‘PAVEMENT MANAGEMENT SYSTEM USING DEFLECTION PREDICTION MODEL OF FLEXIBLE PAVEMENTS IN BANGLADESH’.

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ABSTRACT

This thesis work attempts to develop a viable model for predicting the deflection of flexible pavements based on experimental data of flexible pavements of various ages utilizing International Roughness Index (IRI) values. A better road network is required. However, it is currently unavailable in several areas of Bangladesh. Although there are some areas where traffic is heavier or sufficient, Bangladesh lacks a well-developed road network. The deflection, IRI, age, breadth, and AADT of the pavement all have a role in road maintenance. As a result, the purpose of deflection testing is to determine pavement qualities in order to determine what should be attempted as restoration work and how solid it should be, as well as what should be fixed with an acceptable plan. We built an IRI estimation model based on regression analysis using IBM SPSS v.26 software to address the challenges of pavement roughness measurement. To know what treatment is necessary for the deflection, we should know the value of IRI, width, age, and AADT of the Pavement. After analyzing this secondary data, we were able to come up with a result that will aid in the creation of a road design that is both safe and cost-effect.

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CHAPTER 1
INTRODUCTION

1.1 Introduction:

The durable emergence of a road, airstrip, or similar place is referred to as Pavement in civil engineering. The transmission of masses to the sub-base and underlying soil is the primary function of a pavement. Sand and gravel, or broken stone, are compacted with a hydrocarbon binder, such as asphalt, tar, or mineral oil, in trendy, multifunctional pavements. This type of pavement has sufficient physical properties to absorb shock. Rigid pavements are made of Portland cement, coarse and fine aggregates, and steel rod or mesh, and are often reinforced with steel rod or mesh.

Pavement is the solid paving of a road, airstrip, or area in primary planning. Pavement's primary limitation is its ability to transport weights to the sub-base and crucial soil. Sand and rock, or rock stone compacted with a folio of bituminous material, comparable to dark top, tar, or asphaltic oil, make up today's flexible Pavement. This type of pavement is adaptable enough to accommodate paralysis (Dewan, 2004).

There are two types of pavements:

1. Rigid Pavement
2. Flexible Pavement.

On a prepared subbase of granular material or obviously on a granular subgrade, Rigid Pavement develops Portland solid, essential parts. By flexing the lumps, the weight is transferred through the pieces to the covered-up subgrade. Several different thicknesses are combined to form rigid pavements. The flexure of the slabs allows the load to be transmitted through the slabs to the underlying subgrade.

Because of their low flexure strength, these pavements twist when subjected to heavy traffic. combined movement of the Pavement's various layers achieves the underlying limit of a flexible pavement, which is referred to as the underlying limit of a flexible pavement The rubbish from the trucks is simply spread out on the wearing track to do its work. It is dispersed (in the form of a truncated cone) with depth in the base, subbase, and subgrade courses, and then finally to the ground level. The surface layer has the greatest firmness (as measured by the robust modulus) and hence contributes the most to pavement strength, as a result of the stress caused by traffic stacking being concentrated at the top. Because they have a lower stiffness, the layers beneath the pavement have a comparable impact on its layout. Subgrade layers are responsible for transporting the waste from the upper layers to the lower layers. When designing flexible pavements, it is important to consider how much increase will arrive at the subgrade and whether this would exceed the bearing capacity of the subgrade soil. As a result, the thicknesses of the layers over the subgrade vary depending on the soil strength, which has an impact on the cost of developing a pavement system. On a prepared subbase of granular material or obviously on a granular subgrade, Rigid Pavement develops Portland solid, essential parts by flexing the lumps, the weight is transferred through the pieces to the covered-up subgrade. Precisely what rigid pavements are is the progression of a few different thicknesses (Khondhaker Al Momin, 2021).

1.2 Rigid pavement is classified into four types:

1. Jointed plain concrete pavement (JPCP): The pavements have enough joints to accommodate all of the natural cracks that occur in concrete. All of the essential cracking occurs at the joints of the slabs, and not elsewhere inside the slabs. Unlike other concrete products, JPCP does not contain any steel reinforcing. However, there could also be weight transfer devices at crosswise connections, as well as distorted steel bars (for example, tie bars) at longitudinal joints, in addition to the load transfer devices. For slabs 7-12 in. (175-300 mm) thick, the distance between crosswise joints is typically between twelve (3.7 m) and fifteen (4.5m).

2. Joint reinforced concrete pavement (JRCP): Continuously concrete pavements (CRCP) are concrete pavements that do not require any cross-contraction joints and are therefore more environmentally friendly. During the construction of the block, cross fractures are predicted to appear at intervals of one.5 - half dozen feet (0.5 - 1.8 m). The CRCP is designed to have enough embedded reinforcing steel (about zero.6-0.7 percent by cross-sectional area unit) to ensure that cracks are closely controlled along their length. Pavement & #39s styles often cost more than JPCP or JRCP styles at first, owing to the increased amount of steel used in its construction. Their long-term better performance (normal style service lives area unit 30-40 years) and cost-effectiveness, on the other hand, will be demonstrated. In their major metropolitan traffic corridors, a number of freeway agencies choose to use CRCP designs, particularly where traffic volume during the pavement & #39s service life is on the order of tens or hundreds of thousands of equivalent load repetitions.

3. The tight crack widths and nominal vertical movement between adjacent joints of CRCP make it an excellent candidate for resurfacing with asphalt concrete, and the restraint from the steel helps to reduce the frequency and severity of reflective cracking, making it an excellent candidate for resurfacing with asphalt concrete.

4. Continuous reinforced concrete pavement (CRCP): Jointed reinforced concrete pavements (JRCP) are concrete pavements that are reinforced with steel mesh (sometimes referred to as distributed steel). In JRCP, designers purposefully increase the joint spacing and incorporate reinforcing steel to transport mid-panel cracks along the length of the panel. For transverse joints, the standard spacing is thirty feet (9 meters), with some agencies utilizing a distance as lovely at one hundred feet (36 meters) (30.5 m). The usage of this type is now limited to a few numbers of agencies, owing to performance issues caused by the embedded steel & #39s inability to maintain its position along mid-panel cracking, and the erosion/faulting of such cracks as a result.

5. Prestressed concrete pavement (PCP): Prestressed concrete pavements were designed and constructed so that they could be prestressed in the grips of tensile stresses induced by external weights caused by numerous moving objects such as automobiles on the road or aircraft in airports. Because of their relatively thin thickness, prestressed concrete pavements provide adequate performance for their intended use (Younger, 1982).

1.3 Flexible Pavement is classified into three types:

• Full-depth asphalt pavement: A full-depth asphalt pavement area unit is created by laying hydrocarbon layers directly on the soil subgrade, resulting in a continuous asphalt layer. This is frequently much more acceptable when there is a lot of traffic and native materials do not appear to be accessible. Containing rock asphalt mats are formed by sandwiching dense/open hierarchical combination layers between two asphalt layers.

• Contained rock asphalt mat (CRAM): Contained rock asphalt mats are formed by sandwiching dense/open hierarchal combination layers between two asphalt layers. Changed thick hierarchical asphalt concrete laid higher than the subgrade can significantly reduce the vertical compressive strain on the soil subgrade while also protecting it from surface water infiltration. Unbound or bituminous raw materials are used in the production of flexible pavement. A uniform scattering of the applied weight with importance causes the critical element to be transported from the sub-level to the upper level of significance. In addition to a bituminous material surface course, critical base and subbase courses are used in the construction of flexible pavement. The bituminous substance has a dark top that is even more common, and its nature allows for significant plastic deformation. Flexible Pavement can be defined as an asphalt layer composed of a mixture of totals and bitumen that has been properly warmed and blended before being spread and compacted on top of a bed of granular layer. They are designated as "adaptable" because the entire asphalt structure twists or redirects as a result of the amount of traffic on the road surface. In most cases, a flexible pavement construction is composed of a couple of layers of materials that can withstand the "flexing" of unbending asphalts while remaining structurally sound. Portland solid concrete is used to cover the surface of these structures (PCC). Since of the great immovability of PCC, these types of asphalts are referred to as "unyielding" asphalts because they are far stiffer than flexible asphalts. It is common practice to include an improved subgrade (ISG) layer made of stream sand between the black-top and the subgrade to compensate for the subgrade's low bearing breaking point and weak bearing breaking point. According to the current understanding, the sand ISG also serves as a leakage layer, allowing for equal ejection of water from both the top and bottom directions. In a replacement plan, all of these pavement types distribute load over the subgrade in a similar manner. The high solidity of PCC allows Rigid Pavement to course the pile over a relatively long area of subgrade, which will result in a smooth and consistent surface finish. The critical portion itself provides the majority of the fundamental cutoff of a stiff asphalt. Flexible Pavement has a more adjustable surface course and distributes loads over a more discrete zone than traditional pavers. In order to provide weight to the subgrade, it employs a combination of layers. This Guide is organized on the concept of adaptable pavement. The majority of dark top surfaces are supported by a stone base. On the subgrade, a dark major facade of 'full significance' is developed in a distinct manner. Depending on the temperature at which it is applied, the dark top is arranged as a hot blend black-top (HMA), a warm mix dark top, or a cold mix dark top, among other variations. This type of pavement is so named due to the fact that its asphalt surface reflects the complete shirking of all the resulting layers caused by the traffic load circling back to it. Using a layered system to create a flexible pavement design relies on the retailer passing on aspects of the system (Hassan, 2015-12)

1.4 Pavement Management System:

When it comes to pavement management systems (PMS), they are devices that provide a systematic technique for collecting, storing, analyzing, and modeling data on avenue conditions in order to aid in decision-making linked to maximizing assets throughout a pavement network. Models of future pavement damage caused by visitors and weather are included in PMS software program bundles. It supports the preservation and repair of the road's pavement based on the kind and age of the pavement as well as a variety of currently available pavement quality metrics (Arifuzzaman Bhuyan, 2009-10).

