is to address the influence of overloaded freight transportation by noting the reason for the existence of the overload and applying engineering theories to show its contribution on the reduction in the fatigue life of pavements so that the result will have some contribution in the minimization of pavement distresses like (crocodile cracking, rutting, shoving etc…) which are caused due to the *overloading*.

Therefore, if the impact of overloading on pavements life is addressed and investigated well, problems like the ones stated above will be reduced because solutions for the main problem (i.e. overloading) will be forwarded through the conclusions as well as recommendations obtained from the results of this paper. And hence, the study will have some contribution in the minimization of overloading and its consequences.

➔ ***The specific objectives include:***

- To investigate the extent of overloading problem with in the country;
- To investigate the level of pavement deterioration / damage as a result of overloading;
- To identify the gaps between the problem & the actions taken and make appropriate recommendations.

Chapter 2

Literature Review

2.1 Over View

Over load is a worldwide problem. And it is defined as a load that exceeds the legal truck load limit. AASHO studied the damage effect of axle loads on pavement structures by conducting the ring road test and arrived at the conclusion that the damage effects of vehicles on pavements is directly proportional to the nth power of axle loads. Important conclusions were also obtained from other related studies like overload vehicles are expected to contribute more dramatically to the accumulative damage and the increase in the overload occurrences was found to cause a noticeable increase in damage done to pavements [6].

These days the overwhelming problem of overloaded freight transportation is becoming a major problem in contributing for the damage of pavements not only in the developing countries but also in the developed once like the U.S and Australia because enterprises and truck drivers will save money by reducing the running as well as overhead cost as they tend to overload their trucks for transporting freight. As a result of this, the impacts of overloading up on the whole country and society have tended to be ignored. A good example for this could be China; where the economy has grown rapidly from the 1990's and freight demand has increased simultaneously. However the road network cannot bear the huge growth of freight demand therefore pavement was damaged by excess traffic [7].

2.2 Vehicle overloading influence on Road pavements (Developing as well as Developed Countries)

It is known that roads are one of the infrastructures that are very important for the day to day life of the society as they act as a transport communication medium. For instance, the transportation of goods from one place to another will deliver a significant contribution in the promotion of economic growth and living standards of the society. Other benefits of roads will be for the society to travel to any place he or she wants to go like; markets, places of work, clinics and hospitals, educational institutions, places for sport and leisure activities, vacations and others. But these assets (roads) are being affected by the increased load, from overloaded vehicle, up on them for example research in the USA and South Africa has shown that damage to the road by axle loads exceeding the legal limit,

increases out of all proportion to the loads: for example, an axle carrying double the legal load may cause from 4 to 60 times as much damage as one legal axle load, depending on the condition of the structure and type of road. It is estimated that between 15 and 20% of all heavy vehicles travelling on South African roads are overloaded. It has been found that legally loaded heavy vehicles cause a relatively small amount of damage to road pavement structures, as opposed to overloaded heavy vehicles which are responsible for approximately 60% of the damage to the road network, representing some 400 million Rands per annum. During 1996, there were 58 904 heavy vehicles weighed at weighbridges in South Africa, 33% of which were overloaded. More than half a million kilometers of road have a current replacement value in excess of R165 billion & approximately R2 155 million per annum is currently spent in South Africa on road construction and maintenance to safeguard this national asset. Therefore, heavy vehicles should be given a great deal while studying the damage on road pavements as there is a greater percentage of goods transportation by roads than other mode of transportation. [8]

There are also standards available in India which is of size, weights and dimensions of the truck body but these are, in general, not largely followed. For instance; vehicle owners make changes and have wider and higher bodies so that a truck can carry more goods than permissible, thus producing a considerable reduction in haulage charges. It is not very strange that newly constructed flexible pavements, particularly those with unbound bases, frequently show signs of distress shortly after they are opened to traffic. The immediate effects of overloading are less obvious on pavements with bound bases but their service lives are significantly reduced than normally expected. Heavy traffic loading produce rapid differential compaction in the upper layers of pavement in addition to fracture of the asphalt surfacing. Implications of overloading on overall transport costs have been examined worldwide and it is evident that vehicle overloading seriously affects the improvements of road network in many developing countries including India largely because of increased demands for maintenance and rehabilitation due to pavement's damage caused by heavy axles.[9]

In Thailand also the overloaded truck problem is a remarkable social issue. And according to the statistics in 1996 overloading usually occurs on ten wheel trucks (class 5 three-axle single-unit vehicles) which occupies around 25% of all trucks combined and carries 78% of the shipment by weight (Worsak 2005). And based in the statistics collected by weigh in motion (WIM), they found that 33% of ten-wheel trucks are overloaded. Where 94% of these weighed between 21tonnes &

30tonnes, while 21tonnes is the legal weight for a ten-wheel truck (axle weight is 8.2tonnes). Worsak (2005) indicated that 81% of total damage to the highway is caused by 33% of overloaded trucks [7].

Apart from the damage caused by overloading up on road structures (i.e. pavements bridges…), it is also becoming influential indirectly up on traffic (for example due to overloading; situations like, failure of breaking system mechanism, bursting of tires, instability of the vehicle due to shifting of the centre of gravity etc…will happen) where these situations might follow in traffic congestion as well as accidents. Every vehicle which passes over a road causes a momentary, very small, but significant deformation of the road pavement structure. Thus, improper use or unregulated use may result in damage to the asset, and premature or fast deterioration. Therefore, roads like any other asset have to be properly used in order to provide the intended service and to last for the planned life span. *Also it has to be preserved in order to protect the investment made.* This is especially important for roads as their capital cost is relatively high. It is estimated that the cost of constructing a new asphalt concrete surfaced road is approximately TShs 1,000mio/km and is expected to last more than 15 years before rehabilitation or reconstruction is considered. Among the measures required for regulating the road use is to observe the legal limit of weights which include axle load limits and Gross Vehicle Weight (GVM). The regulation business is undertaken by TANROADS mostly over the trunk roads and few important regional roads. Currently operations are carried out using 28 permanent weighbridge stations, 17 mobile weigh scales and employ 600 staff. On other hand, heavy vehicles have increased tremendously on the road network from 33,808 vehicles in 2005 to over 68,000 vehicles in 2012. The increase is attributed to growth in transport demand due to economic activities and the shifting of cargo from railway to roads. Roads currently carry over 95% of the total freight in the country and that to/from neighboring countries. Importance of regulating the road use is therefore emphasized with the objective of protecting the asset and also to make them last over the designed life span. Short of that we might witness fast deterioration and short life before rehabilitation or reconstruction is required. [4]

2.3 Distresses up on pavements due to overloading

It is the vehicular traffic on the road which is the major cause of road deterioration, especially on heavily trafficked roads and every vehicle which passes over a road causes a momentary, very small, but significant deformation of the road pavement structure. Hence, the passage of many vehicles has a cumulative effect which gradually leads to permanent deformation and road surface deterioration

by cracking [8]. Pavement wear or pavement distress is the degradation of pavement quality due to loading by traffic and/or climate. For instance, see some of the distress modes on flexible pavements (visible distress together with the deterioration process causing it) [10]:

- ***Rutting [10]***

  Rutting is the development of depressions in the pavement surface along the wheel paths, typically with a width of several decimeters and a length of tens to thousands of meters. The three main categories are

  • **Primary rutting:** rutting due to permanent deformation of bituminous layers, (Permanent deformation can be due to (post) compaction or (plastic and viscous) deformation caused by shearing stresses.)

  ➔ "For Instance, Plastic deformation is a material failure of the asphalt concrete. The mix is displaced from under the tires and typically humps up outside the wheel tracks. Plastic deformation sometimes appears as shoving or corrugations in the pavement as well as rutting. A cross-section of a pavement exhibiting plastic flow deformation will typically look like Figure 2" [11].

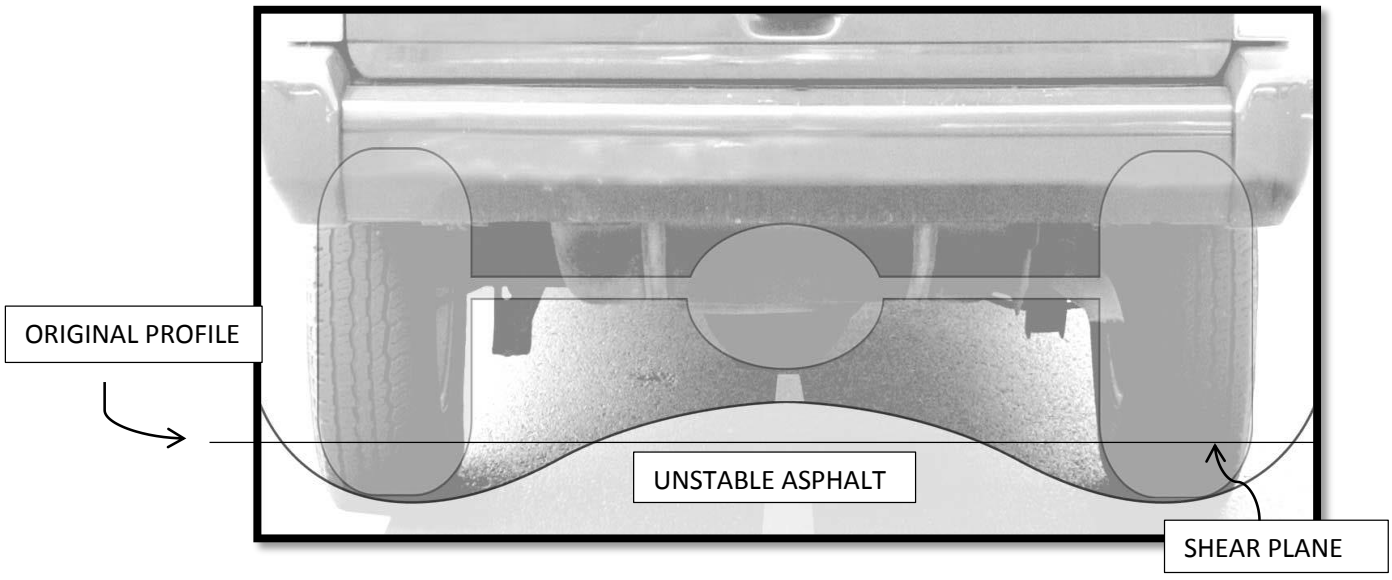


Figure 2: Plastic deformation [11]

• **Secondary rutting:** rutting due to permanent deformation in the subgrade or in granular layers below the asphalt layers [10].

• **Rutting** due to abrasion of the pavement surface by studded tires [10].



Figure 3: Rutting [12]

- ***Crocodile cracking [13]***

Crocodile cracking which is also called *fatigue cracking* or *alligator cracking*, is a common type of distress in asphalt pavement. It is usually studied under the transportation section of civil engineering. Crocodile cracking is characterized by interconnecting or interlaced cracking in the asphalt layer resembling the hide of a crocodile. Cell sizes can vary in size up to 300 millimeters (12 in) across, but are typically less than 150 millimeters (5.9 in) across. Crocodile cracking is generally a loading failure, but numerous factors can contribute to it. It is often a sign of sub-base failure, poor drainage, or repeated over-loadings. It is important to prevent crocodile cracking, and repair as soon as possible, as advanced cases can be very costly to repair and can lead to formation of potholes or premature pavement failure.

Crocodile cracking is an asphalt pavement distress most often instigated by failure of the surface due to traffic loading. However, crocodile cracking can be greatly influenced by environmental and other effects while traffic loading remains the direct cause. Frequently, overloading happens because the base or sub base inadequately support the surface layer and subsequently cannot handle loads that it would normally endure.

There are many ways that the sub base or base can be weakened.

- Poor drainage in the road bed which is a frequent cause of this degradation of the base or subgrade.
- A heavy spring thaw, similar to poor drainage, can weaken the base course, leading to crocodile cracking.

A good strategy *to prevent overloading*, which is a main cause of crocodile cracking, is to increase the depth of the asphalt layer. According to certain researchers, pavements that exceed a certain minimum strength or thickness can hypothetically handle infinitely many loads without showing structural defects, including crocodile (fatigue) cracking. These pavements are called *perpetual pavements* or long-term performance pavements (LTPP).



Figure 4: Fatigue (Alligator Cracking) [14]

- ***Other distress mode***

• **Raveling**: being the loss of stones in the surface of the pavement as a result of failure of the bond between the aggregate and the binder by a great number of shear loadings in combination with ageing of the material. The primary case, is however insufficient quality of the pavement material [10]. But if left uncorrected raveling could also be possible cause of crocodile cracking as it reduces the thickness of the pavement there by reducing the affected portion's ability to carry its designed loading. This can cause crocodile cracking to develop rapidly, as overloading will happen with loads of less magnitude or frequency [13].

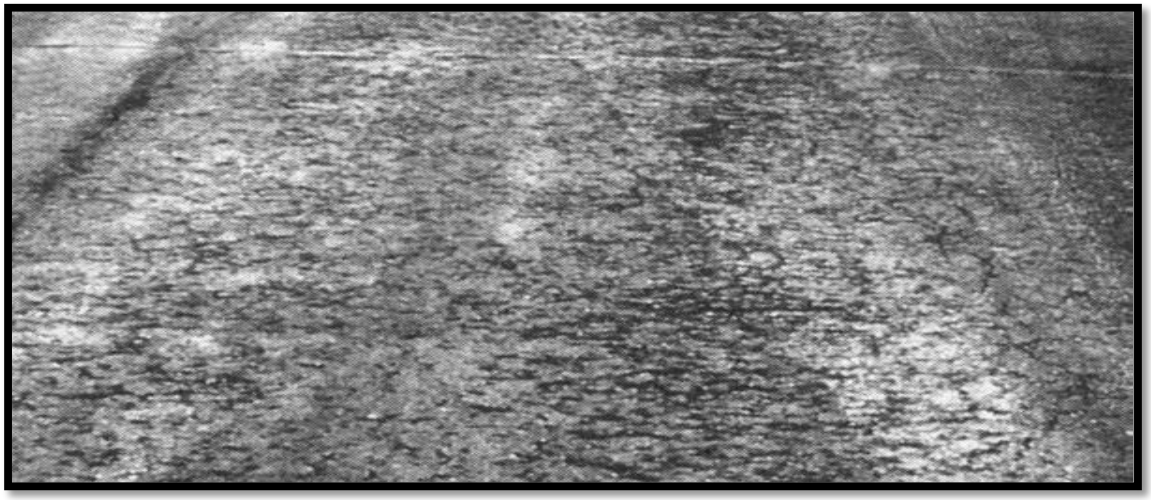


Figure 5: Raveling (Stripping) [14]

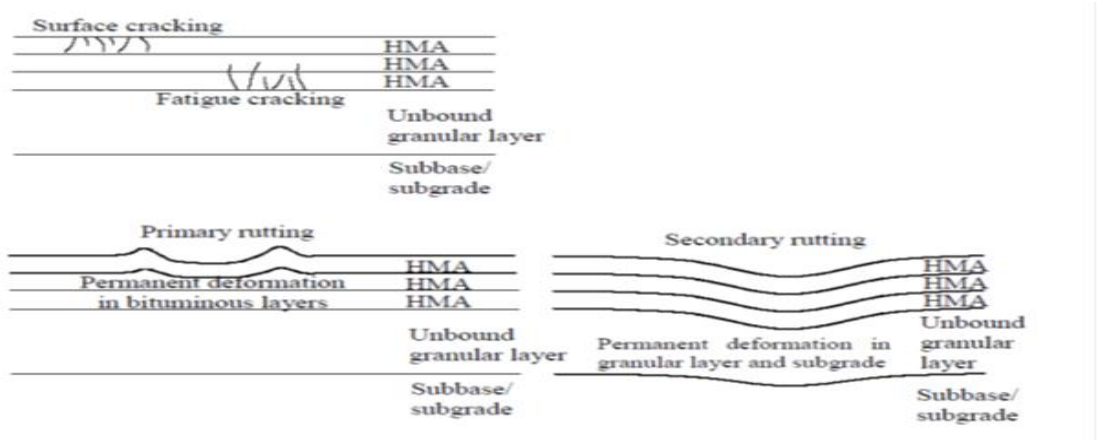


Figure 6: Figurative display of some of the distresses discussed [10]

2.4 Vehicle overloading damage estimation & regulations / enforcements done

2.4.1. Equivalency Concept

"The first systematic attempt to quantify the relationship between the axle load and damage caused to pavement, was made as part of a comprehensive road experiment , known as AASHO (American Association of State Highway Officials) Road test, built and then subjected to traffic, in Illinois, USA between 1956 and 1960. The experiment involved allowing vehicles of various axle loads to travel along different sections of road and comparing the number of load repetitions applied to the road before a defined level of distress in the pavement was reached. This work resulted in the following equivalency formula:

$$\textit{Equivalency Factor } F = \left[\frac{\textit{Actual axle load } (p \textit{ ton})}{\textit{Standard axle load } (8.2 \textit{ ton})}\right]^{n} \quad \ldots\ldots\ldots Eq.1$$

The formula compares the damaging effect on the road structure of any axle load, P, with that of a standard single axle load of 8.16 tons (80KN). An average value of n=4.5 is in practice for determining the equivalency factor for pavement design." [15]

In general, there have been many different reports in the literature regarding the exponent *n* in the load equivalence equation. This relation, comparing the damage caused by axles of different loads is [10]:

$$\frac{N_{ref}}{N_x} = \left(\frac{W_x}{W_{ref}}\right)^{n} \quad \ldots\ldots\ldots\ldots Eq.2$$

Where:

Wx = the axle load considered;

Wref = the reference axle load (i.e. the legal axle load);

Nx and *Nref* = the corresponding number of load applications.

Cebon concludes that the damage factor "n";

- For flexible pavements, values of 1.3 – 6 has been reported in the literature,
- For composite and rigid pavements, values are thought to be as high as 8 – 33.

COST 334 also makes a distinction between individual distress modes, and reports that:

- Cracking of bituminous layers has a value of 4 − 7,
- Permanent deformation of the subgrade has an exponent of perhaps 3 − 4 and,
- Permanent deformation of bituminous layers a value of 1 − 2.

This formula has been used for calculating the damage effect of axle load up on pavement life in many countries. For instance; In south Africa, for the purpose of design of the pavements, the damaging power of the axle is related to a "standard axle of 8.16 tonnes" using equivalency factor, which has been derived from empirical AASHTO studies as:" [4]

$$\textit{Equivalency Factor} = \left[\frac{\textit{Axle load in tonnes}}{8.16}\right]^{4} \ldots\ldots\ldots \textit{Eq.3}$$

"The power law" derived from the original analysis of the American association of State Highway and Transportation Officials (AASHTO) test data is often taken to have an exponential of 4. Though, in many road maintenance studies in the Southern African Development Community (SADC) region, a power of 4.5 is applied in order to derive the number of equivalent standard axles for a road. The exponential number considers; tendency of overloading, type and characteristics of the materials forming the sub-grade and base courses of pavement thickness. The Pavement and Materials Design Manual of the Ministry of Works, 1999 also puts the value of the exponential number at 4.5. The cumulative effect resulting due to the passage of many vehicles will gradually lead to pavement deformation as well as road surface deterioration by cracking. As a result of this, the influence of overloading couldn't be seen in one day but gradually over the period of time of the pavement performance. In order to determine the cumulative axle load damage that a pavement will sustain during its design life, it is necessary to express the total number of heavy vehicles that will use the road over this period in terms of the cumulative number of equivalent standard axles. [4]

"For instance, if a dual wheel axle is loaded say by 10t, it causes damage equivalent to standard axle = $(10/8.16)^{4.5}$ = 2.496, tandem axles carrying 18t causes damage equivalent to standard axle =

$(18/15)^{4.5}$ = 2.272 An Axle limited to 10t potentially causes 54% more deterioration if it is overloaded by 1t. Table below shows the effect of vehicle overloading on the pavement life. Therefore, dedicated axle load control is considered necessary since wear factor indicates such steeply rising function of axle weight." [4]

Table 1: Vehicle Overloading Vs Pavement Life [4]

% Overload on Axle	% increase in damage	Reduced Working Life (Years)
0	0	20
5	22	16.4
10	46	13.8
20	105	9.8
30	185	7.0
40	285	5.2

Source: AASHTO and Mid North Weights of Loads Group –Australia

The application of the Equivalency Factor, F, makes it convenient to convert all axle loads and vehicle configurations into an equivalent number of standard axles. This relationship indicates, for example, that a single four-wheel axle load which is only 25% over the legal load limit of 9 tons, i.e. 11.25 tons, is equivalent to the loads of 3.8 standard axles and has 2.6 times the damaging effect on the road of a 9 ton legal axle. Also if we consider an axle carrying twice the legal load (18 tons) has 18.4 times the damaging effect of a legal axle load where the damage factor considered in this case is 4.2. In other words, the passage over the road structure of one such overloaded axle is equivalent to the passage of approximately 18 legally loaded axles as shown in the figure below:

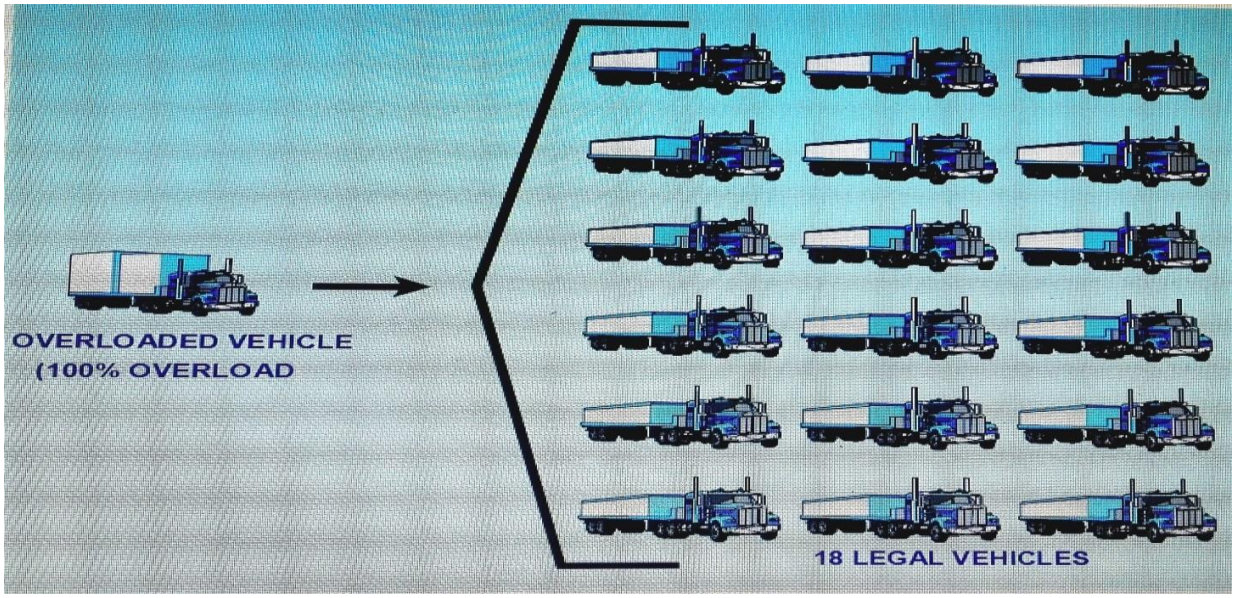


Figure 7: Comparison of damaging effect of a 100% overloaded truck over a legal one [8]

2.4.2. Rules and Procedures

Although the history of attempting to control truck overloading worldwide, including Tanzania, started long ago, the undesirable situation still persists. On the attempt to control vehicle over load on Tanzanian road network, weighbridges are being used to check both axle loads and Gross Vehicle Weights. The operations are governed by a legislation which is also harmonized with the Southern African Development Community (SADC) and East African Community (EAC) [4].