Individuals on the ground, visually from a transferring vehicle, or through the use of automatic sensors installed in a car can all be used to collect data. PMS software is frequently used to assist customers in the creation of composite pavement pleasant rankings based on pavement special measures taken on roads or street section segments. Predictive maintenance recommendations are frequently skewed in favor of performing preventative maintenance rather than allowing a road to deteriorate to the point where it requires more spectacular and extensive reconstruction. The following are examples of duties carried out by pavement administration structures:

• Take an inventory of pavement conditions, distinguishing between good, truthful, and awful surfaces.

• Create significance rankings for avenue segments based on factors such as visitor traffic, useful street class, and neighborhood demand.

• Arrange for suitable road protection on a regular basis to keep them in good condition.

• As soon as possible, schedule repairs of dreadful and honest pavements while funds are still available.

1.5 About AADT:

The term "Annual Average Daily Traffic" refers to the fact that the AADT virtually represents the total number of motors that handled a given factor in a year divided by 365, on an annual basis. The process by which AADT is calculated: As we all know, AADT is an abbreviation for annual average daily traffic. First and foremost, we must acquire a representative sample of road volume data, which can be accomplished manually or with the use of a piezo-sensor, radars, or a machine. After gathering this information, we can use the AADT determine formula to figure out what is the AADT.

1.6 Some data table for determination of AADT:

Hour	Vol.	HEF	Hour	Vol.	HEF
6-7 AM	294	42.01	6-7 PM	743	12.4
7-8 AM	426	22.99	7-8 PM	700	17.5
8-9 AM	560	22.06	8-9 PM	660	20.4
9-10 AM	657	15. 8	9-10 PM	488	25.2

10-11 AM	722	17.11	10-11 PM	384	26
11-12 PM	667	18 .52	11-12 AM	360	34.3

12-1 PM	660	18 .71	12-1 AM	241	51. 8
1-2 PM	739	16.71	1-2 AM	150	8 2.3
2-3 PM	8 32	14. 8 4	2-3 AM	100	13.4
3-4 PM	8 36	14.77	3-4 AM	100	12.4
4-5 PM	961	12. 8 5	4-5 AM	8 5	14.4
5-6 PM	8 52	13. 8 5	5-6 AM	137	5.02

Day of Week	Vol.	DEF
Sunday	78 95	9.515
Monday	10714	7.056
Tuesday	9722	7.727
Wednesday	11413	6.572
Thursday	10714	7.012
Friday	13125	5.724
Saturday	11539	6.51
Total Weekly Volume = 75,122		

Hour	Volume
7- 8 AM	400
8-9 AM	535
9-10 AM	650
10-11 AM	710
11-12 AM	650

Day of Week	ADT	MEF
January	1350	1.756
February	1200	1.976
March	1450	1.635
April	1600	1.486
May	1700	1.395
June	2500	0.948
July	4100	0.521
August	3750	0.632
September	2500	.948
October	2000	1.186
November	1750	1.355
December	2300	1.092

Like This collected data shown below on Sunday during the month of April, now we will see how to determine AADT of the road below:

Estimate the 24hour volume for Sunday using the factors given in Table 1:

$$\frac{(400 * 22.99 + 535 * 22.06 + 650 * 15.8 + 710 * 17.11+ + 650* 18.52)}{5}$$

= 11091

Adjust the 24-hr volume for Sunday to an average volume for the week using the factors given in Table:2

Total 7 Day volume = 11091 * 9.515

$$\text{Average 24-Hour Volume} = \frac{11091 * 9515}{7}$$

=15075

Since the data were collected in April use the factor shown in Table 3 to obtain the AADT:

AADT = 15075 * 1.486 = 22402

At first, we are manually collected a road traffic data then we estimated 24 hours volume for Sunday, we divided these values by 5, cause of that we collected 5 times value of Sunday. Then using factors of weekly data, we average 24 hours data of Sunday. Same way we calculate AADT,it is so easy process to calculated if we can collect traffic data firstly.

1.7 Determination process of IRI:

The International Roughness Index (IRI) is a well-known and widely used measure of pavement roughness in the field of pavement management. In order to measure the IRI, a variety of different types of devices can be utilized. These devices, on the other hand, are typically mounted on a large vehicle and are tough to use. Furthermore, these devices are prohibitively expensive. The development of improved approaches for determining IRI size is a necessity for pavement administration systems and other components of the street administration sector in general. There is a strong association between the in-car axis acceleration and the IRI, as demonstrated by the quarter-car mannequin and the automotive vibration induced by road roughness. The model of the automobile's velocity throughout the dimension system has a significant impact on the calculation of IRI. In the past, researchers worked on developing a size machine that was equipped with axis accelerometers and a GPS system. To test the feasibility of the self-designing size machine, which was developed mostly in accordance with the methods presented in this study, we conducted a small-scale area test (Hamim, 2019)

Treatment	Operational Window	Cost (CAD) Per/km
Resealing	IRI >= 1 to >= 2 and Crack >=90	10853
Overlay	IRI >= 2 to >= 4 and PSDI >=65	14454
Major Rehabilitation	IRI >= 4 to >= 6 and PSDI >=50	34704
Reconstruction	IRI >= 6 SAI <= 65	38377

Note: CRACK = % of surface without cracks, rutting = % of surface with rutting, PSD =pavement distress index and SAI = structural adequacy index. (2010).

The following factors provide a comprehensive overview of the IRI idea; the ramifications of these factors are discussed later: In this case, the IRI is calculated from a single longitudinal profile. For accurate computations, the pattern interval must be no more than 300 mm in length. The required decision is dependent on the level of roughness, with the ultimate decision being desired for clean roads as a result. It is appropriate to make an ali judgment at the level of 0.5 mm. It is believed that the profile has a consistent slope between the elevation locations that were sampled. Surface smoothing is accomplished with a transferring common, the base length of which is 250 mm. Smoothed profiles have been used to filter the results of a quarter-car simulation, which had unique parameter values, and was carried out at an average speed of eighty kilometers per hour (49.7 mph). It is necessary to accumulate the simulated suspension action linearly and divide it by the size of the profile in order to obtain the initial resistance index (IRI). As a result, the International Research Institute (IRI) has slope units such as inches per mile or meters per kilometer.

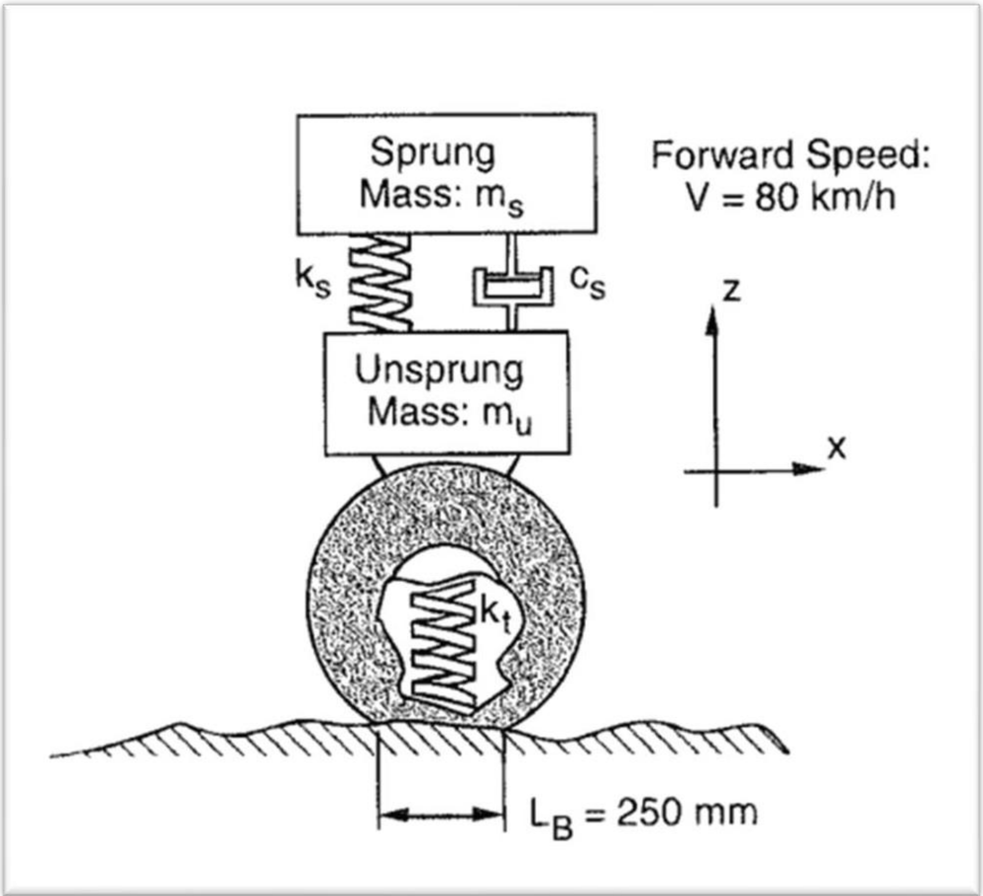

Fig. 1 Quarter-car mode

1.8 Deflection:

In engineering, deflection is defined as the amount to which a structural element is shifted under the influence of a load. The degree to which an avenue formation is replaced when subjected to a load is measured in degrees of deflection. Deflection Bowl - This demonstrates the deformation of the pavement floor's structure caused by the application of a gear to the pavement surface. Maximum Deflection (also known as maximum vertical motion) is the largest vertical motion detected in the pavement. When a load is applied, the road's shape is deflected, which is referred to as deflection. In order to determine the condition of the road, a deflection test must be performed. When deflection is increased, the road quality deteriorates dramatically. Seismometers, speed transducers, and accelerometers have all been used to measure deflections in the past.