Act and Regulation [4]

Axle load control is regulated under the Road Traffic Act No.30 of 1973, [The Maximum Weight of Vehicles] Regulation 2001.The Regulation clearly defines responsibilities of the Road Authority (Ministry of Works and TANROADS) in collaboration with the Ministry of Home Affairs. Compared to previous legislation, the new legislation is easier to enforce due to the following characteristics:

• It introduces an administrative fee schedule to simplify the normal criminal court procedure.

• It provides a realistic compensation system for overload damage to roads and bridges.

• It empowers a weighbridge operator to impose fees on the spot to owners of an overloaded vehicle without necessarily going to criminal court proceedings.

The Regulations include the following provisions [4]:

• Enforcement procedures to be followed and give guidance as regards to the limits of its applications, procedures for weighing, issuance of abnormal and awkward loads permits, imposition and payment of fees, and administration of appeals.
• Definition of the maximum allowable single axle load limit, which is 10 tonnes and a maximum gross vehicle weight of 56 tonnes.
• All vehicles with loading capacity of equal or more than 3.5 tons must be weighed.
• All overloads beyond 5% of legal limit must be offloaded into another vehicle or re-arranged
• To proceed with 5% overload, the transporter shall pay a surcharge fee of 4 times its overload.



Figure 8.1: Weighing a first axle group of vehicle on the weighbridge



Figure 8. 2: Weighing the Second axle group of the same vehicle on the weighbridge

Figure 8: Vehicles being examined on the weighbridge [4]

In Ethiopia enforcements are also stipulated. For instance the legal load limit specified by the *"Council of Ministers Regulations No. 11/1990" (Council of Ministers Regulations to amend the vehicle size and weight regulation)* [17] states that vehicles, here in Ethiopia, examined on different control stations should not exceed:

- ***8tons*** for the steering axle (front axle) & also an axle equipped with a single tire whereas;
- ***10tons*** for the rear axle equipped with dual tires.

Plus for all types of vehicles, trucks or others that use Ethiopian roads should pay annually in accordance to the tariff that has been stipulated under regulation no. 340/2015 on *annual license renewal fee based on axle load* [18] see table below:

Table 2: Tariff in Annual Vehicles License Renewal Fee based on Axle load [18]

No.	Vehicle Type and Loading Capacity	Annual Fee (birr)
1	**Automobiles and Public Transport Vehicles**	
1.1	Up to 5 seats	125
1.2	6 up to 13 seats	150
1.3	13 up to 29 seats	200
1.4	30 up to 44 seats	250
1.5	Above 44 seats	800
2	**Freight Trucks with a Loading Capacity**	
2.1	Up to 15 Quintals	300
2.2	16 up to 35 Quintals	550
2.3	36 up to 70 Quintals	1,000
2.4	71 up to 120 Quintals	1,500
2.5	121 up to 180 Quintals	2,000
2.6	Above 180 Quintals	2,500
3	**Fuel/Liquid Loading Trucks with a Loading Capacity**	
3.1	Up to 10,000 Liters	750
3.2	10,001 up to 13,000 Liters	1,250
3.3	13,001 up to 14,000 Liters	1,500
3.4	Above 14,000 Liters	2,000
4	**Others**	
4.1	Motorbikes	50
4.2	Special-Mobile equipment (Off-road operating vehicles)	300
5	**Issuance of replacement sticker**	100

Also paper published by Indian Road Congress showed the importance of enforcement on overweight vehicles by using Weigh-in-Motion (WIM). With low enforcement, the overweight reached 25% whereas with high enforcement, overweight was as low as 0.5%. In addition, the fourth power law was applied to show that overweight of 10% causes damage of road more than 40% as shown in the figure below [5]:



Figure 9: 10% overload increase pavement damage by 40% [5]

If we also see the summarized general functional form between enforcement visibility and overweight violation rate based on several studies performed by seven state enforcement agencies in the U.S. as shown in the table below, we can see the inverse relation between overloading and enforcement [7]

Table 3: Overweight Violation Rate across State Agency (U.S.) [7]

State	High Enforcement Level Violation rate	Low Enforcement Level Violation rate
Virginia(2*)	0.5to2%	12to27%
Maryland(2)	1.0%	34%
Arizona(2)	1.5%	30%
Wisconsin(3)	1.0%	20%
Idaho(4)	11.9%	32%
Florida(5)	1.4%	13%
Montana(6)	1.0%	29%

**Number represents number of weigh stations included in the study*

Similar system is used by most developed countries in order to control overloaded truck traffic. Complete legislation and twenty four hour all weather monitoring system is the most important means of overloaded truck traffic control. USA has adequate experience and resources to control trucks that are overloaded but still there is small portion of overloaded trucks (0.5-2.0%). If the government want to eliminate this small portion of the overloaded vehicle, it will be forced to feed in huge resources for the inspection purpose. Therefore, rules like less than 5% of overloaded truck traffic are tolerated in the pavement management system. Apart from monitoring and legislation the overloaded truck control strategy in Anhui is also based on education, which is a noticeable strategy and even though it cannot show its effect immediately, it provides dividends in the long term. [7]

Overloading of trucks must cease in order to improve road safety as well as reduce the expenses incurred in road maintenance. A 5 percent overload can lead to a 22 percent increase in road damage and an 18 percent decrease in pavement life. An overloaded truck is a disaster waiting to happen. Overloaded trucks cause damage in the road pavement that results in potholes, cracks and other structural irregularities. The higher the axle load, the greater the damage, for instance; a 5-ton axle

load will result in lesser pavement damage than a 9-ton axle load. An overloaded truck is also more likely to be unable to halt or avoid obstacles in its path as it's difficult to steer a truck that is less than stable. Typically, the brakes of an overloaded truck are likely to wear out faster than those of a vehicle that carries cargo within prescribed weight limits. Generally, in the event of a traffic accident, the impact of a heavy truck will far outweigh that of a smaller vehicle, say a sedan as the tires are under massive strain that causes them to overheat and lead to blow outs. In addition an overloaded truck also burns more fuel [16]. Therefore; in order to reduce the above said consequences of overloading, proper enforcements as well as rules and regulations should be done.

2.5 Conclusion

As from the different literatures reviewed, overloading is a serious problem all over the world; it affects the economy of the country in that when the roads are deteriorated early because of the increased load repetition to the power of "n" due to overloading the maintenance and rehabilitation cost will increase as well for example 10% overload will result in 40% pavement damage applying the fourth power law (for "n" value of 4). Not only this, the society will also be affected indirectly because of delayed transportation of goods as the trucks might face technical problems due to loading beyond their capacity. It was also seen that with good law enforcements the rate of overloading could be minimized up to 0.5%. Therefore, in order to reduce this influence of overloading on roads, proper rules and regulations should be put on different overloading control stations so that it will minimize the damage caused upon pavements and widen the chance for roads to serve for their designed life time.

Chapter 3

Research Methodology

In order to come up with the result that reflects the objective of this study; this section of the paper deals with the following methodologies. The methodology will be discussed in two phases of data collection and analysis (i.e. level of overloading & pavement damage analysis). But before the collection of any data, data reliability checking needs to be under taken because with a "reliable data we will have a reliable result". Therefore, this was done by contacting the size and weight department; under ERA, about the calibration date checking of the equipment and it was satisfactory (i.e. the equipment's at different control stations had annual calibration date checking certificate which satisfies the requirements of ES .A. D1 260 Ethiopian standards on Weighing Instruments-Tolerance) *"refer Annex 'A' for samples of some of the stations"*. Hence, the data collection procedure was then started.

3.1 Study Area & Observation Method

The study area of this paper was first chosen by analyzing the secondary data collected at five size & weight control stations (i.e. Modjo, Holeta, Awash, Sululta as well as Alemgena) where there is a *weighbridge* that will enable for collecting the axle load of the respective freight transporting trucks. Apart from the analysis, other criteria's that reinforces the choice of the best road route or control station were:

- ➔ The existence of high rate of freight transporting vehicles &,
- ➔ Pictures (that show the type of distress which are signs of overloading) taken on the chosen road were done, which will be further discussed later below.

The study was designed based on "longitudinal study" where the measurement of the wanted data is undertaken over a period of time). So that the wanted data for the analysis will be collected for an elapsed duration at the chosen road routes. For example the primary data was collected at the chosen road route / control station in two days interval one day afternoon & one day morning.

3.2 Data Collection

Collection of data includes secondary data i.e. the six year annual count of legal & illegal vehicles, where the vehicles are counted to be illegal if they carry beyond the legal load limit, at the different size & weight control stations stated above. Condition survey report of the different roads in Ethiopia was also collected. The two information's gathered from ERA make possible to know which road route accommodates a large number of illegal vehicles (i.e. level of overloading assessment) and on that road route visual observation about the road condition (like taking pictures of the different distress seen along the route was done), which helped in choosing the best road route / control station for the study.

In addition, a format similar with those used at the different size & weight control stations was prepared to collect the primary data. This format helped in easily jotting down the measured loads from each axle (i.e. front & rear) of the respective trucks that were examined randomly on the weighbridges plus it also helps in the process of separating the same axle group vehicles from the whole data (for analysis purpose). Interviews were also made at the chosen size & weight control stations to collect data that is mostly related with measures done to date & what they expect to be done in the future to alleviate the problem of overloading on pavements.

3.3 Data Analysis

The data analysis procedure includes implementation of the ***fourth power law*** as well as ***AASHTO remaining life analysis approach***.

The specific tasks in the data analysis procedure include:

- Categorization of the collected data as overloaded or legal based on each axle load weight instead of GVW and showing the proportion of the overloaded axles to the different cases of overloading (i.e. upto10% overload, 11-20% overload…).

- Calculation of the equivalence factors for the collected axle loads by relating each measured / examined axle loads (i.e. from each measured axles (i.e. Front & Rear) of the vehicle examined) with the standard axle using a damaging factor of n=4.3 (*ERA standard*), since the considered road is the recently constructed rigid pavement which was open for traffic on the late 2015. Estimation of equivalent standard axles (ESA) of the examined vehicles was then carried out and comparison was made with the expected ESAL of the road for a design period of 40years.

- Remaining life analysis was also carried out using the results of the comparison above and needed overlay thickness, due to the overloaded axles, for the unexpected rehabilitation and maintenance was shown.

➢ Finally, conclusions and recommendations that are thought to reduce the negative influence of overloading were made from the results of the different analysis done.

3.2 Flow Chart of Research Methodology

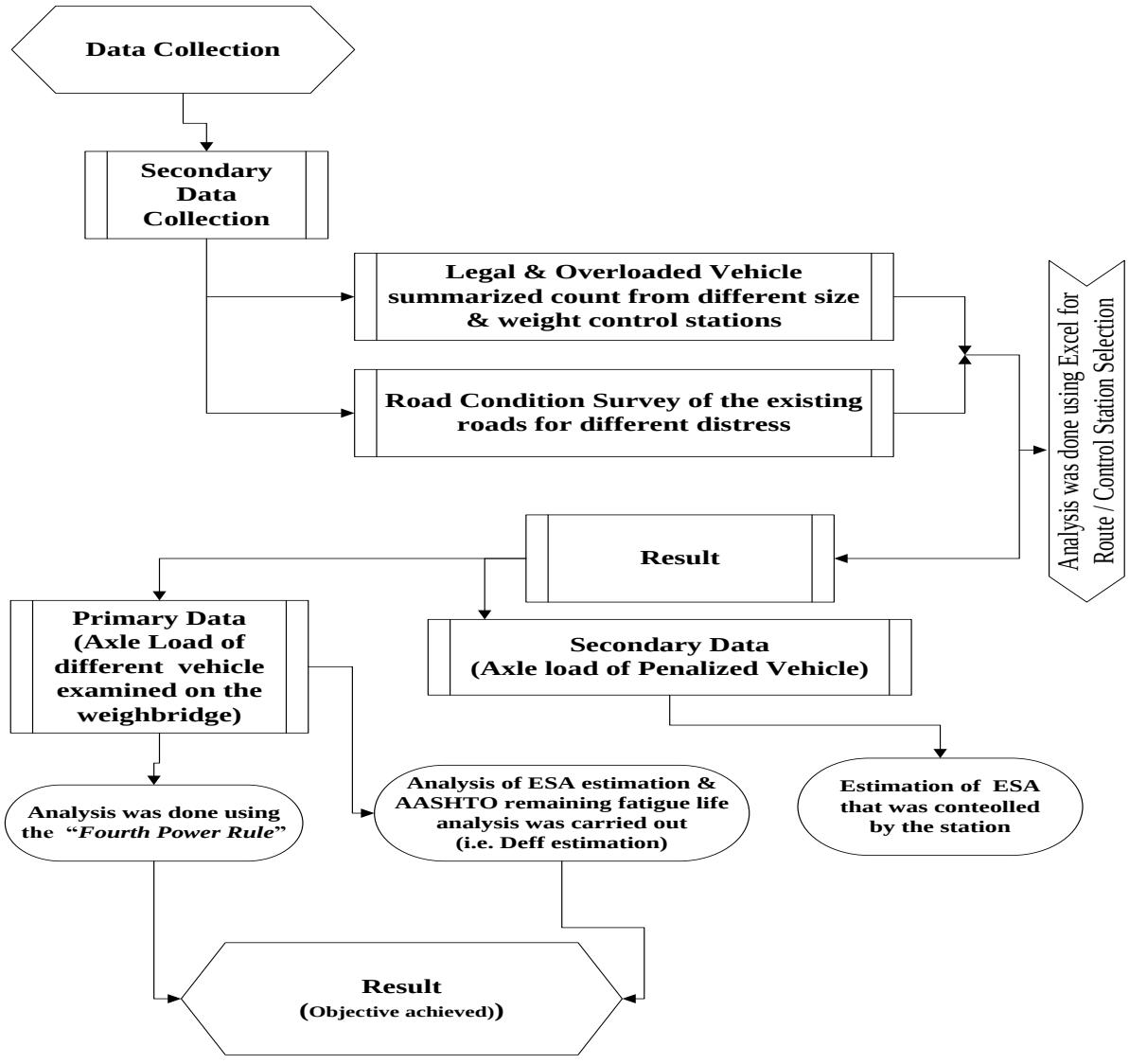


Figure 10: Flow Chart of research methodology

Chapter 4

Analysis and Results

4.1 Level of Overloading (Phase I)

This phase includes collection of data from *"Ethiopian Roads Authority" (ERA)* where it helps to choose which road route is more affected with overloading and which is not. This data is essential as it contributes in the endeavor of showing the influence of overloading up on pavements life because the result from the collected data assessment will guide in choosing the road route which is more exposed to overloaded freight transporting vehicles. Following this (i.e. to know the level of overloading of different stations in Ethiopia), the data collection on this phase includes; secondary data from different control stations (with weighbridges) which contains the summarized data about the number of vehicles that were found to exceed more than the allowed (legal) load limit in relation to the axle distribution (i.e. front axle "F" and rear axle "R") of the vehicles that were examined *"refer Annex 'B'"*.

The other is road condition survey data for general overview of the conditions of our roads which contains information regarding the road segments in "kilometer" and condition of the road in "percentage" and "kilometer" for the ratings "GOOD", "FAIR" & "POOR" of the different road routes of Ethiopia *"refer Annex 'B'"*. Also pictures of the different distresses seen on the chosen route were also collected.

As stated in the literature review earlier, the legal load limit specified by the *"Council of Ministers Regulations No. 11/1990" (Council of Ministers Regulations to amend the vehicle size and weight regulation)* [17] states that vehicles, here in Ethiopia, examined on different control stations should not exceed:

- ***8tons*** for the steering axle (front axle) & also an axle equipped with a single tire whereas;
- ***10ton***s for the rear axle equipped with dual tires.

And it was based on these criteria's that the data about the number of vehicles that exceeds from the allowed load limit were gathered.

Data Analysis

The analysis procedure starts with assessing the summarized data about the number of vehicles found beyond the legal load limit at different load control stations as well as the condition survey data.

Assessment of the number of vehicles beyond the legal load limit

At different road routes in Ethiopia there are load control stations (with weighbridges), that control the number of vehicles which are found below or above the legal load limit. And the five main corridors out of Addis Ababa are; Modjo, Holeta, Awash, Sululta as well as Alemgena size and weight control stations. Hence the data collected from these stations helps in the assessment of finding out which road route is more susceptible to overloading among these five stations (i.e. it helps in choosing the study road route / station of this paper). And according to the assessment of the gathered data the following results were obtained:

- *From Modjo size and weight control station*:

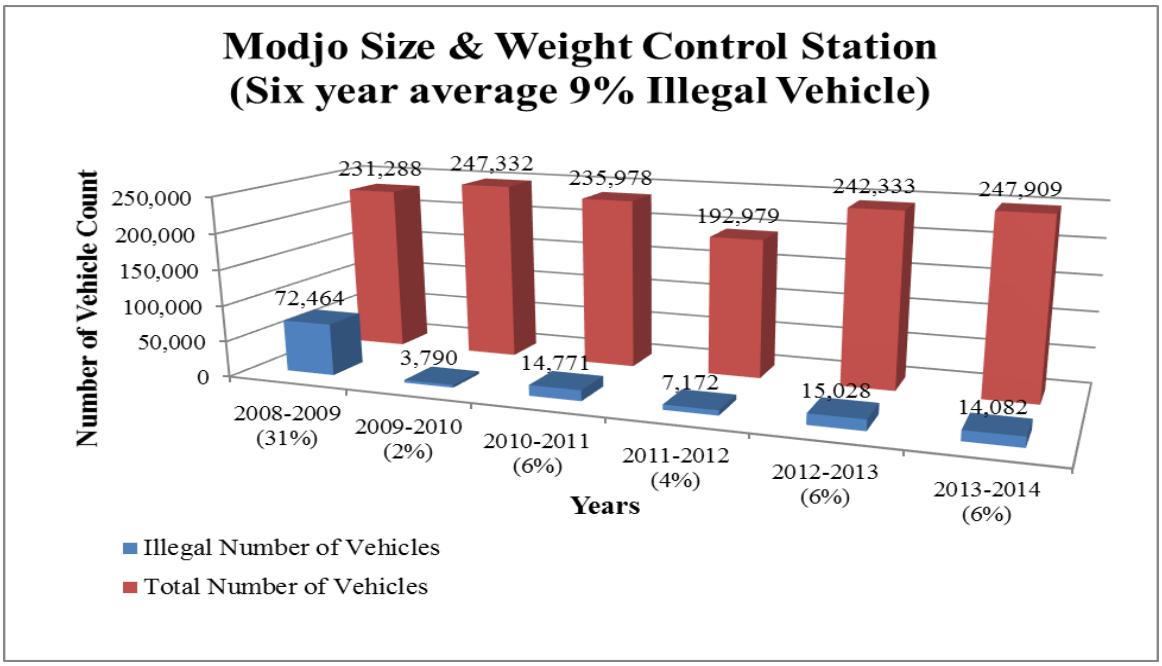


Figure 11: Modjo Station

- *From Holeta size and weight control station:*

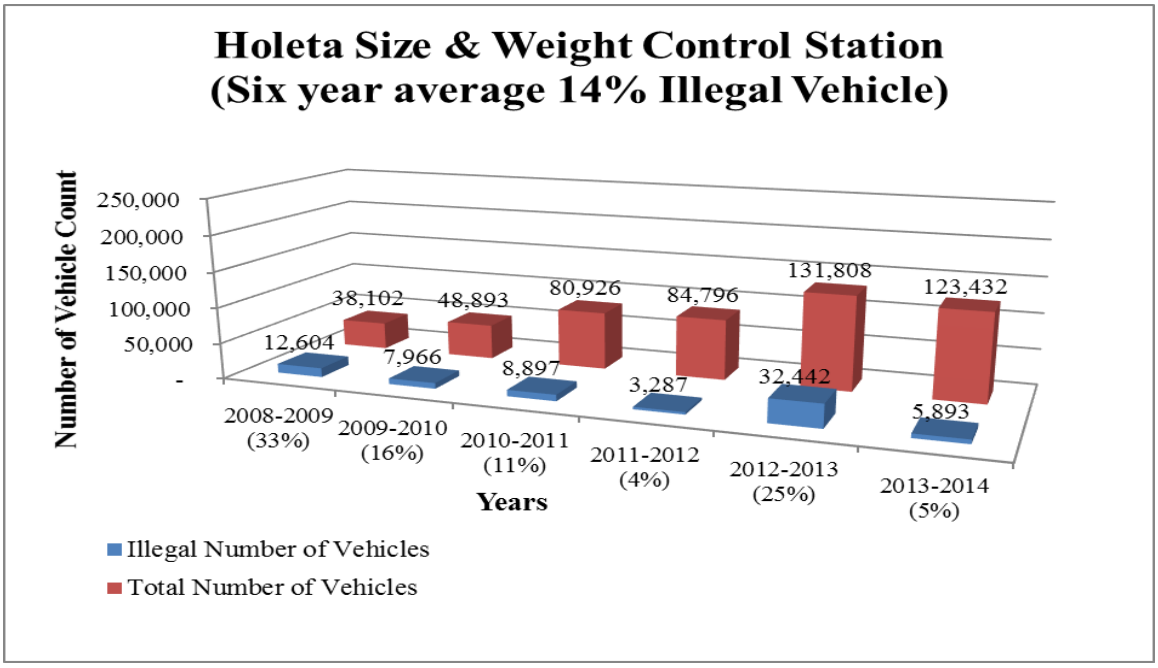


Figure 12: Holeta Station

- *From Awash size and weight control station:*

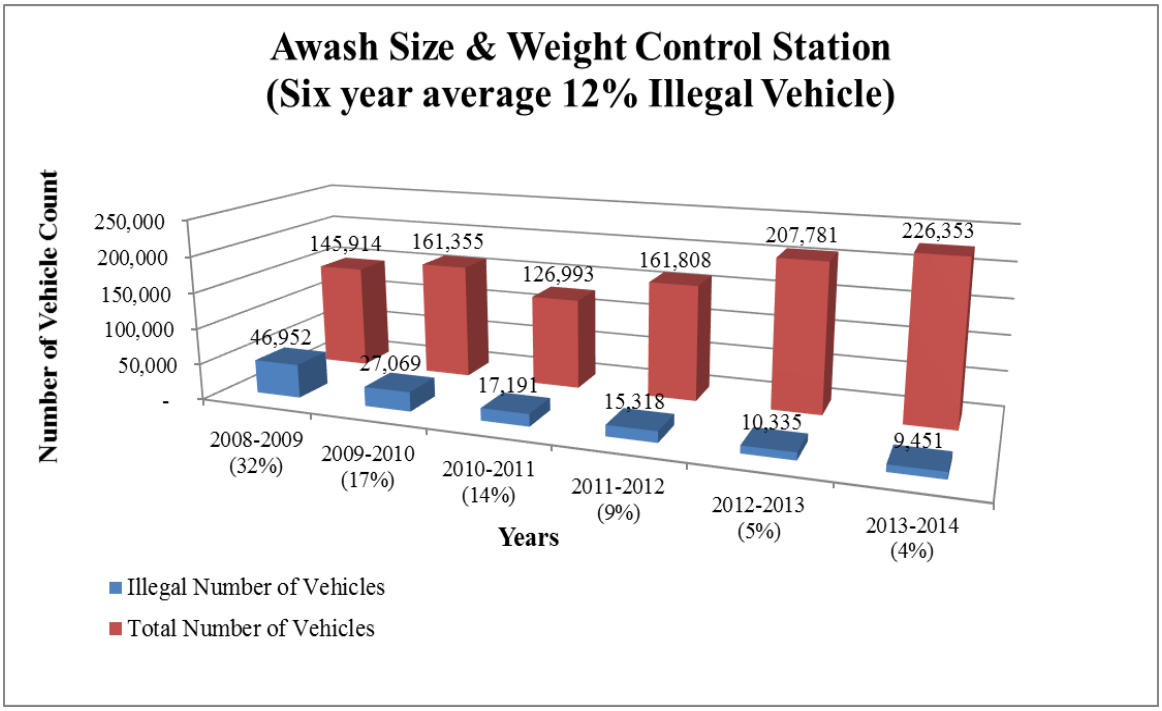


Figure 13: Awash Station

- *From Alemgena size and weight control station:*

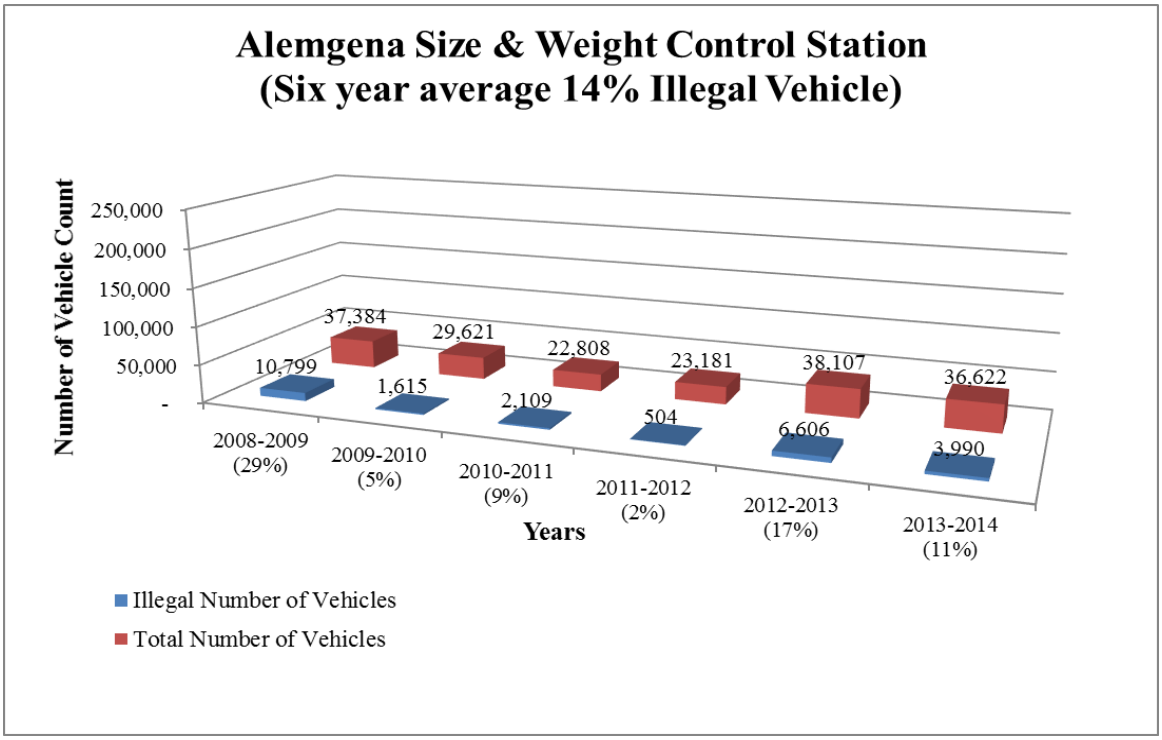


Figure 14: Alemgena Station

- *From Sululta size and weight control station:*

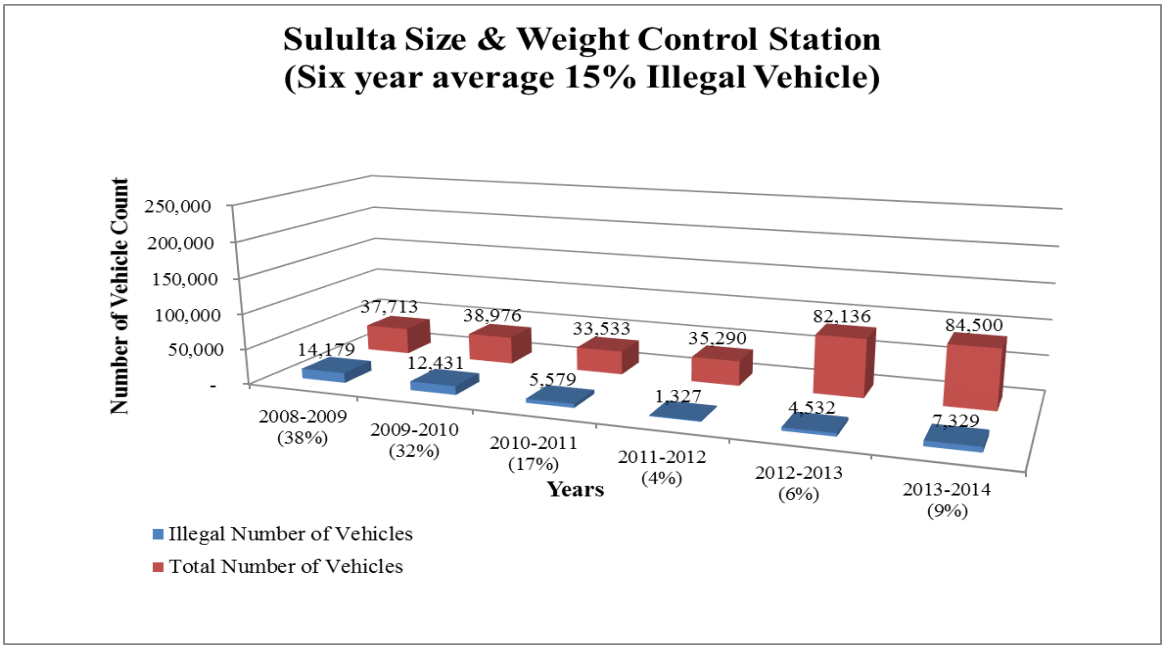


Figure 15: Sululta Station

The figures above try to show that the amount of overloaded vehicles tend to decrease with in the past six years and *the ratio of the total number of overloaded vehicle count to the total number of vehicles examined for the last six years* is also stated in percentage for each control station which eliminates Modjo size and weight control station as its number of illegal vehicle in percentage for the last six years is much less than the others (i.e. **9%**) plus the number of vehicles that are heavily loaded (as seen in *Figure 16*) are less than that of Awash (which have the maximum value). Meanwhile; the number of vehicles counted with in the year 2012-2013 at Holeta and Alemgena control stations shows a drastic change of the number of illegal vehicles (i.e. from 3,287 to 32,442 then down to 5,893 (for Holeta) and from 504 to 6,606 then down to 3,990 (for Alemgena) as shown on *Figure 12* & *Figure 14* respectively.

Information collected from ERA personnel signifies that Alemgena size and weight control station, which examines the vehicles passing through from / to both Jimma and Butajira road routes, is going to be demolished for hospital construction around the area and the new control stations are planned to be constructed at each road routes (i.e. one for Jimma & one for Butajira). So it will be unlikely to show the influence of overloading considering the traffic from both Jimma & Butajira road routes while in the future there will be two different control stations for the said two road routes (which contradicts) so the study will not be feasible. Therefore considering these conditions; the Alemgena size and weight control station is eliminated.

For Holeta size and weight control station, the graphical figure results above show that there is a drastic change in the year (2012-2013) which raised the percentage of illegal number of vehicles for the last six year average to **14%**. This happened due to transportation of construction materials for different infrastructures like cement factories (For instance; Dangote Cement Factory started construction on that year as information gathered from personnel at Holeta control station). Plus the number of illegal vehicles found during examination at the control stations are mostly of one or two tones beyond the legal load limit (refer under *Annex 'B'* the summarized illegal number of vehicles "*From July 1, 2012-June 30, 2013"*) which can also be clearly seen on *Figure 16* below that Holeta has a small number of illegal vehicles that are heavily loaded (i.e. >13tonnes for the rear axle and > 10tonnes for the front axle) compared with Sululta and Awash control stations. Therefore, Holeta size and weight control station is also not chosen as the best study station because the drastic influence seen in the year (2012-2013) is a result from the count of illegal number of vehicles around

the margins of the legal load limit plus it will not be a representative count for the station as the drastic change existed due to the different activities within that year (2012-2013).

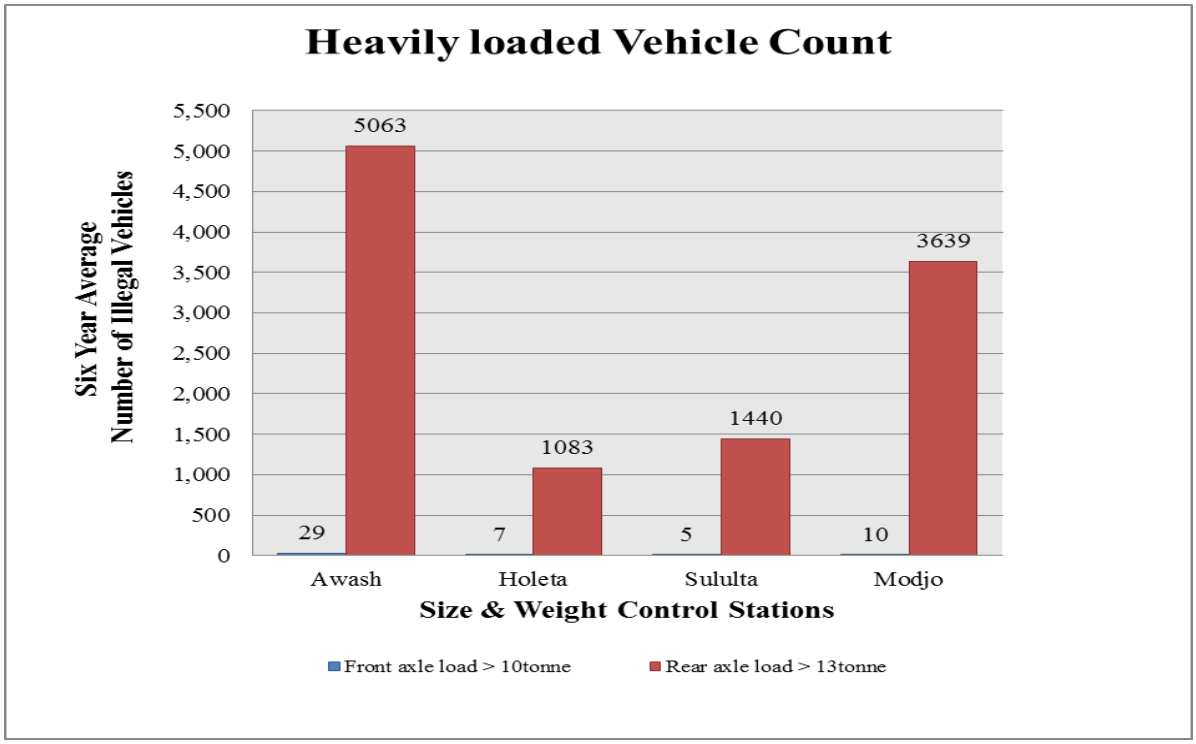


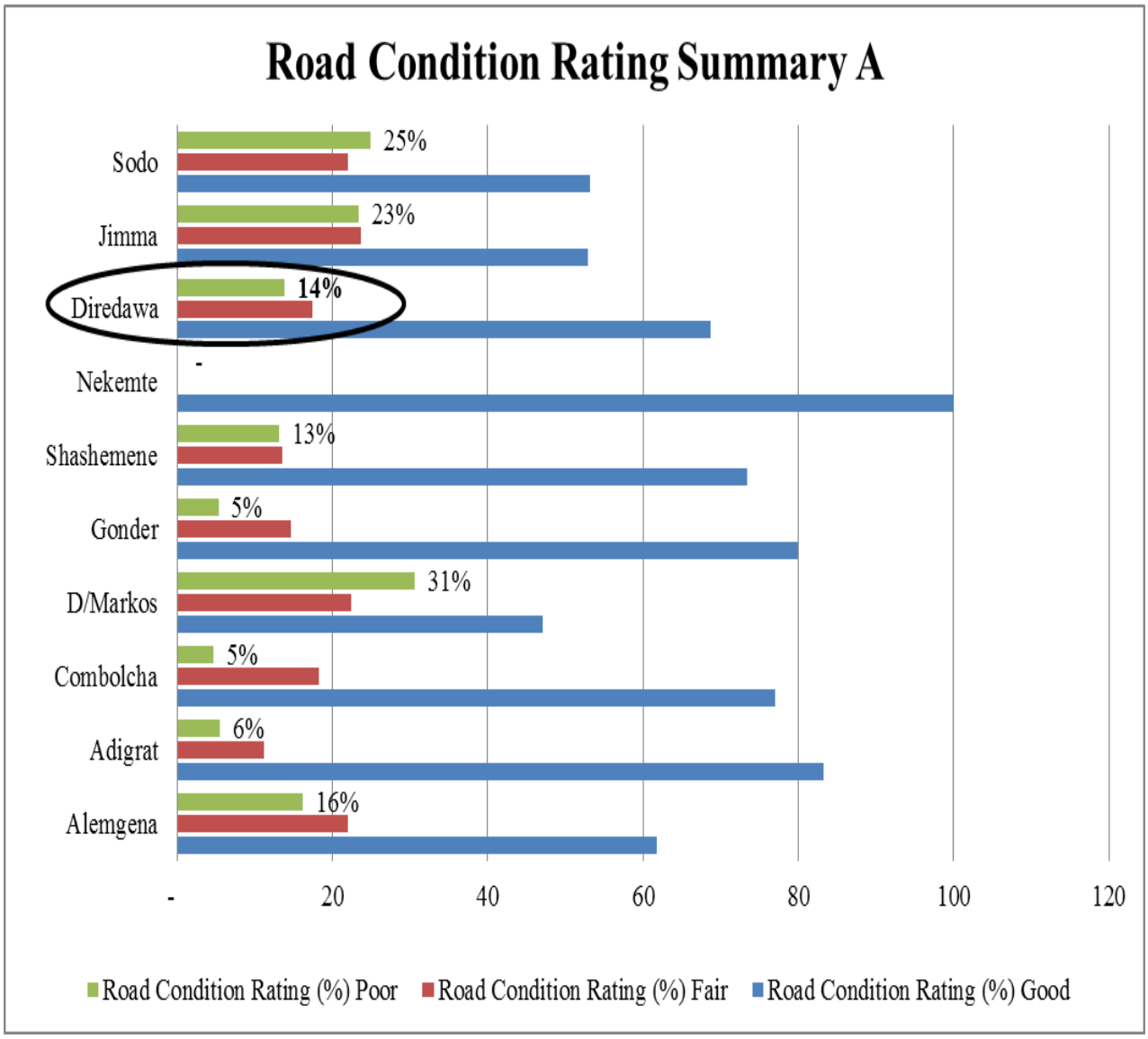
Figure 16: Heavily Loaded Vehicle Count

Finally the control stations left for comparison are Awash and Sululta. On average among the total number of vehicles examined from 2008 to 2014, about **12% from Awash** and **15% from Sululta** were found to be illegal vehicles. But most of the number of illegal vehicles counted at Sululta control stations are on the margins (i.e. between 10.1 – 13tonnes) *"refer Annex 'B' 'Form Ax-001' of Sululta size and weight control station".* It is also clearly seen in *Figure 16* above that Awash control station had greater illegal number of heavily loaded vehicle count than Sululta which is investigated *for the rear axle (>13tonne) and front axle (>10tonne) where the legal load limit is 10 and 8tonnes respectively***.** In addition, to go online with the objective of this paper (i.e. showing the influence of overloaded freight transportation on the life of pavements), from the two stations Awash have *more exposure to freight transportation.*

Additional justification will also be discussed below in the road condition survey analysis for the choice of Awash size and weight control station.

Road condition survey data assessment

The different roads in Ethiopia have got a condition survey study made by RNMD (Road Network Management Directorate) which will assist in knowing the status of our roads (assets). There are 10 (ten) RNMD's in Ethiopia and the investigation done for last year with condition ratings for the roads classified as *"GOOD", "FAIR" or "POOR* "is shown in the figure below. The RNMD that includes Awash control station is the Dire Dawa RNMD with 14% of the road rated poor.



Source: Ethiopian Roads Authority (ERA)

Figure 17: Road Condition Rating

Even though the classification i.e. *poor* is of course couldn't only be by overloading, it was seen, from the road condition survey (*visual observation*), that most of the distress (like rutting) are results of overloading from the heavy vehicles transporting goods (i.e. mostly affected lane is the right lane in the direction to Addis Ababa & left lane in the direction to Awash as seen in the figures below).

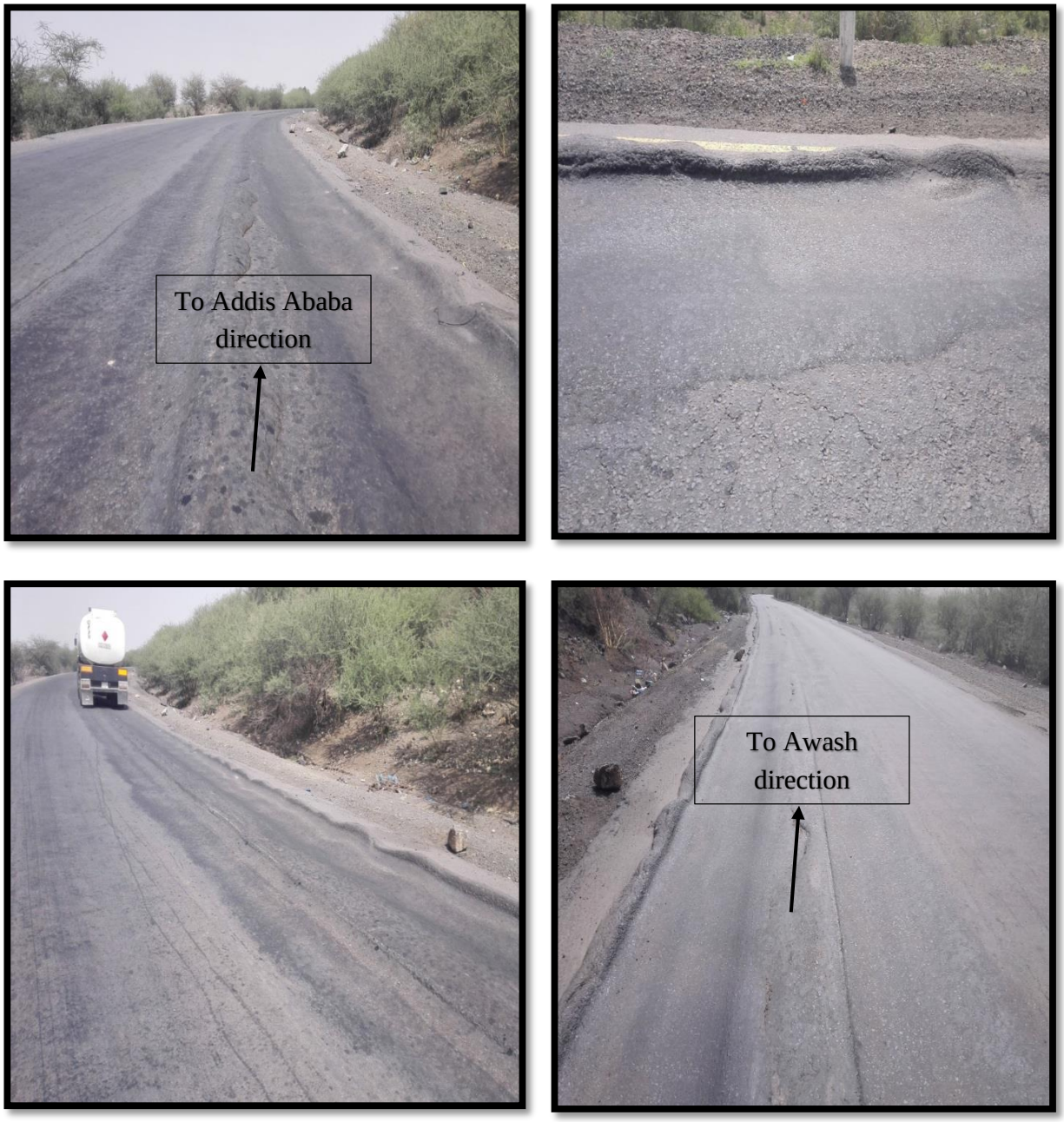


Figure 18: Distresses due to overloading (mostly rutting)

(Pictures taken along the route from Addis Ababa to Awash (Around Methehara))

As it is recalled earlier, from the result of the summarized illegal number of vehicle count investigation and the figures above plus the corridors' susceptibility to freight transportation, Awash size and weight control station was chosen as the best study station to show the influence of overloaded freight transportation on pavements life.