1.9 Deflection Measurement:

A used (either static or dynamic) load causes a vertical deflection of the pavement surface, which is quantified as a deflected distance on the pavement surface. The extra better size gadgets record this vertical deflection in more than one area, providing a comprehensive additional characterization of pavement deflection in a single measurement. The deflection basin is a collective term that refers to the area of pavement deflection beneath and close
to the point of load application.

1.10 About RHD:

In terms of nondestructive deflection testing equipment, there are three broad categories to consider:

1. Deflections that are constant
2. Consistent deflections of the kingdom
3. Deflections caused by impact loads (FWD)

The typical principle is to observe a load of known magnitude applied to the pavement floor and then evaluate the shape and magnitude of the deflection basin in order to calculate the electricity of the pavement shape and its electrical conductivity. A non-destructive method of investigating the structural condition of an in-service pavement is through the use of static deflection testing. Over the years, a variety of deflection testing tools have been developed for this purpose, ranging from simple beam-like machines equipped with mechanical dial gauges to ultra-modern equipment based on laser technology. To be sure, all pavement deflection checking out equipment functions essentially in the same way: a known load is applied to the pavement, and the resulting maximum floor deflection or an array of floor deflections positioned at constant distances from the load, referred to as a deflection basin, is measured .

The Benkelman beam is the most important piece of equipment in the static loading strategy. In accordance with stage arm principles, the Benkelman beam system is constructed with the tip of the system being positioned between the twin tires of a single axle that is loaded to eighty KN (18,000 lbs) and the tires are inflated to 480 to 500 kPa (70 to eighty pounds/inch2). As the truck is carried ahead, the operator records the dial size as the pavement rebounds from the axle's weight and the truck is archived. The Benkelman beam's limitations include its inability to measure a deflection basin and only the most extreme floor deflection, It is extremely labor-intensive requirements for use, and its slow rate of checking out, which necessitates visitors to manipulate for halted situations. The Benkelman beam has a number of advantages, the most significant of which is that it is extremely affordable (Saha, 2016). Department of Roads and Highways (RHD) is a Bangladeshi government branch that is responsible for the construction and maintenance of highways and bridges. It is located in the industrial area of Tejgaon in Dhaka, the country's capital city, and has a staff of approximately 2,000 people. The following characteristics should be present in an ideal pavement:

1.The subgrade soil must have sufficient thickness to transfer the wheel load strains to a secure price on the surface soil.

2. Structurally sound, able to withstand any and all of the stresses that may be placed on it.

3. A sufficient coefficient of friction to prevent cars from skidding is also required.

4. A smooth surface that provides comfort to road users, even at high speeds.

5. Make the tiniest amount of noise possible from moving cars.

6. A dustproof surface to ensure that traffic safety is not compromised as a result of reduced visibility.

7. The impermeable surface is designed to provide enough protection for subgrade soil.

8. A long style life combined with a cheap maintenance cost.

As an example, a typical layer of a standard flexible pavement has the following components: seal coat; surface course; tack coat; cover course; prime coat; base course; sub-base course; compacted sub-evaluation; and a common sub-gradation.

1. Seal coat: Seal coat is a minor surface treatment that is used to water-confirm the surface and provide sliding opposition.

2. The second type of coating is known as tack coat, and it is a high light utilization of black-top, which is often black-top emulsion that has been thinned with water. It provides adequate holding between two fastener course layers and should be used sparingly, uniformly covering the entire surface, and setting promptly after application.

3. Prime coat: A prime coat is a thin layer of low gooey reduction bitumen applied to a retentive surface, such as granular bases, over which the cover layer is laid down and hardened. It provides holding between two layers of material. Prime coat, in contrast to

tack coat, penetrates into the layer beneath it, filling up any spaces and forming a water tight surface structure.

4. Surface Course: The surface course is the layer that comes into direct contact with traffic loads and, for the most part, is constructed of materials of unsurpassed durability and quality. It is common for them to be constructed with thick, evaluated black-top concrete (AC).

• It imparts characteristics such as grating, perfection, waste, and so on. Also prevented will be the entry of large amounts of surface water into the primary base, sub-base, and sub-grade of the structure.

• It should be difficult to resist bending under the influence of traffic while providing a smooth and slip-safe riding surface.

• Water verification should be performed in order to protect the entire base and subgrade from the destructive effects of water.

5. Binder course: This layer is responsible for the majority of the black-top solid construction's structural integrity. Its primary goal is to create a reasonable strain on the base course as a result of this. Generally speaking, because the folio course has totals with less black-top and does not require the same level of quality as the surface course, replacing a piece of the surface course with a fastener course results in a more economical plan.

6. Base course: The base course is the layer of material that is immediately beneath the outside of the fastening course, and it provides additional weight conveyance while also contributing to the subsurface waste accumulation. A variety of untreated or balanced-out materials, including crushed stone and squashed slag, could be used to construct it.

7. Sub-Base course: The base course is the layer of material immediately beneath the essential capacity that provides underlying assistance by reducing waste and reducing the interruption of fines from the sub-Base course, among other things.

A level in the asphalt structural framework the sub-base course with the highest number of fines can act as a filler between the subgrade and the base course if the base course is openly evaluated at that point. There are times when a sub-base course is not necessary or utilized. For example, an asphalt pavement constructed over a superior, hardened sub-evaluation may not require the additional features provided by a sub-base course. An additional sub-base course may not be offered in such instances. Topsoil or subgrade is a layer of ordinary soil that is structured in a way that it absorbs the anxieties generated by the layers above it. Fundamentally, the importance of soil subgrade cannot be overstated. When compacted to the desired thickness and close to the desired moisture content, it should seem appealing.

1.11 Measurement Techniques:

Fig. 2 Typical cross section of a flexible pavements

1.12 Some benefits of using flexible pavements:

Repairs are simple, and it tends to be opened and fixed.

1. Materials are reasonable.
2. Settlement can be effectively fixed.
3. Resists ice coat development.
4. Short curation time implies short traffic and business disturbances.
5. No joints needed during establishment.
6. Braking proficiency is better.
7. Flexes under load, subsequently the irrelevant misery gives seriously restricting power.

A treasured benefit of flexible pavement is that it can be opened for site visitors 24 hours after completion. Also, the restoration and renovation of flexible pavement are handy and price- effective. We look out for the importance of flexible pavement, and if we consider this, we can give a question-answer, why we will use the flexible pavement (Haas R.C.G, 1978).

CHAPTER 2
LITERATURE REVIEW

2.1 literature review:

Using the deflection and Prediction Model of Flexible Pavement, we are developing a pavement management system for use in the country of Bangladesh. We'll take a quick look at and examine this type of job right now. Keeping up with the continuous development of infrastructure asset management ideas, it is essential to have a clear understanding of the distinctions between pavement management and infrastructure asset management when applying asset management ideas to the management of an infrastructure organization. The purpose of this study is to clarify key snarls that may occur with the implementation of asset management principles for maintaining pavements. An asset management technique for managing a pavement organization is the subject of this research, which explores many options. There is an explanation of the relationship and difference between an asset management framework and a pavement management framework in this document. It also depicts the components that are necessary from a pavement management framework that is part of a larger asset management framework overall. An overview of pavement management and asset management concepts is followed by a discussion of issues comparing pavement management and asset management concepts, a depiction of parts that should be remembered for either case and/or the two points, and a discussion of the benefits that can be obtained by implementing asset management concepts on pavements. One of the most significant outcomes of this research is that it makes it easier to identify the approaches and instruments that should be used to transmit messages accurately to stakeholders of infrastructure assets, particularly pavement organizations. Pavement management instruments are used in a variety of ways in different products to provide superior organization-level management of pavements. There is no doubt that the concept of infrastructure asset management is distinct from other, more advanced ideas that have drawn the interest of numerous organizations that operate and claim some form of asset. Despite the fact that asset management is a developing concept, a thorough grasp of how to manage pavements in conjunction with this emerging concept is essential.

For over two decades, pavement engineers have been managing pavements through the use of pavement management concepts. With no prior experience, it has been a convenient ride that has brought us one step closer to the implementation of a pavement administration framework (PMS) indoors. A corporation is in the process of establishing an internal structure to support the pavement administration framework (PMS) implementation. Several hurdles or barriers have to be overcome in order for the framework to be completed. Regardless, many firms are confident in their ability to provide a great image while also managing and maintaining their pavements with the help of PMS at this time. At the moment, while asset management ideas are making their way into architects' conversations and usages, the implementation of asset management can encounter similar reactions, such as reluctance from designing office supervisors and even from staff who are already utilizing some type of project management system (PMS). Road rater deflection data were used to determine the in-place subgrade strength as well as the in-place structural capacity of the existing pavements in this study. It is possible to convey about pavement behavior through a reduced thickness of "reference" quality paving materials or a reduced modulus of elasticity for asphaltic cements-built consistency (Hasan, 2020).

There were mathematical correlations established, which made it possible to "program" the evaluation process (in a modular framework) into small hand calculators or minicomputers for use in the field. When it comes to making recommendations for overlay designs, the pavement evaluation technique has been successfully used for a number of different pavement portions Road rater deflection data were used to determine the strength of the in-place subgrade and the structural capacity of the currently installed pavement. Rutting and roughness of the pavement surface were also considered when determining the final overlay thickness recommendations. It may be easier to put a framework into action if all of the involved parties have a thorough understanding of the framework's concepts.