4.2 Pavement Damage Analysis (Phase II)

This phase involves collection of primary and secondary data as well as interviews on the selected station (i.e. Awash Size & Weight control station). The data collected on site was the axle load data of different vehicles. The discussion of data interpretation as well as analysis will be as follows:

Primary Data Analysis

The primary data consists of the load from front as well as each rear axles of different vehicles examined on the weighbridges and a total of 411 axles were measured / examined out of which 198 axles were found to be beyond the legal limits (i.e. 8ton for the front axle & 10ton for the rear axle), which implies that about 48% of the axles from different vehicles examined were found to be overloaded. Sample of one truck being examined for all its axles at Awash Size & Weight control station is shown below:



Figure 19. 1: "Front axle"



Figure 19. 2: "Rear Axle 1"



Figure 19. 3: "Rear Axle 2"



Figure 19. 4: "Rear Axle 3"



Figure 19. 5: "Rear Axle 4"



Figure 19. 6: "Rear Axle 5"

Figure 19: Vehicle being examined on weighbridge at Awash size & weight control station

The primary data collected at awash size & weight control station is as tabulated below:

Table 4: Primary data collected at Awash size & weight control station

Primary Data Collected at Awash Size & Weight Control Station						
Item	**Axle Load (Ton)**					
	F1	**R1**	**R2**	**R3**	**R4**	**R5**
1	7.40	11.00	9.60	10.80		
2	6.90	12.02	11.70	12.64	9.90	11.40
3	7.00	12.60	13.10	11.10	10.30	8.70
4	7.30	13.10	12.00	10.50	9.40	9.90
5	5.40	13.20	11.90	10.00	10.00	9.40
6	6.60	13.20	12.40	9.70	9.30	10.50
7	6.80	13.20	12.80			
8	6.70	12.30	12.10	10.00	9.40	9.90
9	4.10	9.90	10.20	13.10	11.30	
10	7.30	9.80	9.00			
11	6.00	11.60	11.50	9.30	9.90	8.20
12	6.40	11.40	11.20	10.80	9.60	9.90
13	5.80	11.10	11.60	9.10	7.90	6.60
14	7.50	9.90	9.70	9.70	9.10	9.40
15	6.20	9.50	9.10	11.90	11.40	
16	6.10	10.20	10.20	12.10	9.90	11.40
17	6.20	15.40	9.10	9.10		
18	5.40	15.00	15.00			
19	8.00	12.60	11.70	9.10	8.80	8.90
20	7.30	12.90	11.40	12.70	9.70	9.40
21	7.10	12.70	12.40	9.70	9.40	9.50
22	6.00	11.90	11.30	9.20	8.00	9.10
23	6.70	11.80	11.20	10.10	6.40	
24	7.40	11.10	10.60	12.00	9.40	8.60
25	7.90	12.10	11.80	10.30	7.80	8.80
26	6.70	14.20	14.50			
27	6.80	13.10	12.90	9.70	9.90	10.00
28	6.90	13.30	12.90	10.10	9.90	9.70
29	6.90	13.20	13.30	10.10	9.00	9.40
30	5.90	8.80	9.90	12.20	9.90	12.10
31	6.60	12.60	12.20	9.40	9.50	9.70
32	7.00	12.90	12.80	9.80	9.80	9.20
33	5.70	12.40	12.20	9.50	8.80	9.10

34	8.30	11.80	11.50	9.40	9.90	10.10
35	6.90	12.70	12.20	8.70	9.10	9.10
36	7.40	11.90	11.50	8.80	10.70	12.50
37	7.10	12.20	12.40	9.70	8.70	9.40
38	7.70	11.70	11.80	11.20	9.10	9.10
39	7.70	9.50	9.60	10.80	9.60	7.70
40	7.50	13.20	12.10	9.90	11.00	10.40
41	6.00	8.80	9.10	9.40		
42	7.20	12.10	12.10	9.80	7.70	7.90
43	7.00	11.70	11.10	12.00	9.20	10.10
44	5.80	12.50	11.00	11.80	9.10	9.70
45	7.30	11.40	11.00	10.10	10.00	10.10
46	6.70	12.20	11.40	9.50	9.80	9.20
47	5.90	11.10	11.20	11.60	10.80	12.20
48	7.80	11.20	11.30	10.00	9.60	9.20
49	6.90	12.80	12.10	9.70	10.10	8.30
50	7.90	10.10	9.80	8.60	11.60	11.40
51	6.90	12.00	11.40	14.10	11.30	12.10
52	5.70	12.00	12.20	9.90	9.10	8.70
53	7.50	13.10	12.80	11.10	10.60	9.90
54	7.10	12.70	12.60	9.60	10.10	9.90
55	8.00	13.30	12.80	10.20	10.60	10.10
56	7.40	12.70	12.20	10.30	8.70	9.20
57	6.40	10.00	10.00	10.60	11.20	13.70
58	7.10	12.30	12.40	8.80	9.30	9.70
59	7.80	12.20	12.10	9.70	10.00	9.30
60	6.50	12.60	12.00	9.50	9.80	9.40
61	7.00	11.90	11.60	12.70	10.00	13.00
62	5.80	12.40	10.10	12.10		
63	6.80	13.10	12.70	10.00	10.10	9.70
64	6.80	13.10	12.20	10.80	9.50	8.50
65	6.10	10.40	10.30	11.20	11.00	11.10
66	7.30	13.00	12.20	9.90	10.60	8.80
67	6.30	10.80	10.70	11.10	11.10	11.50
68	6.20	10.30	10.80	11.10	11.30	11.60
69	7.30	12.30	12.50	9.80	10.40	9.40
70	6.00	9.80	10.10	9.70	6.70	9.20
71	5.30	12.00	11.40	8.40	10.20	6.20
72	6.00	13.00	15.50	15.00		
73	6.00	15.00	13.50	11.50		

At the size and weight control station it was observed that vehicles with rear axle loads on the margins (i.e. 11 to 12 ton) were tolerated and assessment was done for the rear axles because most of the rear axles are beyond the legal limit whereas only one front axle was found to be overloaded. Therefore, the rear axles were assessed to show the different cases of overloading. See the analysis in the tables below:

Table 5: Number of overloaded rear axles for each Truck / Trailer (TT*)

Six & Five Axle Vehicles (No. of overloaded rear axles for each Truck/Trailer)			
10.1-11	**11.1-12**	**12.1-13**	**>13**
	3	1	
1	1	1	1
1	1		1
	1		1
1		1	1
		2	
	2		
1	2		
	2		
2	1	1	
	1	1	
	1	2	
		2	
	2		
1	2		
1	1	1	
		1	1
1		1	1
1			2
		2	
		2	
		2	
		2	
1	2		
		2	
1	2	1	
		2	
	3		
1			
2		1	1

Overloaded Axles				
			2	
	1	3		
	1	1	1	
	3	1		
		1	1	
	1	3	1	
		2		
	1		2	
	1	2		
		3	1	1
		1	1	
	1	1	1	
	1		2	
	3		1	
	1		2	
	1	1		1
			2	
			2	
		1	1	
		2	2	
	1		1	1
	1		1	1
	3	2		
	1		2	
	2	3		
	2	3		
	1		2	
	1			
	1	2		
	1	1		1
		2		
	1	2		
Sum	**45**	**64**	**56**	**14**
Total no. of axles			**179**	
TT*	**25%**	**36%**	**31%**	**8%**

Table 6: Number of overloaded rear axles for each Heavy Truck (HT*)

Four &Three Axle Vehicles (No. of overloaded rear axles for each Heavy Truck)				
Overloaded Axles	10.1-11	11.1-12	12.1-13	>13
	2			
			1	1
				1
				2
				2
	1		2	
			1	2
		1		2
Sum	**3**	**1**	**4**	**10**
Total no. of axles			**18**	
HT*	**17%**	**6%**	**22%**	**56%**

As seen from the above tables, the overloaded rear axles counted from the different truck / trailers and heavy trucks were categorized to different cases of overloading as shown in table 7 below:

Table 7: Truck / Trailer (TT) & Heavy Truck (HT) percentage for different cases of overloading

	Percentage of overloaded axle loads from collected vehicles (i.e. Truck / Trailer & Heavy Truck)			
Axle load (ton) / Vehicle Type	10.1-11	11.1-12	12.1-13	>13
TT*	25%	36%	31%	8%
HT*	17%	6%	22%	56%

The Annual Average Daily Traffic (AADT) for rigid pavement approach design – Awash junction (road project) [19], which is $AADT_{TT}$ = 1341 and $AADT_{HT}$ = 206, was used to obtain the weighted average of the two truck compositions (i.e. TT & HT) and it is summarized in table 8 below:

Table 8: Weighted average overloading composition from TT and HT axles

AADT	**TT**	**1341**	**HT**	**206**
Axle load (ton)	**10.1-11**	**11.1-12**	**12.1-13**	**>13**
Weighted Average $\frac{(TT^* \times 1341)+(HT^* \times 206)}{1341+206}$	**24%**	**32%**	**30%**	**14%**

The graphical representation of table 8 is shown below:

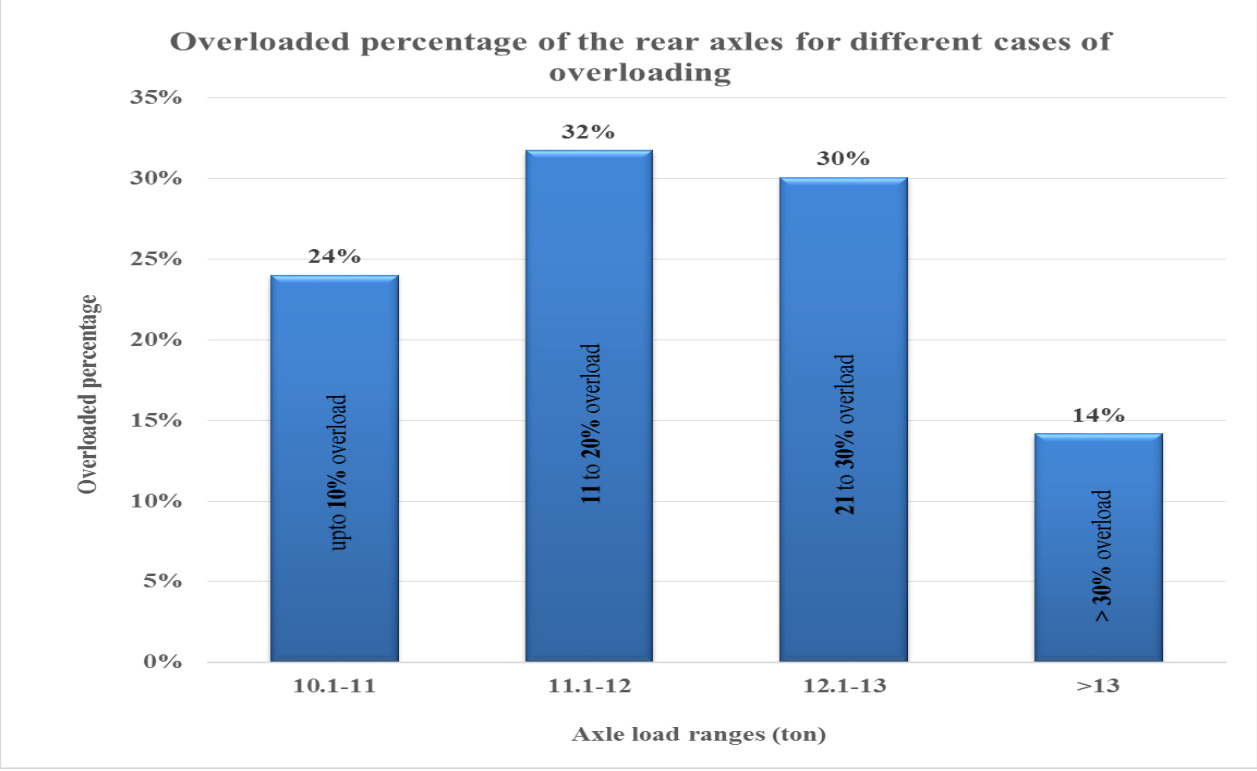


Figure 20: Categorization of the overloaded rear axles to different cases of overloading

As seen from the figure 20 above 24% of the rear axles are in the range (10.1 – 11 ton) while 32% of the rear axles are in the range (11.1 – 12 ton), which implies that 56% of the total overloaded rear axles are in the margins. Therefore, tolerance of these loads on the margins should be avoided because it will have adverse effect when it is projected for the roads' design period which will be further shown in the remaining life analysis later.

In addition to the above analysis, we can also see how the pavements design period is affected due to overloaded freight transportation using the *AASHTO remaining life analysis*.

The design lives of pavements are expressed in terms of the Equivalent Standard Axles (ESAs) they are designed to carry. Therefore, the following analysis involves ESA estimation for the truck/trailers and heavy vehicles data collected. In this process, the equivalency factors (EF) of each axle should be determined first as the sum of the individual EF values for each axle of the vehicle gives the equivalence factor of the vehicle as a whole. As per ERA's standard [20], [21] the equivalency factor is expressed as:

$$ef = (L/8160)^n \text{ , (for loads in kg) } \ldots\ldots\ldots\ldots Eq.4$$

$$\text{or } ef = (L/80)^n \text{ , (for loads in KN) } \ldots\ldots\ldots\ldots Eq.5$$

Where:

ef = number of equivalent standard axles (ESAs)

L = axle load (in kg or KN)

n = damage exponent (n = 4.5 for flexible pavement and 4.3 for rigid pavement).

The detail procedure in obtaining the equivalency factors of the vehicles is tabulated below:

Table 9 : Examined axles of truck/trailer with their respective load factors

Primary Data Collected at Awash Size & Weight Control Station (Truck/Trailer)													
Item	**Axle Load (Ton)**												
	F1	**LF**	**R1**	**LF**	**R2**	**LF**	**R3**	**LF**	**R4**	**LF**	**R5**	**LF**	**Total LF**
1	6.90	0.49	12.02	5.29	11.70	4.71	12.64	6.57	9.90	2.30	11.40	4.21	23.56
2	7.00	0.52	12.60	6.48	13.10	7.66	11.10	3.76	10.30	2.72	8.70	1.32	22.44
3	7.30	0.62	13.10	7.66	12.00	5.25	10.50	2.96	9.40	1.84	9.90	2.30	20.62
4	5.40	0.17	13.20	7.91	11.90	5.07	10.00	2.40	10.00	2.40	9.40	1.84	19.78
5	6.60	0.40	13.20	7.91	12.40	6.05	9.70	2.10	9.30	1.75	10.50	2.96	21.17
6	6.70	0.43	12.30	5.84	12.10	5.44	10.00	2.40	9.40	1.84	9.90	2.30	18.24
7	4.10	0.05	9.90	2.30	10.20	2.61	13.10	7.66	11.30	4.05		0.00	16.67
8	6.40	0.35	11.40	4.21	11.20	3.90	10.80	3.34	9.60	2.01	9.90	2.30	16.11
9	6.20	0.31	9.50	1.92	9.10	1.60	11.90	5.07	11.40	4.21		0.00	13.10
10	6.10	0.29	10.20	2.61	10.20	2.61	12.10	5.44	9.90	2.30	11.40	4.21	17.46
11	8.00	0.92	12.60	6.48	11.70	4.71	9.10	1.60	8.80	1.38	8.90	1.45	16.54
12	7.30	0.62	12.90	7.17	11.40	4.21	12.70	6.70	9.70	2.10	9.40	1.84	22.64
13	7.10	0.55	12.70	6.70	12.40	6.05	9.70	2.10	9.40	1.84	9.50	1.92	19.16
14	7.40	0.66	11.10	3.76	10.60	3.08	12.00	5.25	9.40	1.84	8.60	1.25	15.83
15	7.90	0.87	12.10	5.44	11.80	4.88	10.30	2.72	7.80	0.82	8.80	1.38	16.13

16	6.80	0.46	13.10	7.66	12.90	7.17	9.70	2.10	9.90	2.30	10.00	2.40	22.07
17	6.90	0.49	13.30	8.17	12.90	7.17	10.10	2.50	9.90	2.30	9.70	2.10	22.72
18	6.90	0.49	13.20	7.91	13.30	8.17	10.10	2.50	9.00	1.52	9.40	1.84	22.43
19	5.90	0.25	8.80	1.38	9.90	2.30	12.20	5.64	9.90	2.30	12.10	5.44	17.30
20	6.60	0.40	12.60	6.48	12.20	5.64	9.40	1.84	9.50	1.92	9.70	2.10	18.38
21	7.00	0.52	12.90	7.17	12.80	6.93	9.80	2.20	9.80	2.20	9.20	1.68	20.68
22	8.30	1.08	11.80	4.88	11.50	4.37	9.40	1.84	9.90	2.30	10.10	2.50	16.97
23	6.90	0.49	12.70	6.70	12.20	5.64	8.70	1.32	9.10	1.60	9.10	1.60	17.34
24	7.40	0.66	11.90	5.07	11.50	4.37	8.80	1.38	10.70	3.21	12.50	6.26	20.94
25	7.10	0.55	12.20	5.64	12.40	6.05	9.70	2.10	8.70	1.32	9.40	1.84	17.49
26	7.70	0.78	11.70	4.71	11.80	4.88	11.20	3.90	9.10	1.60	9.10	1.60	17.47
27	7.50	0.70	13.20	7.91	12.10	5.44	9.90	2.30	11.00	3.61	10.40	2.84	22.79
28	7.00	0.52	11.70	4.71	11.10	3.76	12.00	5.25	9.20	1.68	10.10	2.50	18.41
29	5.80	0.23	12.50	6.26	11.00	3.61	11.80	4.88	9.10	1.60	9.70	2.10	18.69
30	7.30	0.62	11.40	4.21	11.00	3.61	10.10	2.50	10.00	2.40	10.10	2.50	15.84
31	6.70	0.43	12.20	5.64	11.40	4.21	9.50	1.92	9.80	2.20	9.20	1.68	16.07
32	5.90	0.25	11.10	3.76	11.20	3.90	11.60	4.54	10.80	3.34	12.20	5.64	21.42
33	7.80	0.82	11.20	3.90	11.30	4.05	10.00	2.40	9.60	2.01	9.20	1.68	14.86
34	6.90	0.49	12.80	6.93	12.10	5.44	9.70	2.10	10.10	2.50	8.30	1.08	18.54
35	7.90	0.87	10.10	2.50	9.80	2.20	8.60	1.25	11.60	4.54	11.40	4.21	15.57
36	6.90	0.49	12.00	5.25	11.40	4.21	14.10	10.50	11.30	4.05	12.10	5.44	29.95
37	7.50	0.70	13.10	7.66	12.80	6.93	11.10	3.76	10.60	3.08	9.90	2.30	24.41
38	7.10	0.55	12.70	6.70	12.60	6.48	9.60	2.01	10.10	2.50	9.90	2.30	20.54
39	8.00	0.92	13.30	8.17	12.80	6.93	10.20	2.61	10.60	3.08	10.10	2.50	24.21
40	7.40	0.66	12.70	6.70	12.20	5.64	10.30	2.72	8.70	1.32	9.20	1.68	18.71
41	6.40	0.35	10.00	2.40	10.00	2.40	10.60	3.08	11.20	3.90	13.70	9.28	21.41
42	7.10	0.55	12.30	5.84	12.40	6.05	8.80	1.38	9.30	1.75	9.70	2.10	17.68
43	7.80	0.82	12.20	5.64	12.10	5.44	9.70	2.10	10.00	2.40	9.30	1.75	18.16
44	6.50	0.38	12.60	6.48	12.00	5.25	9.50	1.92	9.80	2.20	9.40	1.84	18.06
45	7.00	0.52	11.90	5.07	11.60	4.54	12.70	6.70	10.00	2.40	13.00	7.41	26.63
46	6.80	0.46	13.10	7.66	12.70	6.70	10.00	2.40	10.10	2.50	9.70	2.10	21.82
47	6.80	0.46	13.10	7.66	12.20	5.64	10.80	3.34	9.50	1.92	8.50	1.19	20.20
48	6.10	0.29	10.40	2.84	10.30	2.72	11.20	3.90	11.00	3.61	11.10	3.76	17.12
49	7.30	0.62	13.00	7.41	12.20	5.64	9.90	2.30	10.60	3.08	8.80	1.38	20.42
50	6.30	0.33	10.80	3.34	10.70	3.21	11.10	3.76	11.10	3.76	11.50	4.37	18.76
51	6.20	0.31	10.30	2.72	10.80	3.34	11.10	3.76	11.30	4.05	11.60	4.54	18.72
52	7.30	0.62	12.30	5.84	12.50	6.26	9.80	2.20	10.40	2.84	9.40	1.84	19.59
53	6.00	0.27	11.60	4.54	11.50	4.37	9.30	1.75	9.90	2.30	8.20	1.02	14.25
54	5.80	0.23	11.10	3.76	11.60	4.54	9.10	1.60	7.90	0.87	6.60	0.40	11.39
55	6.00	0.27	11.90	5.07	11.30	4.05	9.20	1.68	8.00	0.92	9.10	1.60	13.58
56	6.70	0.43	11.80	4.88	11.20	3.90	10.10	2.50	6.40	0.35		0.00	12.07
57	5.70	0.21	12.40	6.05	12.20	5.64	9.50	1.92	8.80	1.38	9.10	1.60	16.80
58	7.70	0.78	9.50	1.92	9.60	2.01	10.80	3.34	9.60	2.01	7.70	0.78	10.84
59	7.20	0.58	12.10	5.44	12.10	5.44	9.80	2.20	7.70	0.78	7.90	0.87	15.31
60	5.70	0.21	12.00	5.25	12.20	5.64	9.90	2.30	9.10	1.60	8.70	1.32	16.31
61	6.00	0.27	9.80	2.20	10.10	2.50	9.70	2.10	6.70	0.43	9.20	1.68	9.17
62	5.30	0.16	12.00	5.25	11.40	4.21	8.40	1.13	10.20	2.61	6.20	0.31	13.67
63	7.50	0.70	9.90	2.30	9.70	2.10	9.70	2.10	9.10	1.60	9.40	1.84	10.63
											Average		**18.35**

Table 10: Examined axles of heavy truck with their respective load factors

Primary Data Collected at Awash Size & Weight Control Station (Heavy Truck)													
Item	Axle Load (Ton)												
	F1	LF	R1	LF	R2	LF	R3	LF	R4	LF	R5	LF	Total LF
1	6.80	0.46	13.20	7.91	12.80	6.93							15.30
2	6.20	0.31	15.40	15.35	9.10	1.60	9.10	1.60					18.85
3	5.40	0.17	15.00	13.71	15.00	13.71							27.58
4	6.70	0.43	14.20	10.83	14.50	11.85							23.10
5	5.80	0.23	12.40	6.05	10.10	2.50	12.10	5.44					14.22
6	7.40	0.66	11.00	3.61	9.60	2.01	10.80	3.34					9.62
7	6.00	0.27	13.00	7.41	15.50	15.78	15.00	13.71					37.16
8	6.00	0.27	15.00	13.71	13.50	8.71	11.50	4.37					27.06
9	7.30	0.62	9.80	2.20	9.00	1.52							4.34
10	6.00	0.27	8.80	1.38	9.10	1.60	9.40	1.84					5.09
											Average		18.23

This collected data and its analysis was compared with the original design of a road project (rigid pavement approach design – Awash junction). And the result from the analysis was used to show how the lives of pavements will be severely affected due to the inculcation of an overloaded vehicle passage (especially vehicles with axles on the margins as it was observed at the station that they are mostly tolerated and take most of the percentage). The analysis consists of calculating the cumulative Equivalent Standard Axle Load (ESAL) of the examined vehicles projected for a period of 40years using equation 6.

$$ESAL = \left(\sum_{i=1}^{m} p_i F_i\right)(ADT)_0(T)(A)(G)(D)(L)(365)(Y)$$

...Eq.6 [22], [23]

The directional distribution factor of 0.5, and growth rate of: 6% for Light commercial vehicle (LCV's), 5% for Medium Trucks (MT) (2axles), 5.5% for Heavy Trucks (HT) (3 axles) as well as Light/Heavy Bus (L/HB) and 7% for Articulated/truck and trailer (TT), 7.5% Passenger car/4WD are used. The annual average daily traffic count (AADT) of 2014 was used which is summarized on the table below where the base year is estimated using the stated growth rates [19].