It is critical to understand what asset management will be used for prior to putting it into action. Various types of assets, such as physical assets, human resources assets, financial assets, cash assets, report assets, and so on, can be purchased. The concept of asset management can be extraordinarily complex depending on the type of help provided. Despite the fact that pavement is a physical asset, it is not truly saleable on the open market, unlike many other types of assets. It is possible for successful asset management to boost productivity in terms of administration of assets while also assisting managers in maintaining their support with the smallest amounts of potential charges. In order to maintain an overall asset management interaction, a powerful PMS should assist management agencies in demonstrating greater accountability to asset owners (public). Tradition has it that the responsibility for public assets is expressed through conventional reports, such as financial statements. Because of the Governmental Accounting Standards Board's declaration, referred to as GASB 34

(GASB 1999), it is necessary for all government agencies in the United States to account for infrastructure in their financial statements. In this vein, a pavement network, as a major infrastructure component, should be managed in order to comply with wide asset management and standard announcing requirements, among other things. The information contained in the Sixth International Conference on Managing Pavements (2004) TRB Committee on Pavement Management Systems is intended for use by individual practitioners in state and local transportation agencies, researchers in academic institutions, and various individuals from the transportation research local area. Unless otherwise stated, all of the information in this study was obtained directly from the author's lodging.

It is critical to have a clear understanding of the two concepts "pavement management" and "asset management." The purpose of this study is to characterize the concepts connected to pavement management and asset management, and then to describe and differentiate the two management ideas described in this paper further. In comparison to typical pavements, the article can assist infrastructure asset managers in managing their assets in a more preferred manner, resulting in improved communication among all involved parties and improved management administrations' viability (Dewan, 2004).

Early corrosion of an 18-mile stretch of road in Bangladesh was the subject of a preliminary investigation, which included Benkelman beam avoidance measurements carried out by TRRL in December 1980. The results of the investigation were used to recommend a further diversion review, which was carried out during the ensuing rainstorm. Having made a quick observation on the causes of failure, the main focus of this work is on comparing these avoidance reviews, which illustrates the deterioration of the road over such a short period of time. Two elements were taken into consideration: natural corruption under traffic and the exacerbating effects of runoff pooling beneath the pavement surface. By obtaining an extra reading in the redirection bowl while employing Wiseman's methods, it was possible to determine the subgrade modulus of elasticity and flexural inflexibility along the road during the second review. It was necessary to classify the road surface condition to complete the overview and make a comparison with the avoidance pattern. At the end of the process, the results of the avoidance were utilized to determine the necessary reinforcement for the road (Younger, 1982).

The conventional flexible plan approach is used to analyze data and plan flexible pavement in Bangladesh, and it is primarily based on test and field circumstances that are prevalent in western countries. These systems do not adhere to environmental and regulatory requirements. The physical conditions of the location. In most cases, these constraints do not correspond to the specifications for setup that are often used in Bangladesh and South Asia. The end result is frequently overdesigned, rendering it uneconomical, or under planned, resulting in high maintenance and rehabilitation expenditures in the long run. During the course of this inquiry, the climatic condition of the area is taken into consideration. As a subgrade material, coarse-grained waterway sand is to be used where possible. In this plan, widely known conventional procedures for flexible pavement configuration are compared for the most part to determine their adaptability to the configuration input conditions prevalent in Southeast Asian countries. For the purpose of analyzing flexible pavement plan methods for Bangladesh, two currently used methodologies have been selected, namely, the AASHTO 1993 Guide for Design of Pavements Structures developed in the United States of America and the Overseas Road Note 31 developed in the United Kingdom. For the purposes of comparison, the Indian Road Congress (IRC 37) is also taken into consideration for this investigation.

Pavement structures are planned by all of the techniques utilizing the identical input parameters that were collected from the Bangladeshi field study. The results reveal that the total thickness predicted by the two approaches is virtually identical. However, the AASHTO 1993 approach advises a thicker solid layer in any scenario. Road Note 31 and IRC 37, on the other hand, suggest a greater set of base and sub-base layers. PC program CIRCLY is used to compute the mechanical reactions at crucial locations in the pavement structure in terms of stresses, strains, and avoidances at critical sites. The harmful factors are calculated with the help of the CIRCLY software. Mechanistic reactions in pavements are frequently associated with certain

failure types. Rutting, permanent deformation, fatigue, and thermal cracking are some of the failure types that occur most frequently. The aftereffects of the two procedures demonstrate that buildings planned using the AASHTO 1993 method are more resistant to rutting and persistent deformation. Failures due to fatigue and thermal cracking. Increasing the thickness of base and subbase layers as advised by Road Note 31 and IRC 37 to compensate for thinner asphalt solid layers does not result in a significant increase in stress reduction. Because of their lower asphalt solid layer thicknesses, the designs indicated by Road Note 31 and IRC 37 may be less expensive in the beginning, but they may fail permanently, necessitating higher maintenance and rehabilitation expenses in the long run (Hassan, 2015-12).

2.2 Pavement in aspects in Bangladesh:

In many ways, pavements in a country have been likened to the blood vessels in a human body, and their significance in a country's financial well-being cannot be overstated. Therefore, a well-organized road network and a functional transportation system are vital for economic growth and industrial transformation. Due to the fact that Bangladesh is a developing country, its infrastructure facilities in the transportation domain are not sufficiently developed to be considered a superior communication framework in the international community.

In any case, the demand for high-quality roads and highways is expanding on day-to-day basis. There is no other option than to provide the communication infrastructure that this country needs in order to further its monetary development. The current road construction pattern in Bangladesh is dominated by bituminous pavement, which accounts for over 95 percent of all roads. Due to the fact that the involved companies are creating flexible pavement without making any attempt to determine the pavement determination cycle or doing any comparative analysis, this is the case.

While the construction of unbending pavement is becoming increasingly popular around the world due to its superior performance as well as its environmental benefits, it would be worthwhile to investigate the possibility of using rigid pavement in road construction in Bangladesh, particularly in terms of better understanding under lowered temperatures and pressures. The need for a smaller number of aggregates, the availability of large quantities of concrete on a local scale, and the late price increase of petroleum on the international market are all factors to consider the use of concrete cement for new roads, as well as the over-laying of concrete on blacktopped roads in need of reinforcing, can reduce the need to re-bituminate existing roads in the future.

2.3 Pavements in Bangladesh Have a Long History:

Unbending pavement is not commonly used in Bangladesh because engineers believe that this type of construction entails a high initial cost with no consideration for a comparative monetary analysis. Rigid pavements are being used and implemented in Bangladesh, but road planners and fashioners have misread the use and implementation of rigid pavements, and they have made incorrect assumptions regarding the building process and associated expenses. However, one of the most significant disadvantages of rigid pavement is the high cost of construction in the outset. Solid concrete roads, on the other hand, are becoming increasingly popular around the world, owing to a variety of functional and operational advantages, as well as, above all, from the perspective of life cycle cost. The introduction of modern methods in the construction of long-lasting, dependable structures, the increase in the value of petroleum, and, above all, the participation of private sector in road infrastructure improvement have resulted in the use of concrete pavement in many high-quality road projects, which are primarily carried out under the BOT concept. According to literature obtained from the Internet, the advantage of long life is generally advantageous to private area projects where the lease time frame is as long as 30 years, because a prudent investor would expect his venture to last for the duration of the full-time franchise without the need for major repairs, overhauls, or rehabilitation. An asphaltic pavement, no matter how properly constructed, will require considerable periodic replacement as the pavement begins to deteriorate both functionally and physically. As discovered in actual care, this can happen once in a while, almost like clockwork, on average. One of the primary concerns of traffic management measures these days is the decline in maintenance work, particularly on occupied roadways, which is on the rise. Flexible pavement deteriorates prematurely in Bangladesh as a result of poor construction quality, severe rains, and poor overall condition. As a result, maintenance work is required on a more frequent basis in Bangladesh. As a result, the government is required to spend a portion of its annual budget on pavement maintenance (Arifuzzaman Bhuyan, 2009-10).