Table 11 : Annual Average Daily Traffic Count

ROUTE No/Name	Length	Cars	Land Rover	Small Buses	Large Bus	Small Truck	Medium Truck	Heavy Truck	Truck/ Trailer
Awash ST. 5	308	7	71	76	12	69	71	185	271
Base Year estimate			82	85	13	76	78	206	1341

Table 12: Estimation of the examined vehicles ESA

AADT (Truck Trailer) =	**1341**	**D =**	**0.5**
AADT (Heavy Truck) =	**206**	**L =**	**0.7**

Vehicle Type	Truck Factor	Equivalent Standard Axle
Truck Trailer	18.35	3.14E+06
Total (Truck Trailer)=	ESA =	**3.14E+06**
Heavy Truck	18.23	4.80E+05
Total (Heavy Truck)=	ESA =	**4.80E+05**
	Total ESAL =	**3.62E+06**

In order to obtain the initial ESA of the new road, the cumulative ESA was projected back from the 40th year ESA with a growth rate of 5.75% (the average growth rate is taken for the considered vehicles, MT, HT, TT and L/HB). The total ESA for a period of 40years was 231,083,303.38 but different considerations were implemented like 35% reduction due to the rail way transportation plus adjustments were also made by dividing the remaining ESA by two assuming additional lanes will be implemented then finally the ESA was adjusted to 75,446,258.191 and a rigid pavement slab thickness of 350mm was designed [19]. Accordingly the same considerations were made on this paper to compare the effect of the obtained data ESA with the original design of the newly constructed rigid pavement to show the influence of overloading in the life of pavements. Thus the obtained total ESA in table 12 above was adjusted to 1.18E+06 and for the designed slab thickness of 350mm the 40th year ESA was projected back to an initial ESA of 5.91E+05. Table 13 below shows the comparison of the original design with the actual condition projected for a period of 40 years.

Table 13: Comparison of projected design traffic with the projected ESA of collected axles

		Y= 40years		r= 0.0575
Actual Years	**Years**	**GY**	**Original designed ESA projected for a period of 40years**	**ESA of collected axles projected for a period of 40 years**
2015	**1**	1	5.91E+05	1.18E+06
2016	**2**	2.0575	1.22E+06	2.42E+06
2017	**3**	3.17580625	1.88E+06	3.74E+06
2018	**4**	4.358415109	2.57E+06	5.13E+06
2019	**5**	5.609023978	3.31E+06	6.60E+06
2020	**6**	6.931542857	4.09E+06	8.16E+06
2021	**7**	8.330106571	4.92E+06	9.81E+06
2022	**8**	9.809087699	5.79E+06	1.15E+07
2023	**9**	11.37311024	6.72E+06	1.34E+07
2024	**10**	13.02706408	7.69E+06	1.53E+07
2025	**11**	14.77612027	8.73E+06	1.74E+07
2026	**12**	16.62574718	9.82E+06	1.96E+07
2027	**13**	18.58172764	1.10E+07	2.19E+07
2028	**14**	20.65017698	1.22E+07	2.43E+07
2029	**15**	22.83756216	1.35E+07	2.69E+07
2030	**16**	25.15072198	1.49E+07	2.96E+07
2031	**17**	27.5968885	1.63E+07	3.25E+07
2032	**18**	30.18370959	1.78E+07	3.55E+07
2033	**19**	32.91927289	1.94E+07	3.88E+07
2034	**20**	35.81213108	2.12E+07	4.22E+07
2035	**21**	38.87132862	2.30E+07	4.58E+07
2036	**22**	42.10643001	2.49E+07	4.96E+07
2037	**23**	45.52754974	2.69E+07	5.36E+07
2038	**24**	49.14538385	2.90E+07	5.79E+07
2039	**25**	52.97124342	3.13E+07	6.24E+07
2040	**26**	57.01708991	3.37E+07	6.71E+07
2041	**27**	61.29557258	3.62E+07	7.22E+07
2042	**28**	65.82006801	3.89E+07	7.75E+07
2043	**29**	70.60472192	4.17E+07	8.31E+07
2044	**30**	75.66449343	4.47E+07	8.91E+07
2045	**31**	81.0152018	4.78E+07	9.54E+07
2046	**32**	86.6735759	5.12E+07	1.02E+08
2047	**33**	92.65730652	5.47E+07	1.09E+08
2048	**34**	98.98510164	5.85E+07	1.17E+08
2049	**35**	105.676745	6.24E+07	1.24E+08
2050	**36**	112.7531578	6.66E+07	1.33E+08
2051	**37**	120.2364644	7.10E+07	1.42E+08
2052	**38**	128.1500611	7.57E+07	1.51E+08
2053	**39**	136.5186896	8.06E+07	1.61E+08
2054	**40**	145.3685143	8.59E+07	1.71E+08

Where the growth factor: $GY = \frac{(1+r)^{Y}}{r}$

The graphical representation of table 13 is shown in *figure* below:

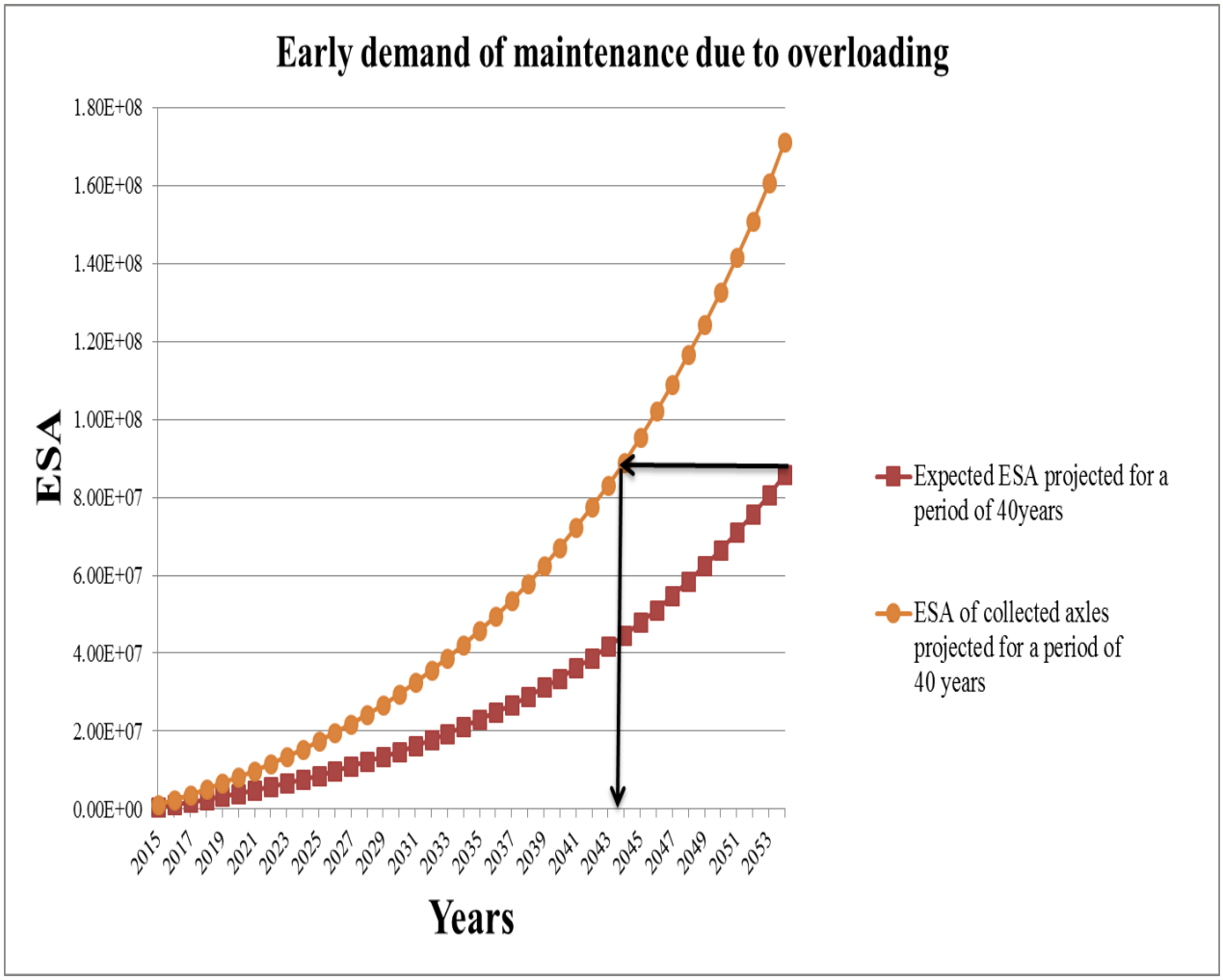


Figure 21: Influence of Overloading on the design period of pavements

The figure above signifies that for a road designed as such, the rehabilitation / maintenance period is estimated to be approximately 28years from the first day opening of the traffic if these overloaded axles keep using the road for the coming years. Therefore, from the analysis of the data collected at Awash control station we can see or conclude that the effect of overloaded freight transporting vehicles on pavements life is severe and should be given a serious attention (especially the tolerance of axles (i.e. 10.1 - 12 ton) on the margins to the legal load limit should be prohibited as they take most of the percentage of the overloaded axles as discussed earlier on figure 20). Further investigation was also made to the result of *figure 21* above to show its influence on roads. The analysis of the effective slab thickness for the newly constructed rigid pavement as well as the overlay thickness that will be needed for the damage at the end of the 28th year from traffic opening was made. This was performed using the famous *AASHTO regression equation* stated below:

$$\log W_{18} = Z_R S_o + 7.35\log(D+1) - 0.06 + \frac{\log[\Delta PSI/(4.5-1.5)]}{1 + 1.624\times 10^7/(D+1)^{8.46}} + (4.22 - 0.32p_t)\log\left\{\frac{S_c C_d (D^{0.75} - 1.132)}{215.63\, J[D^{0.75} - 18.42/(E_c/k)^{0.25}]}\right\}$$

..Eq.7 [22], [23]

Where:

- ✓ Z_R = -1.65 for a reliability "R" of 95%; [19];
- ✓ So= 0.39; [19];
- ✓ Change in PSI = 4.5– P_t = 4.5 – 1.5 = 3.0; [19];
- ✓ Modulus of elasticity of concrete (E_c) = 4.06E+06psi [19];
- ✓ Modulus of rupture of concrete (S_c) = 609 psi [19];
- ✓ Modulus of subgrade reaction (K) = 372 psi/in [19];
- ✓ Load transfer coefficient (J) = 3.1 [19];
- ✓ Drainage coefficient (C_d) = 1.0 [19];
- ✓ W_{18} = 8.59E+07, (Traffic for the designed slab thickness (D = 350mm [19])).

See table below:

Table 14: The rigid pavement approach design [19]

Parameter	Value
Standard Deviation (So)	0.39
Reliability (R %)	95
Normal Deviate (Z_R)	-1.65
Slab Thickness (D) in inches	13.78
Terminal Serviceability (P_t)	1.5
Design Serviceability loss (ΔPSI)	3
Modulus of Elasticity of Concrete (E_c)	4.06E+06
Modulus of Rupture of Concrete (S_c)	609
Modulus of Subgrade Reaction (k)	372
Load transfer Coefficient (J)	3.1
Drainage Coefficient (C_d)	1

	Value
Log $_{10}$ (W_{18}) =	7.93
W_{18} =	**8.59E+07**

The design slab thickness as mentioned earlier was 350mm (13.78inches) and comparison was made with the slab thickness required due to overloading (i.e. 1.71E+08 – 8.59E+07 = **8.53E+07**). In order

to do this, first the remaining fatigue life method was implemented to determine the effective depth of the slab (slab thickness). See tables below for the detail analysis:

Table 15 : Estimation of the required thickness of slab for the additional load from overloading

Parameter	Value
Standard Deviation (So)	0.39
Reliability (R %)	95
Normal Deviate (ZR)	-1.65
Required Slab Thickness (D_f) in inches	13.765
Terminal Serviceability (Pt)	1.5
Design Serviceability loss (ΔPSI)	3
Modulus of Elasticity of Concrete (Ec)	4.06E+06
Modulus of Rupture of Concrete (Sc)	609
Modulus of Subgrade Reaction (k)	372
Load transfer Coefficient (J)	3.1
Drainage Coefficient (Cd)	1

	Value
Log 10 (W18) =	7.93
W18 =	8.53E+07
Remaining Life $RL = 100\left[1 - \left(\frac{N_p}{N_{1.5}}\right)\right]$	3%
Condition factor $CF = RL^{0.165}$	0.561

Table 16 : Effective slab thickness & required overlay thickness determination

The A factor $A = 2.2233 + 0.0099(D_f - D_{eff})^2 - 0.1534(D_f - D_{eff})$	1.66
Required Slab Thickness (D_f)	13.77
Effective Slab Thickness left (D_{eff}) $D_{eff} = CF * D$	7.73
Required overlay thickness (inch) $D_{ol} = A(D_f - D_{eff})$	10.01
Required overlay thickness (mm)	254.30
Overlay Thickness (cm)	**25.43**

From the AASHTO remaining fatigue life analysis shown in the above tables, an overlay thickness of about 25cm was estimated to carry the additional load due to overloading. And it is recalled from figure 20 earlier that totally 56% of the overloaded axles were on the margins to the legal load therefore if strict control is implemented at the size and weight control stations (i.e. control of vehicles with axles greater than the standard limit) defects like unexpected maintenance / rehabilitation which will be caused by overloading will be minimized.

Secondary data analysis

The secondary data collected at Awash size and weight control station consists of penalized vehicle data for the months April, May & June. The data is analyzed and the ESA that was controlled by the size and weight control station is stated on table 19 below:

Table 17: Penalized Vehicles (truck/trailer) with their respective load factors

Penalized Vehicles Axle load data (on April, 2015) at Awash Size & Weight Control Station													
Item	**Axle Load (Ton) for Six Axle Vehicle**												
	F1	**LF**	**R1**	**LF**	**R2**	**LF**	**R3**	**LF**	**R4**	**LF**	**R5**	**LF**	**Total LF**
1	7.00	0.52	14.50	11.85	14.00	10.19	11.00	3.61	12.50	6.26	11.00	3.61	36.03
2	7.00	0.52	15.00	13.71	14.50	11.85	10.00	2.40	11.50	4.37	11.00	3.61	36.45
3	7.00	0.52	14.50	11.85	14.50	11.85	10.50	2.96	11.50	4.37	10.00	2.40	33.94
4	7.30	0.62	14.50	11.85	14.00	10.19	11.00	3.61	11.50	4.37	11.00	3.61	34.25
5	7.70	0.78	14.00	10.19	13.00	7.41	11.50	4.37	8.50	1.19	8.30	1.08	25.02
6	6.40	0.35	15.00	13.71	14.50	11.85	11.00	3.61	11.50	4.37	11.00	3.61	37.50
7	6.20	0.31	15.00	13.71	13.50	8.71	11.00	3.61	11.50	4.37	10.50	2.96	33.67
8	7.00	0.52	14.50	11.85	13.50	8.71	11.00	3.61	11.50	4.37	10.50	2.96	32.02
9	7.00	0.52	14.50	11.85	13.70	9.28	11.20	3.90	11.50	4.37	10.00	2.40	32.32
10	7.40	0.66	14.40	11.50	13.50	8.71	12.00	5.25	11.50	4.37	10.50	2.96	33.45
11	7.00	0.52	14.50	11.85	14.00	10.19	11.50	4.37	11.00	3.61	11.00	3.61	34.15
12	7.20	0.58	16.00	18.09	16.00	18.09	12.00	5.25	10.50	2.96	10.00	2.40	47.37
13	6.90	0.49	15.50	15.78	14.50	11.85	10.50	2.96	11.00	3.61	11.00	3.61	38.30
14	7.00	0.52	14.50	11.85	14.00	10.19	10.50	2.96	11.00	3.61	10.50	2.96	32.08
15	7.00	0.52	14.50	11.85	14.00	10.19	10.00	2.40	12.50	6.26	10.50	2.96	34.16
16	7.10	0.55	14.50	11.85	14.50	11.85	11.50	4.37	12.00	5.25	11.50	4.37	38.24
17	9.00	1.52	14.00	10.19	13.00	7.41	12.00	5.25	11.50	4.37	10.50	2.96	31.70
18	7.30	0.62	14.00	10.19	14.00	10.19	10.30	2.72	10.50	2.96	10.50	2.96	29.63
19	6.50	0.38	8.40	1.13	8.60	1.25	15.00	13.71	14.40	11.50	13.60	8.99	36.96
20	6.70	0.43	14.50	11.85	14.00	10.19	11.00	3.61	11.00	3.61	10.50	2.96	32.64
21	7.50	0.70	15.30	14.92	14.50	11.85	11.50	4.37	11.40	4.21	11.20	3.90	39.95
22	8.50	1.19	14.20	10.83	13.30	8.17	10.70	3.21	11.00	3.61	11.20	3.90	30.91
23	7.00	0.52	14.60	12.20	14.10	10.50	11.00	3.61	12.30	5.84	10.60	3.08	35.75
24	6.90	0.49	14.40	11.50	13.90	9.88	9.80	2.20	9.70	2.10	10.70	3.21	29.37
25	6.50	0.38	14.60	12.20	14.20	10.83	10.40	2.84	10.80	3.34	10.40	2.84	32.42
26	8.00	0.92	13.10	7.66	13.00	7.41	11.00	3.61	11.40	4.21	11.50	4.37	28.18
27	6.70	0.43	14.30	11.16	14.10	10.50	11.10	3.76	11.00	3.61	11.00	3.61	33.07
28	7.00	0.52	16.00	18.09	15.40	15.35	10.30	2.72	12.40	6.05	12.00	5.25	47.97
29	6.50	0.38	15.50	15.78	14.80	12.94	12.00	5.25	12.50	6.26	10.90	3.47	44.08
30	5.40	0.17	13.60	8.99	14.70	12.57	10.20	2.61	10.20	2.61	9.10	1.60	28.55
31	3.90	0.04	15.00	13.71	14.70	12.57	10.10	2.50	10.20	2.61	10.00	2.40	33.82
32	7.20	0.58	15.50	15.78	14.00	10.19	11.00	3.61	11.50	4.37	11.90	5.07	39.60
33	7.60	0.74	15.00	13.71	14.60	12.20	11.00	3.61	11.50	4.37	11.00	3.61	38.24
34	7.00	0.52	14.80	12.94	14.50	11.85	10.30	2.72	10.60	3.08	10.80	3.34	34.44
35	6.70	0.43	14.00	10.19	14.30	11.16	10.50	2.96	10.80	3.34	12.00	5.25	33.32
36	5.60	0.20	14.40	11.50	14.50	11.85	9.80	2.20	10.50	2.96	10.80	3.34	32.04
37	7.20	0.58	14.10	10.50	13.70	9.28	10.90	3.47	10.80	3.34	10.50	2.96	30.14
38	6.80	0.46	14.00	10.19	13.90	9.88	11.00	3.61	10.70	3.21	10.50	2.96	30.30
39	7.50	0.70	14.70	12.57	14.00	10.19	10.80	3.34	10.80	3.34	12.00	5.25	35.38
40	7.10	0.55	15.00	13.71	14.00	10.19	10.50	2.96	11.50	4.37	11.00	3.61	35.39

41	6.40	0.35	14.20	10.83	12.90	7.17	9.40	1.84	11.90	5.07	11.00	3.61	28.86
42	7.00	0.52	14.80	12.94	14.10	10.50	10.50	2.96	11.50	4.37	11.20	3.90	35.19
43	6.60	0.40	14.80	12.94	14.30	11.16	10.40	2.84	11.30	4.05	12.00	5.25	36.64
44	7.10	0.55	14.90	13.32	14.20	10.83	11.00	3.61	11.50	4.37	11.60	4.54	37.22
45	6.80	0.46	14.50	11.85	14.50	11.85	11.00	3.61	11.50	4.37	11.60	4.54	36.67
46	7.80	0.82	14.60	12.20	14.00	10.19	11.30	4.05	11.60	4.54	11.00	3.61	35.42
47	6.00	0.27	15.00	13.71	14.30	11.16	10.90	3.47	12.00	5.25	12.00	5.25	39.11
48	6.90	0.49	15.00	13.71	15.50	15.78	10.60	3.08	11.00	3.61	9.80	2.20	38.86
49	6.80	0.46	14.60	12.20	14.20	10.83	10.60	3.08	11.00	3.61	10.80	3.34	33.52
50	6.80	0.46	15.00	13.71	14.80	12.94	11.80	4.88	11.80	4.88	11.20	3.90	40.77
51	7.30	0.62	15.00	13.71	14.40	11.50	11.10	3.76	12.00	5.25	11.00	3.61	38.44
52	7.00	0.52	15.50	15.78	14.30	11.16	10.80	3.34	12.40	6.05	11.00	3.61	40.45
53	6.70	0.43	14.60	12.20	14.50	11.85	10.70	3.21	12.00	5.25	11.20	3.90	36.84
54	6.00	0.27	15.40	15.35	15.20	14.51	11.00	3.61	11.50	4.37	11.30	4.05	42.16
55	6.50	0.38	15.20	14.51	15.10	14.10	10.50	2.96	11.20	3.90	12.30	5.84	41.69
56	7.10	0.55	14.60	12.20	14.00	10.19	11.60	4.54	11.30	4.05	11.10	3.76	35.29
57	7.40	0.66	14.10	10.50	13.40	8.44	11.40	4.21	11.00	3.61	10.60	3.08	30.50
58	6.90	0.49	14.50	11.85	14.00	10.19	10.30	2.72	11.10	3.76	11.00	3.61	32.61
59	6.20	0.31	11.60	4.54	12.40	6.05	15.00	13.71	11.50	4.37	14.50	11.85	40.82
60	6.00	0.27	8.60	1.25	8.50	1.19	17.00	23.48	9.50	1.92	18.00	30.02	58.13
61	5.90	0.25	7.60	0.74	7.10	0.55	16.00	18.09	15.00	13.71	14.70	12.57	45.90
62	6.20	0.31	14.60	12.20	14.50	11.85	14.00	10.19	11.70	4.71	13.00	7.41	46.66
63	5.70	0.21	11.70	4.71	11.80	4.88	16.20	19.08	13.50	8.71	14.80	12.94	50.54
64	6.30	0.33	11.60	4.54	11.20	3.90	12.00	5.25	12.00	5.25	13.00	7.41	26.68
65	7.00	0.52	15.00	13.71	14.00	10.19	12.00	5.25	11.00	3.61	15.00	13.71	46.98
66	7.50	0.70	15.50	15.78	14.20	10.83	13.20	7.91	12.00	5.25	13.50	8.71	49.18
67	8.00	0.92	16.00	18.09	16.00	18.09	19.00	37.88	17.00	23.48	15.00	13.71	112.16
68	6.60	0.40	14.00	10.19	13.50	8.71	10.00	2.40	11.50	4.37	11.40	4.21	30.28
69	6.50	0.38	15.00	13.71	14.00	10.19	11.50	4.37	10.40	2.84	10.80	3.34	34.82
70	7.80	0.82	14.70	12.57	14.00	10.19	12.20	5.64	11.50	4.37	13.60	8.99	42.58
71	2.50	0.01	15.00	13.71	14.00	10.19	11.00	3.61	11.00	3.61	9.60	2.01	33.14
72	8.70	1.32	11.20	3.90	10.90	3.47	11.50	4.37	12.60	6.48	13.00	7.41	26.95
73	5.00	0.12	13.00	7.41	13.00	7.41	12.00	5.25	9.20	1.68	10.50	2.96	24.82
74	9.00	1.52	10.00	2.40	9.90	2.30	13.00	7.41	13.50	8.71	13.50	8.71	31.05
75	5.00	0.12	13.20	7.91	13.30	8.17	10.00	2.40	11.60	4.54	13.00	7.41	30.55
76	5.70	0.21	13.30	8.17	13.40	8.44	9.00	1.52	14.50	11.85	11.00	3.61	33.81
77	6.20	0.31	13.10	7.66	13.40	8.44	8.90	1.45	11.90	5.07	13.00	7.41	30.33
78	6.00	0.27	11.10	3.76	10.60	3.08	15.70	16.68	11.60	4.54	13.00	7.41	35.72
79	5.00	0.12	13.10	7.66	12.70	6.70	12.50	6.26	11.20	3.90	10.80	3.34	27.98
80	6.00	0.27	14.00	10.19	14.00	10.19	6.80	0.46	8.50	1.19	7.80	0.82	23.11
81	7.00	0.52	13.70	9.28	13.30	8.17	11.50	4.37	10.50	2.96	9.00	1.52	26.82
82	5.30	0.16	14.50	11.85	14.40	11.50	9.40	1.84	10.60	3.08	10.40	2.84	31.26
83	5.40	0.17	14.00	10.19	14.00	10.19	11.80	4.88	11.50	4.37	10.20	2.61	32.41
84	6.70	0.43	14.20	10.83	14.00	10.19	13.00	7.41	11.00	3.61	12.00	5.25	37.72
85	6.20	0.31	14.20	10.83	13.80	9.58	9.60	2.01	10.80	3.34	10.20	2.61	28.67