2.4 Pavement Life Cycle in Bangladesh (As of the Present Situation):

The purpose of this investigation is to predict the assistance life of flexible pavements in Bangladesh under conditions of extreme overloading. Several road locations with flexible pavements constructed by the Roads and Highways Department were studied, and axle load data, international harshness index (IRI), and overlay history of the pavements were acquired for this investigation. First and foremost, survival bends were developed, which demonstrated that the actual pavement life was around 4.88 years. The intersection point of the overlay graphs, which combined the negative factor vs axle load and the pavement life versus axle load graphs, revealed that premature breakdown of flexible pavements occurs at a time of 4.5 years. As a result, it appears that under the current level of congested traffic circumstances, flexible pavements will last only 5 years, or one-fourth of their planned life. This decreasing pavement future as a result of overcrowding is a key source of concern for Bangladesh, as it incurs expensive maintenance costs and prevents funding for new infrastructure enhancement projects from being made available (Hamim, 2019). In many ways, pavements in a country have been likened to the blood vessels in a human body, and their significance in a country's financial well-being cannot be overstated. Therefore, a well-organized road network and a functional transportation system are vital for economic growth and industrial transformation. Due to the fact that Bangladesh is a developing country, its infrastructure facilities in the transportation domain are not sufficiently developed to be considered a superior communication framework in the international community. In any case, the demand for high-quality roads and highways is expanding on a day to day basis. There is no other option than to provide the communication infrastructure that this country need in order to further its monetary development. The current road construction pattern in Bangladesh is dominated by bituminous pavement, which accounts for over 95 percent of all roads. Due to the fact that the involved companies are creating flexible pavement without making any attempt to determine the pavement determination cycle or doing any comparative analysis, this is the case. While the construction of unbending pavement is becoming increasingly popular around the world due to its superior performance as well as its environmental benefits, it would be worthwhile to investigate the possibility of using rigid pavement in road construction in Bangladesh, particularly in consideration of better understanding under lowered conditions, the necessity of fewer aggregates, and the availability of large quantities of locally available aggregates. The use of concrete cement for new roads, as well as the over-laying of concrete on blacktopped roads in need of reinforcing, can reduce the need to re-bituminate existing roads in the future. The History of Pavements in Bangladesh: In Bangladesh, unbending pavement is not commonly used because engineers believe that this type of construction entails a large initial cost that cannot be justified by a monetary comparison. Rigid pavements are being used and implemented in Bangladesh, but road planners and fashioners have misread the use and implementation of rigid pavements, and they have made incorrect assumptions regarding the building process and associated expenses. However, one of the most significant disadvantages of rigid pavement is the high cost of construction in the outset. Solid concrete roads, on the other hand, are becoming increasingly popular around the world, owing to a variety of functional and operational advantages, as well as, above all, from the perspective of life cycle cost. The introduction of modern methods in the construction of long-lasting, dependable structures, the increase in the value of petroleum, and, above all, the participation of private sector in road infrastructure improvement have resulted in the use of concrete pavement in many high-quality road projects, which are primarily carried out under the BOT concept. According to literature obtained from the Internet, the advantage of long life is generally advantageous to private area projects where the lease time frame is as long as 30 years, because a prudent investor would expect his venture to last for the duration of the full-time franchise without the need for major repairs, overhauls, or rehabilitation. An asphaltic pavement, no matter how properly constructed, will require considerable periodic replacement as the pavement begins to deteriorate both functionally and physically.

As discovered in actual care, this can happen once in a while, almost like clockwork, on average. One of the primary concerns of traffic management measures these days is the decline in maintenance work, particularly on occupied roadways, which is on the rise. Flexible pavement deteriorates prematurely in Bangladesh as a result of poor construction quality, severe rains, and poor overall condition. As a result, maintenance work is required on a more frequent basis in Bangladesh. As a result, the government is required to spend a portion of its annual budget on pavement maintenance (Arifuzzaman Bhuyan, 2009-10).

Pavement Life Circle in Bangladesh (Current Condition): The purpose of this investigation is to predict the assistance life of flexible pavements in Bangladesh when subjected to extreme overloading conditions. Several road locations with flexible pavements constructed by the Roads and Highways Department were studied, and axle load data, international harshness index (IRI), and overlay history of the pavements were acquired for this investigation. First and foremost, survival bends were developed, which demonstrated that the actual pavement life was around 4.88 years. The intersection point of the overlay graphs, which combined the negative factor vs axle load and the pavement life versus axle load graphs, revealed that premature breakdown of flexible pavements occurs at a time of 4.5 years. As a result, it appears that under the current level of congested traffic circumstances, flexible pavements will last only 5 years, or one-fourth of their planned life. This decreasing pavement future as a result of overcrowding is a key source of concern for Bangladesh, as it incurs expensive maintenance costs and prevents funding for new infrastructure enhancement projects from being made available. (Hamim, 2019)

2.5 Pavement management system:

A pavement management system has been designed in response to the move from the format and construct mode to the repair and maintain mode in pavement construction projects. Once upon a time, the nation's network of freeways and major roadways was almost completely completed. Historically, one of the most important responsibilities of dual carriageway businesses was to ensure the long-term preservation of the enormous investment in pavements. At the same time, the funds available for pavement maintenance were becoming increasingly sparse. The amount of pavement miles in need of restoration or rehabilitation was increasing as a result of factors such as aging pavement and increased truck traffic. As a result of this situation, there is an increasing backlog of pavement upkeep requirements. Pavement engineers and planners believed that the approach used to construct a structure might be able to provide further low-cost exploitation of limited resources. The concept of premenstrual syndrome (PMS) originated from these assumptions.

Pavement Management Systems contain a one-of-a-kind discussion of the preliminary PMS improvement critical drivers that can be found nowhere else. In the beginning, there were simple statistics processing approaches that evaluated and ranked potential pavement restoration initiatives solely on the basis of new pavement conditions and traffic factors. The forecasting of future pavement conditions was no longer taken into consideration, and no monetary evaluation of preventative vs deferred repair was carried out. Despite the fact that these were project-level frameworks that attempted to view job priorities, they did not officially address network-level planning issues such as the influence of limited resources and desired overall performance expectations for an entire roadway network. From the early 1980s, structures were created with the community's viewpoint formally included, and one of these devices was developed specifically to meet the needs of the Arizona Department of Transportation. Transportation infrastructure has developed unexpectedly over the course of a lengthy period of time and now represents a significant investment of financial resources. Accelerated administration of transportation infrastructure becomes increasingly important as these amenities become older and traffic usage increases. When it comes to delivering transportation services, the pavement shape is one of the most important components of the avenue transportation machine and represents a major portion of the total charge. Sound pavement management techniques are required in order to offer appropriate services through the allocation of funds, equipment, employees, and other resources in an environmentally conscious and efficient manner.

The most important goal for pavement administration is the beautiful and efficient coordination of a variety of activities to deal with supplying and maintaining pavements in a condition that is desirable to the traveling public at the lowest possible life-cycle cost. 1986 According to the American Society of Civil Engineers' "Guide for Design of Pavement Structures," "pavement management in its broadest sense comprises all of the things to do concerned with the planning, design, construction, maintenance, evaluation, and rehabilitation of the pavement element." In the context of a public works program. In many cases, uneven pavement surfaces are to blame for the deaths of motorists on dual carriageway sections of highway. Bad roads also degrade the performance of the car and the driver's overall performance, and they are also accountable for cerebral strain. Observations of test results have determined that the immoderate roughness and uneven velocity of a car can significantly reduce the driver's pulse rate, so altering his overall response. It is therefore vital to classify roughness parameters correctly in order to manage journey fine and ensure safety. In this research, some papers were evaluated that discussed the elements responsible for imposing pavement roughness as well as the methodology used to calculate the unevenness of the pavement surface. The pavement management system has been established as high-quality equipment that will maximize the use of local resources for pavement maintenance and rehabilitation while minimizing the use of imported resources.

2.6 Factors of pavement management system:

A pavement administration system (PMS) is a collection of equipment or processes that assists decision-makers in determining the most effective strategies for providing, reviewing, and maintaining pavements in a functional state for a certain period of time. The pavement is in an excessively serviceable condition immediately following construction. As the pavement ages and the detrimental effects of local weather and fatigue mount, the degree of serviceability diminishes accordingly. Throughout a pavement's serviceability history, several rehabilitation or preservation strategies may be implemented in order to prevent the pavement's serviceability from deteriorating to a level that is less than minimally acceptable. The following are the most important PMS factors discussed in this paper:

1. Functions.
2. Data series and administration of the data
3. Prediction of the overall performance of the pavement.
4. An examination of the economic situation.
5. Evaluation of the priorities.
6. Optimization.

This research described the evolution of the key factors of a PMS over the course of three many years and predicted the future course of each element in the system's critical factors. Over the next ten years, significant advancements in pavement management systems are expected, including: increased linkage between databases and increased access to databases; systematic updating of pavement overall performance prediction models through the use of statistics from ongoing pavement condition surveys; seamless integration of a couple of administration structures of recreation to a transportation organization; and increased use of geographic information systems (GIS).

2.7 Example of Pavement failure in Bangladesh:

For example, the total length of paved roads in the city of Rajshahi is around 186.64 kilometers (2011 statistics). It demonstrates that in failure conditions, around 23% of total road lengths are available for use. This analysis demonstrates an inquiry to determine the categories of flexible pavement failures, to describe and distinguish the reasons for the failures, and to select the most appropriate maintenance for the flexible pavement failures in Rajshahi. There are many other types of losses that can occur on the roadways, including various types of cracks, potholes, raveling, water bleeding, corrugation and shoving, discouragement, and rutting. Poorly designed bituminous blends with low-quality materials, excessive traffic loads, heavy rains, and poor drainage on the pavement are all potential reasons of flexible pavement failures. Because of a lack of suitable planning, inspection, and treatment, the losses are gradually increasing. These failures result in a variety of negative consequences, including traffic congestion, passenger and driver anxiety, increased vehicle operating and maintenance costs, and so on. This investigation reveals that the authorities use pavement failure repair approaches that are approximately 60% similar to the traditional road maintenance methodology in order to fix pavement defects. According to this inquiry's findings, it is recommended that the Roads and Highway Department and the Rajshahi City Corporation carry out maintenance in accordance with the prerequisites of genuine care and asset availability, which were discovered in this research (8) Life cycle of Pavement Management: For three asphaltic concrete pavement purposeful type families, this finding out about studies the fee effectiveness of a range of life-cycle preventative preservation tiers (PM) using a cost-effectiveness analysis. The efficacy and cost associated with each of the available life-cycle PM techniques have been estimated for each individual family member.

The efficiency of a strategy was formerly measured by the increase in carrier lifestyles when compared to a base-case approach. The value of a strategy was previously measured in terms of the costs incurred by employers and individuals in connection with the services provided by that plan. A statistical model was constructed to describe the relationship between life-cycle pavement maintenance effort and its success in extending pavement life at a low cost per unit of time based on the estimated charges and effectiveness. It has been demonstrated that increasing PM is typically associated with increasing value efficacy (but solely up to a particular turning factor past which fee effectiveness decreases). Once upon a time, it was determined that the most fee effective pavement and the corresponding degree of annualized PM are influenced by how the pavement's purposeful kind and value aspects are taken into consideration. The pavement management community is now provided with a consistent approach for estimating the projected changes in pavement carrier lifetimes as a result of changes in PM expenditures (Sinha, 2005).

Prediction of Road Deflection: It is critical to conduct regular evaluations of in-service pavements in order to keep them in great serviceable condition. The development of a reasonable adaptable pavement degradation and maintenance management model necessitates the concentration of implementing companies on pavement maintenance and rehabilitation operations, which involves consideration of cost and financial factors. This model is an equation that relates several parameters of structural evaluation, such as CBR and traffic volume, in one equation. It will be simple to determine the deflection of roadways using this deflection model, which will be useful in determining the deterioration and performance of asphalt pavements. It will be simple to keep the pavement in good condition or to design a new overlay. To construct these models, the current investigation is centered on the Benkelman beam study of 6 stretches each of 1 km of rough rural roads in the neighborhood of NH22, which are currently under investigation. In the Indian state of Himachal Pradesh, it took one year to complete the Test before it was considered successful. It is possible to construct this model with the help of statistical analysis equipment. The CBR of the subgrade and the amount of traffic are two of the yield characteristics.

The Test's ramifications are expected to be completed in April 2019. The examination of the pavement is used to determine the current status of the road, regardless of whether or not the road is functionally and structurally stable. For example, deflection in the road, CBR testing, and traffic considerations are all used in the evaluation of road structure. A considerable section of road pavement layers has been structurally damaged, and this has had a negative impact on the traffic situation for an extended period of time. Pavement deterioration can be exacerbated by an increase in traffic volume and the addition of extra axles. In this case, structural examination is required on a regular basis, and may include pavement deflection, soil testing, and other measures of structural integrity. Progress in the development of a pavement deflection forecast model is critical in this regard.

2.8 Determination of Flexible Pavement Roads in Bangladesh:

It was necessary to identify and classify the different types of pavement failures on the selected rural routes. In the pavement industry, cracking is the most generally recognized type of behavioral failure. The majority of the time, it occurs as a result of the loading action of the moving vehicles; therefore, the Test is carried out in order to discover the exact cause of the failure. To identify the root causes of failure and degradation in a request so that it can be avoided in the future. It is necessary to identify the factors that contribute to pavement failure and deterioration over time in order to prevent this from occurring in the future.

The overlay thickness is determined, and the preferred size is chosen in order to reduce the likelihood of failure. It is necessary to investigate the causes of deflection in flexible pavement (bituminous pavement) before proceeding with the development of maintenance plans for this type of pavement. The most common reason for deflection is the frequent application of weight from moving automobiles and other vehicles to the pavement is a feature of the pavement. Identifying the traffic volume and selecting the appropriate overlay thickness can make a significant difference in lowering the deflection phenomenon of pavement. It is necessary to select the most appropriate and effective treatment and maintenance method. In order to locate the pavement The deflection measurements obtained during treatment processes are quite useful. The strategies for treating the pavement are discovered, and these include repairing, another overlay, and other methods (Jain, 2019).

The pavement on highways is a critical component of transportation infrastructure. Despite the fact that highway pavement provides vital sorts of aid to the general public, it has a substantial impact on the environment. During the course of pavement construction and highway operation, a significant amount of nonrenewable energy is consumed, and a massive amount of greenhouse gas (GHG) is emitted. It is estimated that the transportation sector accounts for almost 14 percent of worldwide greenhouse gas emissions, with road building, rehabilitation, maintenance, administration, and consumption accounting for around 72 percent of total emissions (ASTAE 2009; IPCC 2014). Despite the fact that fossil-fueled cars account for the vast majority of total energy consumption and discharges from highway transportation, pavement conditions and construction maintenance tactics have a significant impact on these figures. Pavement that is structurally incompetent deteriorates quickly and requires more consecutive reconstruction and maintenance, which is likely to generate traffic congestion as well as increased energy consumption and greenhouse gas emissions. Furthermore, upsets like as cracking and rutting are more likely to occur on weak pavement, and they increase the harshness of the road surface as a result. It has been discovered that rough pavement has a detrimental impact on car mileage. Building a solid pavement, on the other hand, necessitates the use of more materials and more focused construction operations, both of which increase construction-related energy consumption and greenhouse gas emissions. The overdesign of roadway pavement that is prone to low traffic volume may not be the best decision in terms of environmental conservation as a whole. As a result, for transportation agencies to create and maintain ecologically friendly pavement, it is crucial that they understand the links between pavement plan/management decisions and life cycle energy consumption and GHG outflows.

In most cases, decisions for pavement design and management are based on considerations of technical, financial, and safety factors. Despite this, highway agencies as a whole are becoming increasingly concerned with evaluating the environmental consequences of their decisions, including energy consumption and greenhouse gas emissions (GHG) (Barandica et al. 2013; Biswas 2014; Giustozzi et al. 2012; Jullien et al. 2015). For example, in Hong Kong, the public authority expressly requires that all agencies lead sustainability assessments of their major initiatives and programs and explain the sustainability implications of those assessments in their submissions to the Policy Committee and the Executive Council, among other things. " Hong Kong has more than 2000 kilometers of highways and almost one million engine vehicles. Performing a life cycle assessment of pavement plan management alternatives to determine their influence on life cycle energy consumption and carbon footprint may aid in the turn of events and the operation of a "greener" highway organization (Chong, 2017).

2.9 Reclaimed Asphalt Pavement in Bangladesh:

It was necessary to identify and classify the different types of pavement failures on the selected rural routes. In the pavement industry, cracking is the most generally recognized type of behavioral failure. The majority of the time, it occurs as a result of the loading action of the moving vehicles; therefore, the Test is carried out in order to discover the exact cause of the failure. To identify the root causes of failure And, degradation in a request so that it can be avoided in the future. It is necessary to identify the factors that contribute to pavement failure and deterioration over time in order to prevent this from occurring in the future. The overlay thickness is determined, and the preferred size is chosen in order to reduce the likelihood of failure. It is necessary to investigate the causes of deflection in flexible pavement (bituminous pavement) before proceeding with the development of maintenance plans for this type of pavement. The most common reason for deflection is the frequent application of weight from moving automobiles and other vehicles to the pavement is a feature of the pavement. Identifying the traffic volume and selecting the appropriate overlay thickness can make a significant difference in lowering the deflection phenomenon of pavement. It is necessary to select the most appropriate and effective treatment and maintenance method. In order to locate the pavement The deflection measurements obtained during treatment processes are quite useful. The strategies for treating the pavement are discovered, and these include repairing, another overlay, and other methods (Jain, 2019). The pavement on highways is a critical component of transportation infrastructure. Despite the fact that highway pavement provides vital sorts of aid to the general public, it has a substantial impact on the environment. During the course of pavement construction and highway operation, a significant amount of nonrenewable energy is consumed, and a massive amount of greenhouse gas (GHG) is emitted. It is estimated that the transportation sector accounts for almost 14 percent of worldwide greenhouse gas emissions, with road building, rehabilitation, maintenance, administration, and consumption accounting for around 72 percent of total emissions (ASTAE 2009; IPCC 2014). Despite the fact that fossil-fueled cars account for the vast majority of total energy consumption and discharges from highway transportation, pavement conditions and construction maintenance tactics have a significant impact on these figures. Pavement that is structurally incompetent deteriorates quickly and requires more consecutive reconstruction and maintenance, which is likely to generate traffic congestion as well as increased energy consumption and greenhouse gas emissions. Furthermore, upsets like as cracking and rutting are more likely to occur on weak pavement, and they increase the harshness of the road surface as a result. It has been discovered that rough pavement has a detrimental impact on car mileage. Building a solid pavement, on the other hand, necessitates the use of more materials and more focused construction operations, both of which increase construction-related energy consumption and greenhouse gas emissions. The overdesign of roadway pavement that is prone to low traffic volume may not be the best decision in terms of environmental conservation as a whole. As a result, for transportation agencies to create and maintain ecologically friendly pavement, it is crucial that they understand the links between pavement plan/management decisions and life cycle energy consumption and GHG outflows. In most cases, decisions for pavement design and management are based on considerations of technical, financial, and safety factors. Despite this, highway agencies as a whole are becoming increasingly concerned with evaluating the environmental consequences of their decisions, including energy consumption and greenhouse gas emissions (GHG) (Barandica et al. 2013; Biswas 2014; Giustozzi et al. 2012; Jullien et al. 2015). For example, in Hong Kong, the public authority expressly requires that all agencies lead sustainability assessments of their major initiatives and programs and explain the sustainability implications of those assessments in their submissions to the Policy Committee and the Executive Council, among other things. " Hong Kong has more than 2000 kilometers of highways and almost one million engine vehicles.

Performing a life cycle assessment of pavement plan management alternatives to determine their influence on life cycle energy consumption and carbon footprint may aid in the turn of events and the operation of a "greener" highway organization (Saha, 2016)

2.10 Design of Flexible Pavement:

Practical techniques, layered elastic, and two-dimensional finite element analysis (FEA) are commonly used in the design of flexible pavements. When it comes to determining stress, stress displacement, and displacement in pavement analysis, there has been a shift toward more incredible mechanistic plan solutions in recent years. This lookup file contains information on the application of 3D finite factor software for forecasting mechanical conductivity and pavement overall performance under a variety of visitor factors. From the perspectives of fatigue and long-term deformation, various axle configurations, tire imprint areas, and inflation stress are explored in this study to determine the extensive effects on pavement injury onset.