86	7.00	0.52	12.40	6.05	12.20	5.64	13.50	8.71	10.80	3.34	13.30	8.17	32.42
87	7.00	0.52	14.00	10.19	14.50	11.85	10.60	3.08	11.50	4.37	11.00	3.61	33.62
88	6.90	0.49	10.90	3.47	11.50	4.37	12.80	6.93	11.90	5.07	13.00	7.41	27.73
89	6.30	0.33	10.20	2.61	10.50	2.96	13.70	9.28	11.80	4.88	14.00	10.19	30.25
90	5.80	0.23	13.80	9.58	13.80	9.58	8.40	1.13	13.00	7.41	13.20	7.91	35.83
91	6.00	0.27	11.60	4.54	10.70	3.21	12.00	5.25	11.00	3.61	14.00	10.19	27.06
92	7.50	0.70	14.20	10.83	13.50	8.71	10.00	2.40	10.50	2.96	10.00	2.40	27.99
93	6.50	0.38	15.50	15.78	15.00	13.71	10.80	3.34	12.50	6.26	12.00	5.25	44.71
94	6.60	0.40	10.00	2.40	15.00	13.71	10.00	2.40	13.50	8.71	12.50	6.26	33.87
95	7.20	0.58	14.00	10.19	13.80	9.58	12.80	6.93	9.50	1.92	9.80	2.20	31.40
96	6.80	0.46	13.80	9.58	13.80	9.58	11.70	4.71	11.00	3.61	11.40	4.21	32.14
97	4.50	0.08	14.00	10.19	14.00	10.19	10.00	2.40	12.30	5.84	11.50	4.37	33.06
98	9.50	1.92	14.20	10.83	14.00	10.19	10.00	2.40	10.40	2.84	10.50	2.96	31.13
99	4.50	0.08	14.00	10.19	13.00	7.41	14.00	10.19	12.00	5.25	13.00	7.41	40.52
100	7.10	0.55	10.00	2.40	9.20	1.68	14.40	11.50	12.00	5.25	13.00	7.41	28.78
101	7.00	0.52	10.00	2.40	10.00	2.40	13.60	8.99	12.40	6.05	13.00	7.41	27.76
102	7.30	0.62	9.80	2.20	10.00	2.40	13.20	7.91	12.80	6.93	13.20	7.91	27.97
103	6.70	0.43	13.60	8.99	13.50	8.71	11.00	3.61	10.90	3.47	11.00	3.61	28.83
104	7.30	0.62	12.30	5.84	12.20	5.64	10.40	2.84	10.80	3.34	13.00	7.41	25.68
105	5.10	0.13	13.00	7.41	12.60	6.48	11.50	4.37	11.20	3.90	10.80	3.34	25.63
106	6.30	0.33	12.50	6.26	12.30	5.84	13.50	8.71	13.60	8.99	13.20	7.91	38.04
107	3.70	0.03	14.20	10.83	14.10	10.50	11.40	4.21	11.10	3.76	10.70	3.21	32.54
108	6.50	0.38	14.50	11.85	14.50	11.85	11.00	3.61	8.50	1.19	10.00	2.40	31.27
109	7.00	0.52	13.80	9.58	14.00	10.19	10.20	2.61	11.10	3.76	10.90	3.47	30.12
110	5.20	0.14	13.50	8.71	13.50	8.71	11.00	3.61	11.60	4.54	11.00	3.61	29.33
111	8.00	0.92	12.20	5.64	12.10	5.44	12.40	6.05	13.50	8.71	13.10	7.66	34.41
112	7.90	0.87	14.60	12.20	13.90	9.88	10.90	3.47	12.00	5.25	14.00	10.19	41.86
113	9.00	1.52	12.00	5.25	11.00	3.61	13.00	7.41	13.00	7.41	13.50	8.71	33.91
114	6.80	0.46	11.00	3.61	11.00	3.61	14.70	12.57	12.30	5.84	13.00	7.41	33.49
115	6.20	0.31	10.50	2.96	10.70	3.21	14.00	10.19	11.00	3.61	14.00	10.19	30.46
116	5.40	0.17	10.40	2.84	10.50	2.96	14.00	10.19	10.60	3.08	13.00	7.41	26.64
117	6.60	0.40	11.00	3.61	11.00	3.61	14.50	11.85	12.00	5.25	12.60	6.48	31.20
118	6.70	0.43	12.80	6.93	12.10	5.44	13.40	8.44	12.00	5.25	13.00	7.41	33.90
119	7.60	0.74	12.60	6.48	12.40	6.05	13.00	7.41	11.00	3.61	14.00	10.19	34.47
120	6.90	0.49	11.80	4.88	11.60	4.54	13.70	9.28	12.00	5.25	13.00	7.41	31.85
121	6.60	0.40	12.10	5.44	11.80	4.88	14.00	10.19	12.00	5.25	13.00	7.41	33.57
122	6.50	0.38	12.00	5.25	11.60	4.54	14.00	10.19	11.30	4.05	13.20	7.91	32.32
123	6.50	0.38	12.40	6.05	12.00	5.25	13.00	7.41	11.60	4.54	13.00	7.41	31.03
124	7.00	0.52	14.20	10.83	13.50	8.71	10.50	2.96	10.20	2.61	9.80	2.20	27.82
125	6.80	0.46	11.70	4.71	11.40	4.21	15.00	13.71	11.50	4.37	13.50	8.71	36.17
126	6.60	0.40	14.20	10.83	14.60	12.20	9.10	1.60	10.40	2.84	11.60	4.54	32.41
127	5.90	0.25	11.60	4.54	11.20	3.90	13.00	7.41	11.50	4.37	12.20	5.64	26.11
128	7.50	0.70	15.50	15.78	14.00	10.19	12.00	5.25	11.50	4.37	15.00	13.71	50.00
129	4.50	0.08	14.90	13.32	15.10	14.10	10.40	2.84	10.50	2.96	10.60	3.08	36.37
130	5.90	0.25	10.80	3.34	10.70	3.21	13.60	8.99	11.40	4.21	14.20	10.83	30.83
131	5.60	0.20	10.50	2.96	10.40	2.84	13.00	7.41	11.60	4.54	13.90	9.88	27.82
132	5.50	0.18	10.60	3.08	10.40	2.84	13.20	7.91	11.30	4.05	13.60	8.99	27.06
										Average			**34.80**

Table 18: Penalized Vehicles (Heavy/Truck) with their respective load factors

Item	Axle Load (Ton) for Four Axle Vehicle												
	F1	LF	R1	LF	R2	LF	R3	LF	R4	LF	R5	LF	Total LF
1	6.70	0.43	13.40	8.44	13.00	7.41	12.60	6.48					22.75
2	5.80	0.23	10.00	2.40	14.00	10.19	14.00	10.19					23.00
3	6.10	0.29	9.80	2.20	14.00	10.19	14.00	10.19					22.86
4	6.40	0.35	16.00	18.09	14.00	10.19	10.00	2.40					31.03
5	7.20	0.58	11.00	3.61	14.50	11.85	15.00	13.71					29.75
6	6.10	0.29	19.00	37.88	10.00	2.40	11.00	3.61					44.17
7	7.20	0.58	15.00	13.71	13.00	7.41	13.00	7.41					29.11
8	7.40	0.66	14.00	10.19	12.00	5.25	12.00	5.25					21.35
9	6.20	0.31	15.00	13.71	13.60	8.99	13.40	8.44					31.45
10	8.00	0.92	16.50	20.65	13.00	7.41	12.00	5.25					34.23
11	7.10	0.55	16.70	21.75	16.20	19.08							41.38
12	6.90	0.49	12.50	6.26	14.00	10.19							16.93
										Average			**29.00**

Table 19: Estimation of Penalized Vehicle ESAL

AADT (Truck Trailer) =	**1341**	**D =**	**0.5**	
AADT (Heavy Truck) =	**206**	**L =**	**0.7**	
Vehicle Type		**Truck Factor**		**Equivalent Standard Axle**
Truck Trailer		34.80		5.96E+06
Total Truck Trailer=			ESA =	**5.96E+06**
Heavy Truck		29.00		7.63E+05
Total Heavy Truck=			ESA =	**7.63E+05**
		Total ESAL =		**6.72E+06**

Therefore, as we can refer from *table 19* above, due to the penalized vehicles recorded data for three (3) months, ESA of 6.72E+06 was found to be controlled by the station. Therefore giving due attention for these stations (i.e. with the necessary facilities and modernized equipment's for examining different vehicles) is very essential as such.

4.2.1 Importance of Axle Configuration

Axles are part of the vehicle that transfers the load of the vehicle, together with the goods it carries, to the pavements. And it is important to give due attention on how axles should be arranged on vehicles transporting heavy goods because as the number of axle groups increase on a certain vehicle even though the vehicle carries a heavy load the configuration of the axles will reduce the damage effect up on the pavements. For instance, a tridem axle will share a load to six double wheels while a tandem axle shares the load to four double wheels which will impose larger load on the pavements than the tridem axles do. For instance; it is also observed here in Ethiopia how different companies transport heavy loads, like transformers as seen in *Figure 22* below, to reduce severe damage to pavements because at least the truck consists of 12 (twelve) axles, with 8 (eight) wheels for each rear axle on the trailer, as seen on the figure below to distribute the weight of the heavy transformer on each wheel of the axles and decrease the damage effect up on the pavement while travelling from origin to wanted destination.



Figure 22: Load reduction mechanism upon pavements by increasing axles

4.2.2 Gaps seen in the vehicle examination process

There is some gap in the vehicles examination process which is the tolerance of axle loads that are on the margin (i.e. up to 12tones for the rear axle) which should be prohibited.

4.2.3 Measures undertaken to overcome overloading

There have been different measures being undertaken to this end in order to reduce the influence of overloaded vehicle on pavements. Some of the measures undertaken are:

Plantation of size & weight control stations at different corridors of the roads in Ethiopia, where the vehicles are examined (using weighbridges) for the amount of loads they carry (i.e. whether they carry an overload or within the limit). This helps in controlling various number of vehicles from damaging the life of pavements as they pass over carrying a load beyond the legal load limit.

In the size and weight control stations, there are also rooms where the personnel's at the stations nourish a good educational background regarding the negative impact of overloading especially for the drivers who were caught driving an overloaded vehicle / truck. For instance at Awash size and weight control station, some advices are given to drivers regarding the importance of load distribution (axle control) such as:

- ➔ *To load their vehicle / truck in a balancing way* (i.e. even though the vehicle consists different groups of axles, due to poor knowledge of load distribution, they might load the goods (e.g. containers) concentrated on one side of a particular axle groups only (as shown in *Figure 23*) and when the vehicles are examined those particular axle groups will show higher load than the limit). Therefore drivers should be well informed of such scenarios.

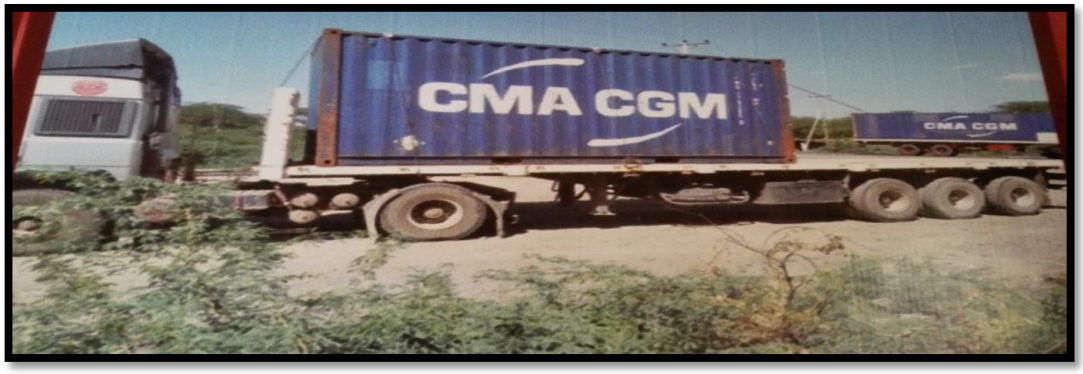


Figure 23: Improper loading of goods on vehicles / trucks

But after this education is given good outputs were seen on behalf of most of the drivers see *Figure 24* below:



Figure 24: Proper loading of goods on vehicles / trucks

- When overloaded vehicles are found, they will be enforced to reduce the goods being transported to another vehicle after the company, which is responsible for transporting the said goods, is informed to send another vehicle that shares the reduced goods from the penalized vehicle. The reduction is done until the vehicle weighs not exceeding the legal load limit. And in case of machineries transportation, since they cannot be shared to other vehicles, they will be loaded on vehicles with greater number of axles so that the weight that will be imposed upon the roads will be minimized. See *Figure 25.1 & 25.2.*



Figure 25. 1: Transferring some of the goods to another vehicle



Figure 25. 2: Transferring heavy machineries to a vehicle with better axle configuration

Figure 25: Activities to reduce overloading

- Modernized law enforcement procedures are also being structured currently to enhance the existing penalizing procedures so that it will contribute much in the endeavor of reducing the occurrence of overloading; thereby decreasing the impact on roads.

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

Roads are valuable assets for a certain country. They are the means of transportation of different freight from a certain origin to a certain destination. They also act as a means of circulation within the city plus as a link between nations. Thus, these assets (roads) need to be protected from different distresses that reduce the life of pavements where these distresses could be caused due to different reasons. One of the causes of distress on roads is loads from an overloaded freight transporting vehicle which is becoming a very critical issue in different countries of the world following the increased growth of transportation of goods on land.

As from the results of the study of this paper it is seen that about 48% of the axles measured / examined, from the primary collected data were found to be overloaded and about 56% of these axles lies on the range up to 20% overloading (i.e. 10.1 - 12ton). In addition, from the AASHTO remaining fatigue life analysis the 48% overloaded axles, when projected for the design period of the considered road, will result in about 25cm overlay thickness required to carry the additional load for the pavement considered & hence reconstruction or early & unexpected maintenance cost will also be incurred as well. Therefore, it is important to upgrade the different size & weight control stations with modernized technologies to minimize the impact of overloading. Overloading not only ceases by just deteriorating the roads but also results in different indirect consequences like: Property damage as well as cost will be incurred on companies transporting goods (i.e. since some vehicles would be overloaded beyond their capacity this will damage parts of the vehicle and also more fuel will be burned to transport the said overloaded good from one place to another); Accidents could also occur especially while maneuvering or travelling around curves in the scenario of transporting overloaded goods because it will lose stability while being loaded beyond its capacity.

In Ethiopia, to date, different mitigative measures are being done and currently new plans are also being structured for future use, but the problem still reigns. Therefore thorough precautions must be done in order to alleviate these problems from overloading because in doing so, we will be able to protect our assets (roads), reduce budget for early & unexpected maintenance, and also to reduce the problems stated above on the society.

5.2 Recommendations

- Well studied survey needs to be accomplished before deciding for the permanent location of different control stations. For instance along the road route from Djibouti to Awash there is only one control station which is located at Awash. Hence if there is an overloaded truck transporting goods from Djibouti, the effect will not be controlled for the road between Djibouti & Awash but if there was one control station around Djibouti border the influence would be well controlled.
- From the gaps seen on the vehicle examination process as well as from the results of collected data analysis at the control station, the tolerated vehicles could be considered as one of the reasons for the distresses seen on the roads (like rutting) which is caused due to permanent deformation instead of elastic deformation. Therefore it will be better if the operators are strongly informed not to tolerate axle loads on the margin beyond the legal load limit (i.e. Axle loads on the range (11 – 12 tones)).
- It is also recommended to educate companies about the importance of axle configuration so that the related companies will buy vehicles designed with good axle configuration to distribute the load from the vehicle to the pavements without causing significant damage
- The education given to teach the penalized drivers regarding the influence of overloading on our assets (roads) by itself will not be sufficient for fighting the occurrence of overloading. Therefore; starting to teach the owners / companies (which are related with freight transportation) about the sever effect of overloading upon roads as well as the indirect effect over the damage of their vehicles as well as goods will enable in contributing a lot for reducing the influence. This could be easily done on Magazines, Mass Medias and the likes.
- The compound of different size and weight control stations should be constructed with concrete / rigid pavements because a lot of legal as well as overloaded vehicles will circulate in the compound before and after they are examined and may create dust which will disturb the employees. Therefore from environmental point of view, especially in hot places like Awash, if such deeds are undertaken, it will create a good environment for the employees at the control station to do their job effectively.

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Annex ‘A’

Certificate of Verification for the updated calibration of the weighbridges

የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ንግድ ሚኒስቴር

The Federal Democratic Republic of Ethiopia
Ministry of Trade

CERTIFICATE OF VERIFICATION

P.O. Box 704
Addis Ababa, Ethiopia
Tel: 251-11-5539177
Fax:251-11-5522415

Date of Issue: 2014-06-15 Certificate number: WVN/124/06

I :ument	**Weighbridge**
Manufacturer	**MASTER K**
Model:	**IDe' 400**
Serial Number	**99486 F**
Customer	**ETHIOPIAN ROADS AUTHORITY**
Registration No.:	**419/MIV/2006**
Number of pages of the certificate	**2**
Date of Verification:	**2014/05/18**
xt Verification date:	**2015/05/18**
Place of Verification	**AWASH**
Maximum Capacity:	**30,000 kg**
Resolution:	**20 Kg**

Seal **Date** **Metrology inspector**

Tamiru Geno
Director, Import Export Commodities,
Quality Control Directorate

2014-06-15 **AREFAINE HAILE**

የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ንግድ ሚኒስቴር

The Federal Democratic Republic of Ethiopia
Ministry of Trade

CERTIFICATE OF VERIFICATION

P.O. Box 704
Addis Ababa, Ethiopia
Tel: 251-11-5539177
Fax:251-11-5522415

Date of Issue: 2014-06-15 Certificate number: WVN/124/06

Measuring results

Applied Standard load [kg]	Instrument Reading [kg]	Error [kg]
0	0	0
1300	1280	-20
2600	2580	-20
3900	3900	0
5200	5200	0
12460	12460	0
13760	13760	0
16360	16360	0
17660	17660	0
25020	25020	0
27620	27640	+20
28920	28940	+20

Comments:

- The instrument satisfies the requirements of ES .A. D1 260 Ethiopian standards on Weighing Instruments-Tolerance. So, it is permitted for internal or outside commercial purpose for a year. However, let us immediately know and reverify it if the error is beyond the indicated any time before it's periodic.

Note:

- This verification certificate is valid only for the item stated in this certificate.
- This verification certificate is not valid without signature and official seal.
- This verification certificate is not valid if change, modification, repair, etc. has been carried on the instrument after verification.

End of certificate

የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ንግድ ሚኒስቴር

The Federal Democratic Republic of Ethiopia
Ministry of Trade

CERTIFICATE OF VERIFICATION

P.O. Box 704
Addis Ababa, Ethiopia
Tel: 251-11-5539177
Fax:251-11-5522415

Date of Issue: 2014-06-15 Certificate number: WVN/119/06

Instrument	**Weighbridge**
Manufacturer	**MASTER K**
Model:	**IDe' 400**
Serial Number	**99486 C**
Customer	**ETHIOPIAN ROADS AUTHORITY**
Registration No.:	**419/MIV/2006**
Number of pages of the certificate	**2**
Date of Verification:	**2014/04/15**
Next Verification date:	**2015/04/15**
Place of Verification	**Mojo**
Maximum Capacity:	**30,000 kg**
Resolution:	**20 Kg**

Seal **Date** **Metrology inspector**

Tamiru Gena
Director, Import Export Commodities
Quality Control

2014-06-15 AREFAINE HAILE

21/7/14

የኢትዮጵያ ፌዴራላዊ ዲሞክራሲያዊ ሪፐብሊክ ንግድ ሚኒስቴር

The Federal Democratic Republic of Ethiopia
Ministry of Trade

CERTIFICATE OF VERIFICATION

P.O. Box 704
Addis Ababa, Ethiopia
Tel: 251-11-5539177
Fax:251-11-5522415

Date of Issue: 2014-06-15 Certificate number: WVN/119/06

Measuring results

Applied Standard load [kg]	Instrument Reading [kg]	Error [kg]
0	0	0
1300	1280	-20
2600	2580	-20
3900	3900	0
5200	5200	0
13160	13160	0
14460	14460	0
15760	15760	0
18060	18060	0
25840	25840	0
28440	28440	0
29440	29440	0

Comments:

- The instrument satisfies the requirements of ES .A. D1 260 Ethiopian standards on Weighing Instruments-Tolerance. So, it is permitted for internal or outside commercial purpose for a year. However, let us immediately know and reverify it if the error is beyond the indicated any time before it's periodic.