According to the results of this study, bendy pavement modeling has been carried out using the ABAQUS software program, and the mannequin dimensions and aspect k as well as ends and meshing techniques were determined through a process of trial and error to achieve the desired accuracy and convergence. As a result, it has been determined to practice ideal tire imprint placement in the functional diagram of pavement for a number of different axle configurations. Applicability of the software program ABAQUS for specific design features, such as traffic-related factors, is extremely practical, as evidenced by the evaluation and determination of pavement overall performance of existing roadways, as well as the discovery and evaluation of the total traffic carrying potential of the existing pavement. The early lookup of site visitors' linked elements in the pattern of flexible pavement below distinctive fabric qualities, mannequin geometries, and so on is archived in this article. Based on the consequences that have been presented in this. According to the research, the tire imprint location is desired to be a rectangle with two semicircles on either side. Round, rectangular, and ellipsoid tire contact areas are no longer ideal since they generate lower amounts of stresses and lines for the same amount of surface area than other shapes. It is important to note that tire pressure does not remain consistent throughout the impression area. A variety of tests have revealed that the expanded version of tire pressure is stable only within the contact area's core area, according to the findings. Extensive research has been done to determine how stress-strain conductivity interacts with the sketch segment of flexible pavement. This piece of paper has only covered a little portion of it.

The primary problem here is that pavements are frequently subjected to shifting truck loads rather than static groupings, and the material response is viscoelastic in nature, creating a problem. It is also necessary to investigate the impact of shifting hundreds and the viscoelasticity of asphalt pavements. A similar approach will be employed in the pavement failure criterion, fatigue, and eternal deformation, and the results will be used to calculate the ESAL for a variety of axle load situations once more. To confirm the software program utility and afterwards improve a low-cost sketching technique based only on finite component analysis, sufficient governmental support is required to make laboratory investments and set up a test environment in which to do so (Jain, 2019).

A low-cost protection program, based on the HDM-4 model, is used by the Roads and Highways Department of Bangladesh to maintain control over its street property. But it has been observed that some of the thin rehabilitation overlay solutions have been shown to be less effective in recent years when applied to a specific design of roads, which is a concern. The HDM-4 has recommended that these roads receive repeated overlays within the next two to three years. As a result, the current structural strengths of these roads were determined through the use of deflection statistics and the application of a Benkelman beam, and the thicknesses of strengthening overlay (thick overlay) were calculated through the application of the Asphalt Institute rehabilitation plan chart. The following example illustrates how to determine the needed thickness of overlay by referring to the Asphalt Institute rehabilitation format chart (see Figure 1). When it came to the American Association of State Highway and Transportation Official equation, consistency used to be evaluated for accuracy. At long last, appropriate remedial intervention standards have been selected, which will allow the HDM-4 to be used to determine the most valuable thicknesses of reinforcing overlay for structurally vulnerable roads in Bangladesh (Chong, 2017).

2.11 Difficulties of Pavement construction in Bangladesh:

In Bangladesh, the construction of a pavement that has been meticulously planned is a challenging undertaking. In many sections of the country, low-lying terrain necessitate the construction of substantial embankments in order to develop roadways above the typical flood level. Various waterways and canals necessitate the construction of numerous scaffolds and courses in order to be crossed. Finally, the paucity of high-quality road material has resulted in the use of imported hauled material in the higher pavement layers for a long period of time. All of these variables contribute to huge conjecture about the feasibility of building a road, despite the fact that a significant investment has been made in this area for the practical betterment of the country. As a result, the total length of paved roads has expanded from 4000 kilometers in 1971 to

20000 kilometers in 2001. Maintaining the rideability of the pavements is yet another major challenge for the Bangladesh road administration. Many RHD (Roads and Highways Department, Bangladesh) roads break far sooner than their planned life expectancy, according to a Road Material Standards Study (RMSS) conducted in 1994. The fact is that many regional (medium traffic) roads reach critical conditions (requiring an overlay or considerable repair work) when only a small amount of their scheduled traffic is carried out. This condition is caused by the rapid degradation of pavements within a couple of years of construction due to cracking, raveling, and potholing. This problem is sometimes exacerbated by a lack of sufficient care, which is commonly the case. Because of the ponding of water, it is easy to see the lack of trainability of the pavements in Bangladesh. The deterioration of block aggregates and the siphoning of particles from the hidden strata are shown by the murky reddish water in the sample. This is how it is put to use.

The use of poor-quality materials, insufficient subsurface drainage systems, insufficient pavement foundations, a lack of quality control during construction, insufficient maintenance, and overloading are just a few of the factors contributing to this horrible state of affairs. Stone quarries can be found on the northern edge of the country, near the border with Canada. In order to meet the country's demand for stones, an enormous quantity of stones is imported from neighboring countries each year. Although better canal sands may be found across the country, coarse sands are only found in the northern half of the country, which is a particular feature of the country. As a result, high pricing due to restricted inventory and large transportation fees due to vast hauling distances make standard road materials prohibitively expensive in many parts of the United States. Consequently, due to a scarcity of stone aggregates, road designs frequently prefer the use of picket (over consumed block OBB) aggregates in their construction. They often meet the established strength requirements for the upper pavement layers, which is a good thing. Unfortunately, quality picket aggregates are also hard to come by because only 8 percent to 10 percent of the yield from a block kiln is made up of quality pickets. Once again, these are widely used in the real estate industry for high-quality work.

As a result, road engineers are attempting to employ more universal brick aggregates in pavement construction in order to save money on financial construction. Their lower strength properties, on the other hand, prevent them from being used in the pavement's top layers. Blocks are readily available for delivery throughout the country. In several countries, better sands (FM 1.00) are also available, which are typically mixed with block aggregates to save money and meet grading requirements. Most people in Bangladesh (80 percent) reside in rural areas, which is typical for the country. Providing an essential level of access to all rural communities is vital to ensure financial improvement in these areas as a whole. As a result, advancement in a practical and sustainable road organization is required, taking into consideration the current condition of limited assets, inferior quality materials, and extreme weather, in order to ensure average accessibility to all country areas. When it comes to practical construction, the use of locally available resources is vital. Block aggregate, fine sand (FM 1.00), and soil are examples of potential local resources to use.

An old-fashioned road subbase material, block aggregates and sand are combined to make it. This blend also has excellent CBR values (more than 80%) for usage in the RHD (Roads and Highway Department of Bangladesh) calculated road base layer, but it does not provide sufficient performance and is therefore avoided in this layer. Additional to moisture-related effects, higher burdens on a road base resulted in faster deterioration of the softer block aggregates and thus, earlier collapse of the pavements. Whatever the case, reinforcing the blend through the use of proper treatment may aid in the improvement of the road foundation layer.

The inclusion of a little quantity of concrete and a variety of various materials, such as fine dirt, fly ash, or filaments, may result in solid and durable materials that are the least expensive to produce. Such an application would be extremely promising due to the fact that the cost of block aggregates is only half that of the standard road base material, which is stone aggregates. A cemented road base would also reduce the amount of water-related damage to pavements, extending the life of those pavements. In this case, the pavement is designed as a flexible type, with unbound foundation layers of thickly graded materials and bituminous surfacing. In order to overcome the exceptionally low CBR (California bearing ratio) values of the subgrades as a rule, a capping layer of fine to medium sand is applied, which is known as a 'enhanced subgrade' in the area. This layer of the pavement is often referred to as the drainage layer of the pavement (Alam, 2004).

CHAPTER 3
DATA COLLECTION

3.1 Introduction:

The main aim of this research study is to compare the effectiveness and efficiency of rigid and flexible pavement in particular relation to construction, maintenance and sustainability in Bangladesh. In order to achieve this, aim it is needed to predict the actual pavement life, the impact of overloading on pavement life, quality control of construction in field level and especially the life cycle costs of the two types of pavements. For assessing the performance of rigid and flexible pavements in the context of Bangladesh it is necessary to collect sufficient and relevant data such as International Roughness Index (IRI) of different road sections to predict the remaining service life of flexible pavements, axle load data from weigh stations set up by Roads and Highways Department at different prime locations to evaluate the damaging factor due to overloading, field observation of construction practice, paving mix ingredients and specimens are also collected to identify to what extent the quality of works are being controlled, design data of rigid and flexible pavements along with the unit cost of construction and maintenance are used to determine the life cycle costs for a design life of 20 years. This chapter is concerned with the data collection, the problems encountered during data collection and the adequate measures that have been adopted, pilot survey and site selection following the procedures described in the Chapter 3.

3.2 Site Selection:

In this study, for achieving the objectives of research work, four types of sites are selected and surveyed. One type was for predicting the actual pavement life using the calculated Pavement Condition Rating (PCR) based on the IRI values for different types of road sections. The second type was for assessing the impact of overloading on overall life of a pavement. The third type of sites was selected for carrying out life cycle cost analysis of rigid and flexible type of pavement. The fourth type of sites was selected for evaluating the quality of construction work by performing field investigation techniques. The detailed description of sites and the rationale of selecting such sites are presented in the following section.

3.2.1 For Predicting Actual Pavement Life:

Initially, a pilot survey was carried out within the RHD road network to find out the suitable road sections for collecting relevant data for successful prediction of actual pavement life. The main criteria for selecting the sites were:

1. Availability of data regarding the last overlay performed on that road section.

2. Representative samples covering all three types of road sections such as national roads, regional roads and Zilla roads.