Note:

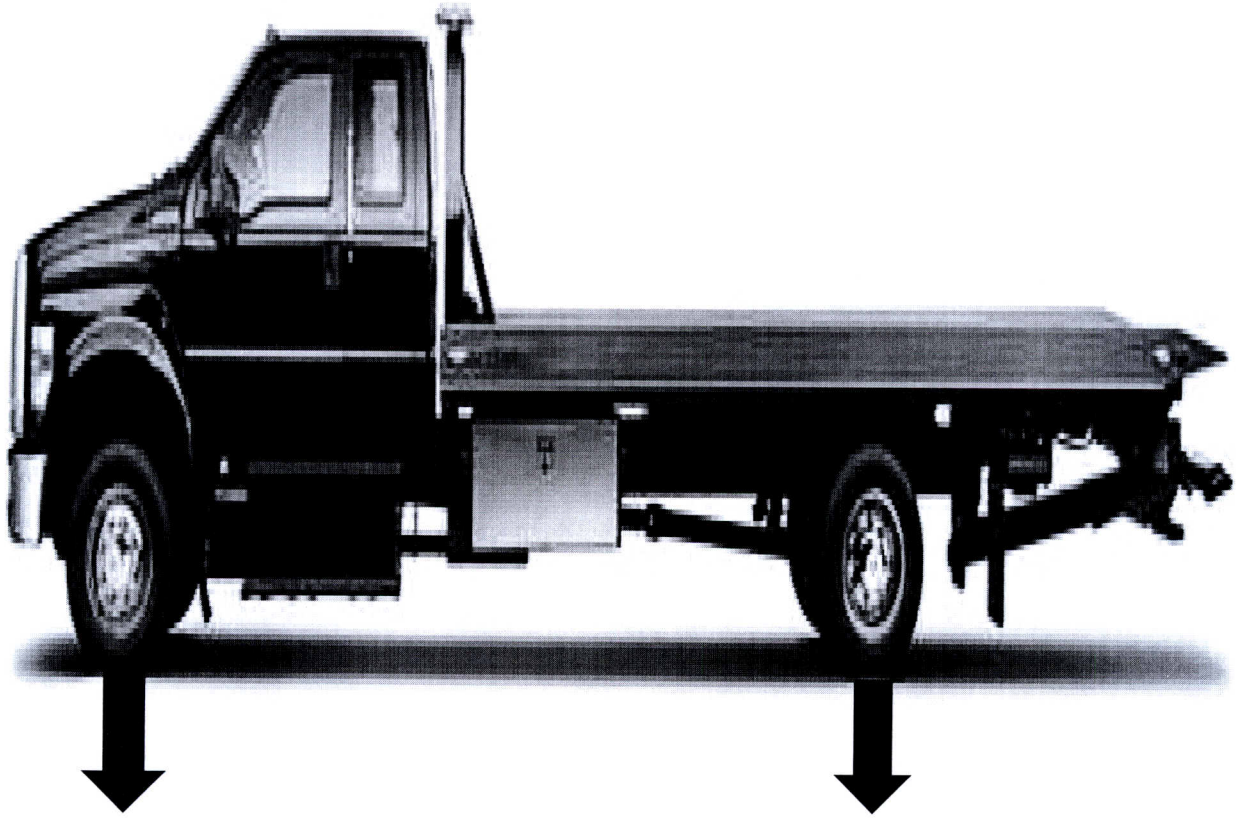
- This verification certificate is valid only for the item stated in this certificate.
- This verification certificate is not valid without signature and official seal.
- This verification certificate is not valid if change, modification, repair, etc. has been carried on the instrument after verification.

End of certificate

Annex ‘B’

Secondary data needed for the choice of the best study station

Front and Rear axle description figure for a certain truck



Front Axle "F"

Rear Axle "R"

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

AWASH

PERIOD 2008-2009

AXLE LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2						1				0		1	
2.1-3				12	3	8	6			0		29	
3.1-4	4	1	8	9	7	27	14			5		65	
4.1-5	398	2	29	71	82	37	41			400		260	
5.1-6	4468		50	213	382	94	75			4468		814	
6.1-7	9303		299	982	1290	2176	429			9303		5176	
7.1-8	12451		602	1107	2264	2267	3516			12451		9756	
8.1-9	127		2117	2238	5922	4092	3312				127	17681	
9.1-10	82		7283	5091	10585	8583	7011				82	38553	
10.1-11	12		10126	10687	3711	4546	3320				12		32390
11.1-12	11		4489	2313	1532	804	446				11		9584
12.1-13	1		662	233	201	245	103				1		1444
13.1-14			250	264	169	157	41				0		881
14.1-15			360	296	142	110	49				0		957
15.1-16			301	159	122	99	32						713
16.1-17			153	106	76	67	22						424
17.1-18			81	23	45	26	10						185
18.1-19			20	2	22	19	9						72
19.1-20			13	2	8	12	5						40
20.1-21			12	2	2	5							21
21.1-22			2		2	3	1						8
TOTAL	26857	3	26857	23810	26567	23378	18442	0	0	26627	233	72335	46719

Form Ax-001

AWASH

PERIOD 2009-10

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

AXLE LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	2	3	0		0		5	
2.1-3	3	0	0	6	7	15	2	0		3		30	
3.1-4	16	0	0	25	15	9	11	1		16		61	
4.1-5	620	2	23	80	74	47	37	0		622		261	
5.1-6	3920	0	101	260	352	124	73	0		3920		910	
6.1-7	8873	0	227	491	626	1355	557	0		8873		3256	
7.1-8	14466	0	1902	1892	2059	2501	3220	0		14466		11574	
8.1-9	548	0	4830	3954	4559	4172	3662	0			548	21177	
9.1-10	106	0	13993	15506	15987	13424	10202	0			106	69112	
10.1-11	18	0	3451	3406	1580	1288	1415	0			18		11140
11.1-12	8	0	569	633	893	1077	630	0			8		3802
12.1-13	0	0	753	893	672	899	331	0			0		3548
13.1-14	0	0	812	989	487	545	282	0					3115
14.1-15	0	0	995	700	384	224	195	0					2498
15.1-16	0	0	562	292	212	118	123	0					1307
16.1-17	0	0	223	130	93	79	57	0					582
17.1-18	0	0	95	55	31	36	21	0					238
18.1-19	0	0	26	7	28	22	19	0					102
19.1-20	0	0	16	0	12	5	7	0					40
20.1-21	0	0	0	0	2	6	6	0					14
21.1-22	0	0	0	0	1	1	1	0					3
TOTAL	28578	2	28578	29319	28074	25949	20854	1	0	27900	680	106386	26389

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

AWASH

Axle Load Report Annual

PERIOD :2010-2011

AXLE										TOTAL AXLE WEIGHET: NO OF VEHICLES			
LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	82	0	0	0	0	0	0	0		82		0	
2.1-3	266	0	545	98	12	0	5	0		266		660	
3.1-4	893	0	514	126	100	18	7	0		893		765	
4.1-5	1520	11	264	919	304	33	79	0		1531		1599	
5.1-6	2006	10	324	617	987	92	139	0		2016		2159	
6.1-7	7838	0	680	853	1155	1181	514	0		7838		4383	
7.1-8	9574	0	1615	1465	2008	2131	2054	0		9574		9273	
8.1-9	216	0	4061	3264	3472	3494	2494	0			216	16785	
9.1-10	108	0	10312	10151	11232	10885	9398	0			108	51978	
10.1-11	32	0	1425	2490	769	609	548	0			32		5841
11.1-12	3	0	522	594	557	680	436	0			3		2789
12.1-13	3	0	526	653	455	651	282	0			3		2567
13.1-14	0	0	552	593	368	403	206	0			0		2122
14.1-15	0	0	566	475	324	198	159	0					1722
15.1-16	0	0	373	240	173	59	106	0					951
16.1-17	0	0	169	98	112	30	71	0					480
17.1-18	0	0	62	39	74	12	36	1					224
18.1-19	0	0	20	7	21	8	18	0					74
19.1-20	0	0	4	0	11	1	4	0					20
20.1-21	0	0	3	0	21	3	4	0					31
21.1-22	0	0	4	0	3	0	1	0					8
TOTAL	22541	21	22541	22682	22158	20488	16561	1	0	22200	362	87602	16829

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

AWASH

Period:2011-2012

AXLE										TOTAL AXLE WEIGHET: NO OF VEHICLES			
LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	3			0		3	
2.1-3	8	0	0	3	2	1	6	0		8		12	
3.1-4	160	2	3	21	6	8	6	0		162		44	
4.1-5	927	7	54	78	136	33	52	0		934		353	
5.1-6	4861	4	304	290	414	181	312	0		4865		1501	
6.1-7	10332	0	779	753	1075	1170	1119	0		10332		4896	
7.1-8	11481	0	2268	2398	3405	3902	3360	0		11481		15333	
8.1-9	266	0	7512	8668	9316	8074	7228	0			266	40798	
9.1-10	108	0	13343	11807	10426	10308	9883	1			108	55768	
10.1-11	28	0	1211	678	721	636	699	0			28		3945
11.1-12	3	0	418	588	573	870	450	1			3		2899
12.1-13	0	0	437	657	482	665	326	0			0		2567
13.1-14	0	0	563	681	497	350	282	0					2373
14.1-15	0	0	616	380	336	137	185	0					1654
15.1-16	0	0	394	168	207	55	95	0					919
16.1-17	0	0	169	29	92	23	62	0					375
17.1-18	0	0	80	6	32	1	9	0					128
18.1-19	0	0	17	0	11	3	4	0					35
19.1-20	0	0	1	0	5	2	0	0					8
20.1-21	0	0	2	0	4	1	0	0					7
21.1-22		0	3										3
TOTAL	28174	13	28174	27205	27740	26420	24081	2	0	27782	405	118708	14913

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

AWASH

July 1,2012-June30,2013

AXLE LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0					0	
2.1-3	0	0	0	0	0	1	1			0		2	
3.1-4	76	0	0	11	10	1	1			76		23	
4.1-5	676	0	63	64	13	10	22			676		172	
5.1-6	5869	0	484	79	70	241	155			5869		1029	
6.1-7	17111	3	656	223	568	716	555			17114		2718	
7.1-8	11402	1	1323	1092	1802	2080	2651			11403		8948	
8.1-9	222	0	5199	6441	7784	10404	8680				222	38508	
9.1-10	70	0	25204	25151	22590	18890	19073				70	110908	
10.1-11	27	0	455	412	359	399	473				27		2098
11.1-12	6	0	240	310	353	470	322				6		1695
12.1-13	0	0	268	385	358	458	235				0		1704
13.1-14	0	0	389	435	321	254	208						1607
14.1-15	0	0	460	432	236	91	142						1361
15.1-16	0	0	396	227	152	32	88						895
16.1-17	0	0	227	83	89	22	57						478
17.1-18	0	0	79	7	24	2	18						130
18.1-19	0	0	11	2	7	3	5						28
19.1-20	0	0	2	0	4	2	1						9
20.1-21	0	0	3	0	2	0	0						5
21.1-22	0	0	0	0	0	0	0						0
TOTAL	35459	4	35459	35354	34742	34076	32687	0	0	35138	325	162308	10010

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

AWASH

Axel Load Report

PERIOD 2013-14

AXLE LOAD IN Ton	Total axles weigh & nomber of vehicles												
	AXLE DISTRUBUTION OF VEHECLIES									FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0	0	0		0	
2.1-3	0	0	0	0	0	1	0	0	0	0		1	
3.1-4	57	0	0	4	1	2	0	0	0	57		7	
4.1-5	386	1	43	33	19	21	24	0	0	387		140	
5.1-6	3580	1	245	147	74	103	122	0	0	3581		691	
6.1-7	14023	10	493	439	663	772	814	0	0	14033		3181	
7.1-8	20000	12	1470	2776	2782	3001	3413	2	0	20012		13442	
8.1-9	211	6	8397	8264	9601	9924	10711	2	0		217	46897	
9.1-10	82	0	25287	24333	23244	21855	19754	0	0		82	114473	
10.1-11	21	0	700	451	463	376	458	0	0		21		2448
11.1-12	3	0	168	219	350	432	362	0	0		3		1531
12.1-13	0	0	246	553	315	325	180	1	0		0		1619
13.1-14	0	0	306	421	231	178	95	1	0		0		1231
14.1-15	0	0	462	446	128	93	73	0	0		0		1202
15.1-16	0	0	288	159	69	29	53	0	0				598
16.1-17	0	0	142	74	51	8	19	0	0				294
17.1-18	0	0	88	15	36	3	8	0	0				150
18.1-19	0	0	21	4	4	4	4	0	0				37
19.1-20	0	0	3	0	1	3	0	0	0				7
20.1-21	0	0	4	0	3	2	2	0	0				11
21.1-22	0	0	0	0	0	0	0	0	0				0
TOTAL	38363	30	38363	38338	38035	37132	36092	6	0	38070	323	178832	9128

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report

Holleta
PERIOD 2008-2009

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2				1		1				0		2	
2.1-3	4		1		1	1				4		3	
3.1-4	100		1	3	4	7	1			100		16	
4.1-5	997		1	12	12	13	12			997		50	
5.1-6	4288		18	24	67	43	32			4288		184	
6.1-7	2499		39	143	90	145	53			2499		470	
7.1-8	2547		83	1033	518	388	215			2547		2237	
8.1-9	143		325	1179	1745	974	943				143	5166	
9.1-10	9		1513	1737	2162	902	621				9	6935	
10.1-11			4146	2267	444	196	68				0		7121
11.1-12			1975	617	54	13	3				0		2662
12.1-13			1920	110	7	2					0		2039
13.1-14			165	31	2	6					0		204
14.1-15			58	14		4					0		76
15.1-16			144	4	1	3					0		152
16.1-17			129								0		129
17.1-18			51								0		51
18.1-19			15								0		15
19.1-20			3								0		3
20.1-21											0		0
21.1-22											0		0
TOTAL	10587	0	10587	7175	5107	2698	1948	0	0	10435	152	15063	12452

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report

Holleta
PERIOD 2009 -10

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2				2		0				0		2	
2.1-3	3	1	1	11	5	2	1			4		20	
3.1-4	109			1	4	5	1			109		11	
4.1-5	1554	1	5	11	22	22	12			1555		72	
5.1-6	5477		18	24	58	102	19			5477		221	
6.1-7	2976		48	265	214	337	150			2976		1014	
7.1-8	2882		212	1162	894	769	608			2882		3645	
8.1-9	183		603	1649	2193	1364	1075				183	6884	
9.1-10	19		6598	4794	2975	1104	584				19	16055	
10.1-11	2		2030	894	196	124	29				2		3273
11.1-12			1559	200	97	43	3				0		1902
12.1-13			1398	119	40	51	3				0		1611
13.1-14			129	87	25	65					0		306
14.1-15			122	33	6	12							173
15.1-16			343	11	1								355
16.1-17			106	3									109
17.1-18			30										30
18.1-19			2										2
19.1-20			1										1
20.1-21													0
21.1-22													0
TOTAL	13205	2	13205	9266	6730	4000	2485	0	0	13003	204	27924	7762

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report
Annual Report

Holleta

PERIOD:From July 1,2010-June30,2011

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	2	0	0	0			0		2	
2.1-3	7	0	0	5	1	1	3			7		10	
3.1-4	148	0	3	11	21	16	13			148		64	
4.1-5	2576	0	6	18	42	56	32			2576		154	
5.1-6	5774	0	28	56	85	188	85			5774		442	
6.1-7	5264	1	79	411	284	846	369			5265		1989	
7.1-8	6593	0	215	1307	933	1585	1564			6593		5604	
8.1-9	175	0	811	3313	4014	3466	3177				175	14781	
9.1-10	24	0	11935	9202	5172	1288	1023				24	28620	
10.1-11	4	0	987	184	68	48	30				4		1317
11.1-12	1	0	2161	110	98	54	2				1		2425
12.1-13	0	0	3826	135	91	78	1				0		4131
13.1-14	0	0	129	89	46	90	0				0		354
14.1-15	0	0	67	36	9	22	0				0		134
15.1-16	0	0	110	9	0	1	0						120
16.1-17	0	0	131	1	0	0	0						132
17.1-18	0	0	57	1	0	1	0						59
18.1-19	0	0	15	0	0	0	0						15
19.1-20	0	0	5	0	0	0	0						5
20.1-21	0	0	1	0	0	0	0						1
21.1-22	0	0	0	0	0	0	0						0
TOTAL	20566	1	20566	14890	10864	7740	6299	0	0	20363	204	51666	8693

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report
Annual Report-2011-2012

Holleta

PERIOD:From July 1, 2011-June 30,2012

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0		0		0	
2.1-3	0	0	0	8	1	2	8	0		0		19	
3.1-4	139	0	0	5	2	7	8	0		139		22	
4.1-5	1771	0	1	3	13	37	21	0		1771		75	
5.1-6	5023	0	10	21	69	255	56	0		5023		411	
6.1-7	5253	0	35	144	263	975	323	0		5253		1740	
7.1-8	8317	0	118	1148	689	1513	1124	0		8317		4592	
8.1-9	209	0	792	1524	3786	3655	3103	0			209	12860	
9.1-10	37	0	18124	12381	6656	2240	1886	0			37	41287	
10.1-11	7	0	147	45	82	30	136	0			7		440
11.1-12	1	0	396	63	86	43	29	0			1		617
12.1-13	0	0	501	111	71	57	33	0			0		773
13.1-14	0	0	204	187	40	40	19	0			0		490
14.1-15	1	0	136	152	17	15	7	0			1		327
15.1-16	0	0	94	46	1	3	3	0					147
16.1-17	0	0	115	29	1	0	0	0					145
17.1-18	0	0	65	6	2	0	0	0					73
18.1-19	0	0	18	0	0	0	0	0					18
19.1-20	0	0	2	0	0	0	0	0					2
20.1-21	0	0	0	0	0	0	0	0					0
21.1-22	0	0	0	0	0	0	0	0					0
TOTAL	20758	0	20758	15873	11779	8872	6756	0	0	20503	255	61006	3032

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report
Annual Report-2010-2012

Holleta

PERIOD:From July 1, 2012-June 30,2013

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	1	0	0	5	0		0		6	
2.1-3	4	2	0	3	0	1	1	0		6		5	
3.1-4	381	1	0	1	2	2	2	0		382		7	
4.1-5	2064	0	3	19	36	28	48	0		2064		134	
5.1-6	6689	0	122	85	108	189	181	0		6689		685	
6.1-7	10704	3	202	190	330	628	481	0		10707		1831	
7.1-8	11839	9	768	834	1222	1890	1497	0		11848		6211	
8.1-9	338	1	1584	2523	3970	6092	6200	0			339	20369	
9.1-10	105	0	13513	9982	7605	3929	3393	0			105	38422	
10.1-11	14	0	13666	9882	2501	1076	880	0			14		28005
11.1-12	1	0	1154	261	105	44	293	0			1		1857
12.1-13	1	0	176	120	47	30	4	0			1		377
13.1-14	0	0	303	252	25	15	8	0			0		603
14.1-15	0	0	290	334	5	8	4	0			0		641
15.1-16	0	0	129	102	2	3	0	0					236
16.1-17	0	0	124	23	0	0	1	0					148
17.1-18	0	0	78	5	0	0	0	0					83
18.1-19	0	0	20	2	1	1	0	0					24
19.1-20	0	0	7	0	0	0	0	0					7
20.1-21	0	0	1	0	0	0	0	0					1
21.1-22	0	0	0	0	0	0	0	0					0
TOTAL	32140	16	32140	24619	15959	13936	12998	0	0	31696	460	67670	31982

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Annual Report-2010-2012

Holleta

PERIOD:From July 1, 2013-June 30,2014

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0	0		0		0	
2.1-3	2	0	0	0	0	2	0	0		2		2	
3.1-4	279	0	0	7	8	9	10	0		279		34	
4.1-5	1134	0	2	18	12	12	30	0		1134		74	
5.1-6	4516	0	48	44	73	225	188	0		4516		578	
6.1-7	9949	5	83	209	213	698	851	0		9954		2054	
7.1-8	13629	14	1119	1239	1359	2282	2706	0		13643		8705	
8.1-9	351	0	7167	5762	3842	6419	5583	0			351	28773	
9.1-10	33	0	19117	14748	7843	3337	2746	0			33	47791	
10.1-11	9	0	1451	1216	827	170	151	0			9		3815
11.1-12	1	0	280	29	58	26	13	0			1		406
12.1-13	0	0	62	51	21	17	3	0			0		154
13.1-14	0	0	257	205	13	10	3	0			0		488
14.1-15	0	0	181	197	5	7	5	0			0		395
15.1-16	0	0	50	75	2	0	2	0					129
16.1-17	0	0	45	20	0	0	0	0					65
17.1-18	0	0	26	5	0	0	0	0					31
18.1-19	0	0	11	1	0	0	0	0					12
19.1-20	0	0	3	0	0	0	0	0					3
20.1-21	0	0	1	0	0	0	0	0					1
21.1-22	0	0	0	0	0	0	0	0					0
TOTAL	29903	19	29903	23826	14276	13214	12291	0	0	29528	394	88011	5499

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report

Modjo
PERIOD : 2008-09

AXLE LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	1	0	5	1	0		0		7	
2.1-3	2	2	3	21	5	14	3	0		4		46	
3.1-4	27	2	2	30	27	23	6	0		29		88	
4.1-5	502	0	17	82	75	56	21	0		502		251	
5.1-6	9620	4	51	264	230	86	31	0		9624		662	
6.1-7	28042	6	192	627	697	391	186	0		28048		2093	
7.1-8	20500	3	537	1207	1753	1540	1246	0		20503		6283	
8.1-9	739	0	6720	6980	6174	6624	5562	0			739	32060	
9.1-10	18	0	17156	17441	10389	7700	5938	0			18	58624	
10.1-11	1	0	30374	26570	4484	1667	783	0			1		63878
11.1-12	0	0	2880	1518	250	288	125	0			0		5061
12.1-13	0	0	835	386	116	58	17	0			0		1412
13.1-14	0	0	308	269	51	56	8	0					692
14.1-15	0	0	164	129	28	27	7	0					355
15.1-16	0	0	83	29	17	14	5	0					148
16.1-17	0	0	79	7	7	4	0	0					97
17.1-18	0	0	30	1	3	2	0	0					36
18.1-19	0	0	14	2	2	0	0	0					18
19.1-20	0	0	6	0	0	0	0	0					6
20.1-21	0	0	0	0	0	0	0	0					0
21.1-22	0	0	2	0	0	1	0	0					3
TOTAL	59451	17	59453	55564	24308	18556	13939	0	0	58710	758	100114	71706

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report

Modjo
PERIOD 2009-10

AXLE LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	3	0	0	2	0		0		5	
2.1-3	2	0	0	8	2	2	2	0		2		14	
3.1-4	21	0	1	17	6	3	4	0		21		31	
4.1-5	490	0	2	27	24	13	8	0		490		74	
5.1-6	6828	2	53	49	86	64	54	0		6830		306	
6.1-7	29824	3	217	377	546	399	372	0		29827		1911	
7.1-8	26487	1	2381	1030	1727	2431	1659	0		26488		9228	
8.1-9	851	0	6998	18070	7573	7017	5859	0			851	45517	
9.1-10	44	0	53725	43360	11830	8050	5833	0			44	122798	
10.1-11	6	0	259	156	115	93	79	0			6		702
11.1-12	0	0	157	84	68	62	52	0			0		423
12.1-13	0	0	132	93	61	51	35	0			0		372
13.1-14	0	0	194	109	72	60	31	0					466
14.1-15	0	0	161	108	64	57	13	0					403
15.1-16	0	0	101	74	31	36	16	0					258
16.1-17	0	0	85	27	14	7	5	0					138
17.1-18	0	0	51	16	8	4	4	0					83
18.1-19	0	0	27	4	1	2	0	0					34
19.1-20	0	0	5	0	0	0	0	0					5
20.1-21	0	0	4	0	0	1	0	0					5
21.1-22	0	0	0	0	0	0	0	0					0
TOTAL	64553	6	64553	63612	22228	18352	14028	0	0	63658	901	179884	2889

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Modjo

PERIOD:From July 1,2010-June30,2011

AXLE LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	1	0	7	2	1	1			1		11	
3.1-4	3	0	0	10	6	12	10			3		38	
4.1-5	321	0	9	21	12	8	10			321		60	
5.1-6	4049	4	34	93	48	27	20			4053		222	
6.1-7	31754	0	93	213	183	99	110			31754		698	
7.1-8	24812	5	3027	1501	1941	2060	1214			24817		9743	
8.1-9	676	0	9514	8001	5665	6076	5328				676	34584	
9.1-10	40	0	42752	46371	11162	8473	6144				40	114902	
10.1-11	9	0	4037	3385	567	328	236				9		8553
11.1-12	2	0	568	325	257	225	152				2		1527
12.1-13	0	0	428	342	186	176	56				0		1188
13.1-14	0	0	491	403	96	130	22				0		1142
14.1-15	0	0	439	466	70	74	19						1068
15.1-16	0	0	121	103	40	34	14						312
16.1-17	0	0	76	27	13	14	9						139
17.1-18	0	0	53	10	4	7	3						77
18.1-19	0	0	16	1	1	1	1						20
19.1-20	0	0	6	0	2	1	2						11
20.1-21	0	0	1	0	1	0	1						3
21.1-22	0	0	1	1	0	1	1						4
TOTAL	61666	10	61666	61280	20256	17747	13353	0	0	60949	727	160258	14044

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

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Axel Load Report

PERIOD:From July 1,2011-June30,2012

AXLE LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	2	0	0	0	0		0		2	
2.1-3	0	0	0	11	1	1	2	0		0		15	
3.1-4	7	5	0	12	4	3	1	0		12		20	
4.1-5	87	3	2	8	8	7	6	0		90		31	
5.1-6	5062	3	7	12	33	24	20	0		5065		96	
6.1-7	25562	0	11	48	171	235	143	0		25562		608	
7.1-8	15697	0	131	240	1670	2753	2671	0		15697		7465	
8.1-9	104	1	1406	2034	6162	6813	7047	0			105	23462	
9.1-10	8	0	42123	41486	10172	7575	6326	0			8	107682	
10.1-11	4	0	841	647	472	239	245	0			4		2444
11.1-12	0	0	298	238	179	93	62	0			0		870
12.1-13	0	0	365	361	97	96	26	0			0		945
13.1-14	0	0	471	427	48	84	18	0			0		1048
14.1-15	0	0	609	578	36	34	13	0					1270
15.1-16	0	0	140	121	11	15	8	0					295
16.1-17	0	0	89	30	4	5	2	0					130
17.1-18	0	0	26	8	1	1	1	0					37
18.1-19	0	0	7	1	2	0	0	0					10
19.1-20	0	0	2	0	1	0	0	0					3
20.1-21	0	0	3	0	0	0	0	0					3
21.1-22	0	0	0	0	0	0	0	0					0
Total	46531	12	46531	46264	19072	17978	16591			46426	117	139381	7055

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Modjo

PERIOD:From July 1,2012- June30,2013

AXLE LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	1	2			0		3	
2.1-3	0	0	0	3	0	2	6			0		11	
3.1-4	8	1	0	1	20	8	2			9		31	
4.1-5	94	0	5	8	33	44	45			94		135	
5.1-6	4258	13	19	31	103	89	100			4271		342	
6.1-7	23298	5	84	98	466	1028	773			23303		2449	
7.1-8	30573	0	213	281	1971	4023	5569			30573		12057	
8.1-9	287	0	4577	4765	5891	9332	9275				287	33840	
9.1-10	74	0	47483	47435	13311	6961	4997				74	120187	
10.1-11	14	0	1838	1811	637	311	217				14		4814
11.1-12	3	0	281	269	231	72	68				3		921
12.1-13	0	0	720	575	215	141	52				0		1703
13.1-14	0	0	1606	1500	118	154	40				0		3418
14.1-15	0	0	1380	1387	96	115	14						2992
15.1-16	0	0	246	235	37	34	5						557
16.1-17	0	0	83	41	17	13	1						155
17.1-18	0	0	38	3	2	5	0						48
18.1-19	0	0	21	0	3	1	0						25
19.1-20	0	0	9	0	0	0	0						9
20.1-21	0	0	6	0	1	1	0						8
21.1-22	0	0	0	0	0	0	0						0
TOTAL	58609	19	58609	58443	23152	22335	21166	0	0	58250	378	169055	14650

Form Ax-001

ETHIOPIAN ROADS AUTHORITY
Size and Weight Control Station
Axel Load Report

Modjo

PERIOD:From July 1,2013- June 30,2014

AXLE LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	5	2	2	2			0		11	
3.1-4	19	0	0	3	1	5	7			19		16	
4.1-5	80	0	4	7	18	11	7			80		47	
5.1-6	1842	1	21	14	49	163	187			1843		434	
6.1-7	26788	2	84	90	670	1177	2023			26790		4044	
7.1-8	30876	0	469	492	1570	5237	7317			30876		15085	
8.1-9	136	0	3159	3710	7599	10896	9344				136	34708	
9.1-10	44	0	49403	49529	12469	5144	3329				44	119874	
10.1-11	18	0	2627	2168	356	132	124				18		5407
11.1-12	0	0	219	214	227	44	29				0		733
12.1-13	0	0	563	686	117	66	9				0		1441
13.1-14	0	0	2294	2053	61	70	5				0		4483
14.1-15	0	0	728	668	38	33	5						1472
15.1-16	0	0	116	84	10	3	1						214
16.1-17	0	0	45	8	3	3	0						59
17.1-18	0	0	40	0	2	1	0						43
18.1-19	0	0	21	1	0	0	0						22
19.1-20	0	0	8	0	0	0	0						8
20.1-21	0	0	1	0	0	0	0						1
21.1-22	0	0	1	0	0	0	0						1
TOTAL	59803	3	59803	59732	23192	22987	22389	0	0	59608	198	174219	13884

Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Alemgena

Axel Load Report

PERIOD 2008-2009

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2										0		0	
2.1-3	5			8	4	4	4			5		20	
3.1-4	57		8	15	23	12	16			57		74	
4.1-5	643		23	38	47	46	24			643		178	
5.1-6	3209		44	64	73	96	52			3209		329	
6.1-7	3292		138	147	159	229	125			3292		798	
7.1-8	2776		367	475	351	610	403			2776		2206	
8.1-9	84		1624	980	913	891	732				84	5140	
9.1-10	9		2875	2143	1598	722	520				9	7858	
10.1-11	1		2205	1539	307	83	34				1		4168
11.1-12			1775	913	26	22	3				0		2739
12.1-13			686	1598	8	7	4				0		2303
13.1-14			186	852	3	7	1				0		1049
14.1-15			69	198	3	3					0		273
15.1-16			34	67									101
16.1-17			32	22									54
17.1-18			8	7									15
18.1-19				1									1
19.1-20			1										1
20.1-21			1										1
21.1-22													0
TOTAL	10076	0	10076	9067	3515	2732	1918	0	0	9982	94	16603	10705

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Form Ax-001

FORM AX-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Alemgena

PREIOD 2009-2010

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2										0		0	
2.1-3	2				4	2				2		6	
3.1-4	9			3	6	4	2			9		15	
4.1-5	158		9	24	26	19	20			158		98	
5.1-6	1622		99	96	77	87	56			1622		415	
6.1-7	3149		286	252	207	241	209			3149		1195	
7.1-8	2781		626	586	483	466	377			2781		2538	
8.1-9	155		1354	1308	999	893	642				155	5196	
9.1-10	21		4840	3221	1407	786	568				21	10822	
10.1-11	4		11	14	24	53	11				4		113
11.1-12			22	38	43	17	4				0		124
12.1-13			132	147	21	14	3						317
13.1-14			241	192	7	16							456
14.1-15			85	75	6	13	1						180
15.1-16			73	22	8	7							110
16.1-17			69	5	1	1							76
17.1-18			39	5									44
18.1-19			14										14
19.1-20			1										1
20.1-21													0
21.1-22													0
TOTAL	7901	0	7901	5988	3319	2619	1893	0	0	7721	180	20285	1435

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Form Ax-001

FORM AX-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Alemgena

Period : From July 1,2010-June 30,2011

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	0	0	0	0			0		0	
3.1-4	56	0	7	5	7	10	3			56		32	
4.1-5	376	0	15	13	16	32	28			376		104	
5.1-6	1206	0	56	34	40	45	72			1206		247	
6.1-7	2025	0	109	143	133	133	197			2025		715	
7.1-8	1849	0	316	297	291	359	321			1849		1584	
8.1-9	69	0	905	953	784	707	573				69	3922	
9.1-10	6	0	3138	2524	1303	920	698				6	8583	
10.1-11	3	0	650	536	62	31	55				3		1334
11.1-12	1	0	110	15	6	5	1				1		137
12.1-13	0	0	69	43	14	9	0				0		135
13.1-14	0	0	64	71	7	6	1				0		149
14.1-15	0	0	75	61	0	4	1						141
15.1-16	0	0	32	25	2	2	1						62
16.1-17	0	0	27	22	0	0	0						49
17.1-18	0	0	14	3	1	0	0						18
18.1-19	0	0	4	0	0	0	1						5
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	5591	0	5591	4745	2666	2263	1952	0	0	5512	79	15187	2030

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Form Ax-001

FORM AX-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Alemgena

Period : From July 1,2011- June 30,2012

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	0	0	0	0			0		0	
3.1-4	41	0	5	4	7	6	3			41		25	
4.1-5	218	0	16	20	16	19	24			218		95	
5.1-6	1060	0	42	29	39	28	56			1060		194	
6.1-7	2117	0	88	126	110	90	238			2117		652	
7.1-8	1965	0	328	298	359	341	421			1965		1747	
8.1-9	43	0	1130	1040	857	791	559				43	4377	
9.1-10	4	0	3627	3003	1468	1192	896				4	10186	
10.1-11	0	0	8	14	6	4	4				0		36
11.1-12	1	0	20	21	6	5	3				1		55
12.1-13	0	0	56	40	6	5	1				0		108
13.1-14	0	0	48	48	6	2	2				0		106
14.1-15	0	0	43	35	0	1	1						80
15.1-16	0	0	15	11	1	1	1						29
16.1-17	0	0	13	17	0	0	0						30
17.1-18	0	0	8	2	0	0	0						10
18.1-19	0	0	2	0	0	0	0						2
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	5449	0	5449	4708	2881	2485	2209	0	0	5401	48	17276	456

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Form Ax-001

FORM AX-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Alemgena

Period : From July 1,2012- June 30,2013

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	6	1	0	1			0		8	
3.1-4	20	0	0	3	5	5	2			20		15	
4.1-5	398	3	4	6	14	15	20			401		59	
5.1-6	1990	0	8	62	50	63	45			1990		228	
6.1-7	3804	2	91	67	166	208	99			3806		631	
7.1-8	3697	1	505	342	343	497	369			3698		2056	
8.1-9	17	0	1061	1153	1085	1021	965				17	5285	
9.1-10	2	0	4945	4521	1445	1117	1276				2	13304	
10.1-11	2	0	2892	2728	94	30	47				2		5791
11.1-12	1	0	78	30	2	1	1				1		112
12.1-13	0	0	128	127	1	1	0				0		257
13.1-14	0	0	143	136	0	0	0				0		279
14.1-15	0	0	49	56	0	1	0						106
15.1-16	0	0	17	7	1	1	0						26
16.1-17	0	0	6	3	0	0	0						9
17.1-18	0	0	2	0	0	0	0						2
18.1-19	0	0	2	0	0	0	0						2
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	0	0	0	0	0						0
21.1-22													0
TOTAL	9931	6	9931	9247	3207	2960	2825	0	0	9915	22	21586	6584

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Form Ax-001

FORM AX-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

Alemgena

Period : From July 1,2013- June 30,2014

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	2	0	0	0	0			0		2	
3.1-4	20	0	17	2	0	0	0			20		19	
4.1-5	394	0	27	8	1	5	0			394		41	
5.1-6	1219	0	82	122	6	22	20			1219		252	
6.1-7	2994	0	314	165	27	151	69			2994		726	
7.1-8	5047	2	594	377	186	518	340			5049		2015	
8.1-9	60	0	1378	2130	747	772	885				60	5912	
9.1-10	5	0	5398	4732	1703	1085	1071				5	13989	
10.1-11	0	0	1225	980	183	55	91				0		2534
11.1-12	0	0	31	33	6	5	1				0		76
12.1-13	0	0	90	94	3	2	0				0		189
13.1-14	0	0	263	270	0	0	0				0		533
14.1-15	0	0	232	214	1	1	0						448
15.1-16	0	0	44	36	1	0	0						81
16.1-17	0	0	27	14	0	1	0						42
17.1-18	0	0	13	5	0	0	0						18
18.1-19	0	0	1	1	0	0	0						2
19.1-20	0	0	0	1	0	0	0						1
20.1-21	0	0	1	0	0	0	0						1
21.1-22													0
TOTAL	9739	2	9739	9184	2864	2617	2477	0	0	9676	65	22956	3925

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Size and Weight Control Station

Axel Load Report

SULULTA

2008-09

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2				1						0		1	
2.1-3	6			1		1	1			6		3	
3.1-4	41		3	4	3	9	7			41		26	
4.1-5	493		7	14	21	13	12			493		67	
5.1-6	1584		23	32	41	27	33			1584		156	
6.1-7	4238		31	87	56	91	103			4238		368	
7.1-8	3120	1	86	136	161	236	282			3121		901	
8.1-9	65		252	369	453	734	1006				65	2814	
9.1-10	14		2344	2138	2142	1900	1191				14	9715	
10.1-11	5		5266	4655	1105	571	367				5		11964
11.1-12			1086	188	32	16	3				0		1325
12.1-13			185	117	12	4	2				0		320
13.1-14			106	86	6	10	10				0		218
14.1-15			76	56	1	5							138
15.1-16			46	21	1	2	1						71
16.1-17			17	3		1							21
17.1-18			19										19
18.1-19			16										16
19.1-20			2										2
20.1-21			1										1
21.1-22													0
TOTAL	9566	1	9566	7908	4034	3620	3018	0	0	9483	84	14051	14095

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ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

SULULTA

PERIOD 2009-10

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	1	0	0	0	0	0	0			1		0	
2.1-3	5	0	0	0	0	0	0			5		0	
3.1-4	22	2	1	1	2	6	1			24		11	
4.1-5	266	0	1	5	13	5	9			266		33	
5.1-6	1122	0	6	5	21	23	46			1122		101	
6.1-7	3234	0	12	27	64	61	113			3234		277	
7.1-8	4826	0	88	155	174	212	337			4826		966	
8.1-9	128	0	918	889	469	861	922				128	4059	
9.1-10	23	0	3550	3243	2092	1680	1055				23	11620	
10.1-11	17	0	3841	3361	1053	805	688				17		9748
11.1-12	0	0	267	63	160	31	13				0		534
12.1-13	0	0	251	226	66	51	6						600
13.1-14	0	0	356	343	26	49	3						777
14.1-15	0	0	178	143	6	35	0						362
15.1-16	0	0	79	38	3	6	1						127
16.1-17	0	0	45	7	1	0	0						53
17.1-18	0	0	33	2	1	0	0						36
18.1-19	0	0	7	1	0	0	0						8
19.1-20	0	0	10	7	0	0	0						17
20.1-21	0	0	1	0	0	0	0						1
21.1-22	0	0	0	0	0	0	0						0
TOTAL	9644	2	9644	8516	4151	3825	3194	0	0	9478	168	17067	12263

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Form Ax-001

ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

SULULTA

period: From July1,2010 - June 30,2011

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	1	0	0	0			0		1	
3.1-4	32	0	0	0	0	1	0			32		1	
4.1-5	231	0	81	79	42	41	41			231		284	
5.1-6	1087	0	214	212	137	134	139			1087		836	
6.1-7	2841	2	235	237	107	125	181			2843		885	
7.1-8	3532	1	282	226	207	297	389			3533		1401	
8.1-9	56	0	801	852	654	918	989				56	4214	
9.1-10	6	0	3789	3396	2222	1795	1404				6	12606	
10.1-11	0	0	1748	1500	403	264	241				0		4156
11.1-12	1	0	167	69	70	36	15				1		357
12.1-13	0	0	126	110	42	17	4				0		299
13.1-14	0	0	188	172	10	16	1				0		387
14.1-15	0	0	81	94	13	10	1				0		199
15.1-16	0	0	43	31	2	1	0						77
16.1-17	0	0	18	10	0	0	0						28
17.1-18	0	0	12	0	0	0	0						12
18.1-19	0	0	1	0	0	0	0						1
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	7786	3	7786	6989	3909	3655	3405	0	0	7726	63	20228	5516

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ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

SULULTA

period: From July1,2011 - June 30,2012

LOAD IN	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
Ton	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	3	0	0	0	0	0	0			3		0	
3.1-4	4	0	0	1	0	1	0			4		2	
4.1-5	141	1	0	0	1	2	2			142		5	
5.1-6	640	1	0	0	5	8	11			641		24	
6.1-7	2678	0	22	28	26	80	101			2678		257	
7.1-8	4305	1	292	245	260	324	539			4306		1660	
8.1-9	48	0	669	742	780	953	1202				48	4346	
9.1-10	4	0	6316	5789	3033	2686	2071				4	19895	
10.1-11	0	0	28	22	54	27	20				0		151
11.1-12	1	0	31	19	48	26	14				1		138
12.1-13	0		55	60	18	14	5				0		152
13.1-14	0	0	221	211	11	6	1				0		450
14.1-15	0	0	140	135	4	2	4				0		285
15.1-16	0	0	39	39	1	1	0						80
16.1-17	0	0	5	3	1	0	1						10
17.1-18	0	0	5	1	0	1	0						7
18.1-19	0	0	0	0	0	0	0						0
19.1-20	0	0	1	0	0	0	0						1
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	7824	3	7824	7295	4242	4131	3971	0	0	7774	53	26189	1274

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ETHIOPIAN ROADS AUTHORITY

Size and Weight Control Station

Axel Load Report

SULULTA

period: From July1,2012- June 30,2013

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	0	0	0	0	0	0	0			0		0	
3.1-4	13	1	0	0	0	0	1			14		1	
4.1-5	227	0	0	0	4	11	8			227		23	
5.1-6	1214	0	12	11	28	79	104			1214		234	
6.1-7	8435	0	137	112	273	705	873			8435		2100	
7.1-8	6413	1	384	438	1319	2022	1778			6414		5941	
8.1-9	138	0	1733	1909	3872	4997	4277				138	16788	
9.1-10	10	0	12202	11903	5440	3070	3598				10	36213	
10.1-11	0	0	530	460	299	65	82				0		1436
11.1-12	0	0	60	41	42	31	24				0		198
12.1-13	0	0	105	67	29	13	7				0		221
13.1-14	0	0	550	473	9	7	4				0		1043
14.1-15	0	0	530	546	5	3	3				0		1087
15.1-16	0	0	148	155	2	0	0						305
16.1-17	0	0	37	29	1	0	0						67
17.1-18	0	0	16	4	0	0	0						20
18.1-19	0	0	4	1	0	0	0						5
19.1-20	0	0	2	0	0	0	0						2
20.1-21	0	0	0	0	0	0	0						0
21.1-22	0	0	0	0	0	0	0						0
TOTAL	16450	2	16450	16149	11323	11003	10759	0	0	16304	148	61300	4384

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Size and Weight Control Station

Axel Load Report

SULULTA

period: From July1,2013- June 30,2014

LOAD IN Ton	AXLE DISTRUBUTION OF VEHECLIES									TOTAL AXLE WEIGHET: NO OF VEHICLES			
										FRONT		REAR	
	F1	F2	R1	R2	R3	R4	R5	R6	R7	LEGAL	ILLEGAL	LEGAL	ILLEGAL
1.0-2	0	0	0	0	0	0	0			0		0	
2.1-3	1	0	0	0	0	0	1			1		1	
3.1-4	11	0	0	0	0	0	0			11		0	
4.1-5	87	0	0	0	5	4	3			87		12	
5.1-6	639	0	3	3	3	10	35			639		54	
6.1-7	5066	1	23	26	152	119	300			5067		620	
7.1-8	12350	0	203	202	501	789	1159			12350		2854	
8.1-9	237	0	949	852	2056	3061	3121				237	10039	
9.1-10	26	1	14206	13854	6765	5642	4969				27	45436	
10.1-11	5	0	1524	1735	282	113	85				5		3739
11.1-12	0	0	129	134	48	37	32				0		380
12.1-13	0	0	74	91	27	16	23				0		231
13.1-14	1	0	533	547	32	11	2				1		1125
14.1-15	0	0	605	553	35	6	7				0		1206
15.1-16	0	0	141	158	6	2	1						308
16.1-17	0	0	24	30	1	1	0						56
17.1-18	0	0	7	2	0	0	0						9
18.1-19	0	0	1	0	1	1	0						3
19.1-20	0	0	0	0	0	0	0						0
20.1-21	0	0	1	1	0	0	0						2
21.1-22	0	0	0	0	0	0	0						0
TOTAL	18423	2	18423	18188	9914	9812	9738	0	0	18155	270	59016	7059

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