3. Reliability of data in terms of accuracy in collection of IRI values.

During reconnaissance survey a large number of sites were found from the RHD database but for only few of the sites the overlay history could be found. So, based on the above-mentioned criteria a total of nine road sections covering about one hundred and seven kilometers and six hundred and seventy-seven meters (107.677 km) were selected for the final survey. These sites included four national roads and three regional roads. For obtaining IRI data from HDM circle of RHD, a permission letter was written to the Chief Engineer, Roads and Highways Department through my thesis supervisor.

3.2.2 For Evaluating the Overloading Impact on Pavement Life:

In order to assess the impact of overloading on pavement life, the axle load data of heavy vehicles running on roads need to be acquired. During the piloting survey phase, a search was conducted to explore the locations where axle load data can be found. For selecting the weigh stations the following criteria were given importance:

• Availability of continuous axle load data throughout the day and night.

• Prime locations being significantly affected by overloaded heavy trucks.

• Reliability of acquired axle load data.

During reconnaissance survey, it was found that a number of weigh stations throughout the country have been placed by Roads and Highways Department but only a few are active now. The main reason behind the inactiveness of the weigh stations are the political unrest situation and the oppression from the truck owners. During this research work, two active weigh stations controlled by Regnum Resource Ltd under the supervision of RHD were found at Shitakundo, Chittagong and Bathuli, Manikgonj. The axle load station located at Bathuli, Manikgonj was selected for the final survey. For obtaining axle load data from the weigh station, due permission was taken from the Executive Engineer, Manikgonj Road Division, RHD.

3.2.3 For Life Cycle Cost Analysis of Rigid and Flexible Pavement:

For determining the initial and life cycle cost of rigid and flexible pavement several ongoing and completed projects by RHD was observed during the reconnaissance survey. The following factors were considered before selecting the roads for performing the life cycle cost analysis:

• Availability of the pavement design data.

• Compatibility in construction and maintenance cost of both rigid and flexible pavement.

• Need of considering costs associated with traffic delay during construction.

For the final survey, in order to compare the initial and life cycle cost of both flexible and rigid pavements, case studies are made on the following road sections and the relevant data were collected accordingly:

a) Debogram-Progoti Sharani Link Road Project,

b) Dhaka-Sylhet Highway Restrengthening Project,

c) Sylhet-Bholaganj Road Project.

For economic analysis, for converting all the costs to Net Present Value (NPV) the discount rate proposed by the Planning Commission, Bangladesh was acquired.

3.2.4 For Field Data Collection for Performing Laboratory Experiment:

In order to assure quality control in pavement construction various field investigations need to be performed. For carrying out field investigations regarding various aspects of flexible pavement construction, data was collected from two construction sites of Dhaka city in the form of critical observation of construction practice, paving mix ingredients and specimens were also collected from these two sites. These two construction sites were selected for the final survey to observe whether proper method is followed in the construction of flexible pavement which were undertaken by Dhaka City Corporation (DCC) engaging local contractors. These two road sections were different from each other with respect to geometric features and traffic loading patterns.

3.3 Description of Sites:

The description of the selected road sections is presented along with the location details, map of the site, geometric features and traffic loading data where necessary.

3.3.1 Site Description for Predicting Actual Pavement Life:

Four national roads N3, N5, N501, N504 of Roads and Highways Department were selected and six road sections from these selected national roads were taken for further analysis. Three road sections were taken from three reginal roads R110, R112 and R370 of Roads and Highways Department. The site description along with google maps are provided in a tabular form and the road sections taken are also identified:

Table 3.1: Chainages of Selected Road Sections

Road Number	Road Section Taken for Analysis	
	Chainage from (km)	Chainage to (km)
N3	0	10
N5	21.987	34.087
	62.947	74.434
	181.907	210.007
N501	0	4.7
N504	0	4.811
R110	0	9.5
R112	0	8.486
R370	20.932	40.023

3.3.1.1 Site Description of N3

Basic Information	
Road Number	N3
Road Name	Dhaka (Banani)-Joydebpur-Mymensingh Road
Class	National Highway
Length (km)	111.583
Starts at	Dhaka (Banani)
Ends at	Mymensingh DC Office

Traffic and Other Information	
Traffic (AADT)	18755 (Motorized: 17864; Non-Motorized: 891)
Average Width (m)	8.19
Number of Bridges	24
Number of Ferry Ghats	0
location	
Division	Length (km)
Gazipur	56.00
Mymensingh	55.59

Figure 3.1 Google Map of N3

3.3.1.2 Site Description of N5

Basic Information	
Road Number	N5
Road Name	Dhaka (Mirpur) – Utholi – Paturia – Natakhola – Kashinathpur - Bogra - Rangpur - Beldanga - Banglabandha Road
Class	National Highway

Length (km)	526.033
Starts at	Mirpur Bridge
Ends at	Banglabandha
Traffic and Other Information	
Traffic (AADT)	8913 (Motorized: 7853; Non-Motorized: 1060)
Average Width (m)	7.17
Number of Bridges	338
Number of Ferry Ghats	0

Traffic and Other Information	
Division	Length (km)
Average Width (m)	7.17
Number of Bridges	338
Number of Ferry Ghats	0
Location	
Division	Length (km)
Dhaka	22.34
Manikganj	55.97
Pabna	28.84
Sirajganj	54.75
Bogra	64.74
Gaibanda	32.85
Rangpur	79.08
Nilphamari	13.31
Dinajpur	51.6
Thakurgaon	30.60
Panchgarh	71.27

Figure 3.2: Google Map of N5

3.3.1.3 Site Description of N501

Basic Information	
Road Number	N501
Road Name	Mirpur Bridge – Dhour Road
Class	National Highway
Length (km)	11.942
Starts at	Mirpur Bridge
Ends at	Dhour
Traffic and Other Information	
Traffic (AADT)	11346 (Motorized: 10823; Non-Motorized: 523)
Average Width (m)	7.33
Number of Bridges	2
Number of Ferry Ghats	0
Location	
Division	Length (km)
Dhaka	11.94

Figure 3.3 Google Map of N501

3.3.1.4 Site Description of N504

Basic Information	
Road Number	N504
Road Name	Nagarbari (Pratappur) – Kashinathpur Road
Class	National Highway
Length (km)	6.653
Starts at	Nagarbari (Pratappur)
Ends at	Kashinathpur
Traffic and Other Information	
Traffic (AADT)	6489 (Motorized: 4713; Non-Motorized: 1776)
Average Width (m)	7.32
Number of Bridges	2
Number of Ferry Ghats	0
Location	
Division	Length (km)
Pabna	6.65

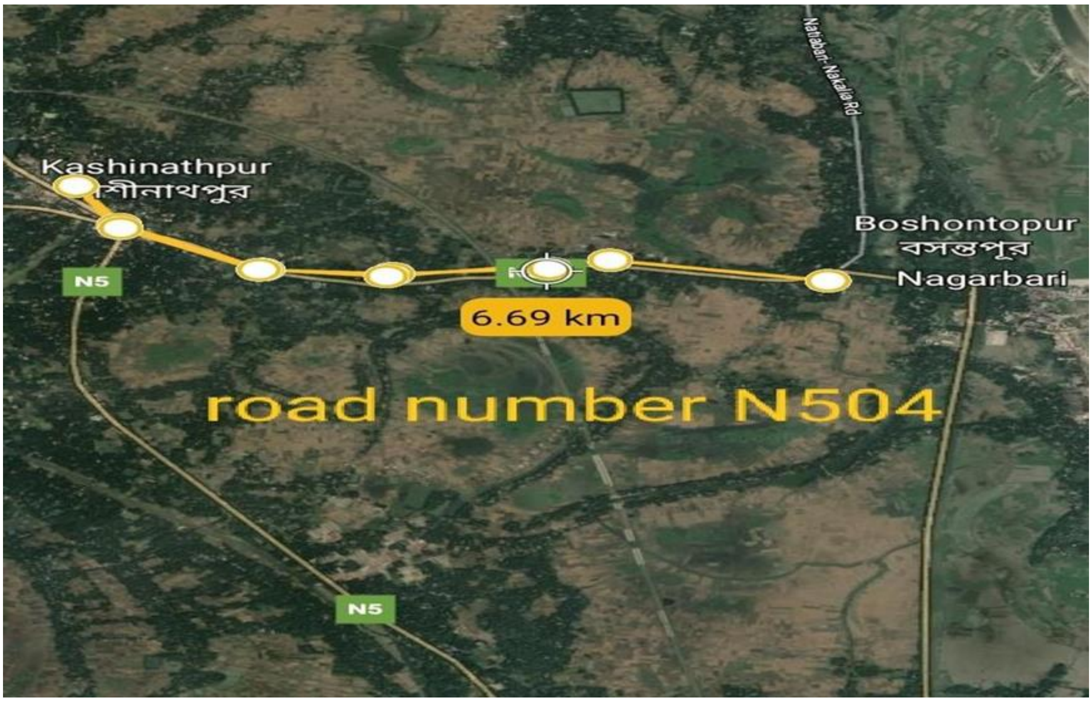

Figure 3.4 Google Map of N504

3.3.1.5 Site Description of R110:

Basic Information	
Road Number	N3
Road Name	Jatrabari – Demra – Shimrail – Narayanganj(Chasara) Road
Class	Regional Highway
Length (km)	18.926
Starts at	Jatrabari
Ends at	Chasara
Traffic and Other Information	
Traffic (AADT)	15309 (Motorized: 12953; Non-Motorized: 2355)
Average Width (m)	8.60
Number of Bridges	8
Number of Ferry Ghats	0
Location	
Division	Length (km)
Dhaka	9.52
Narayanganj	9.40

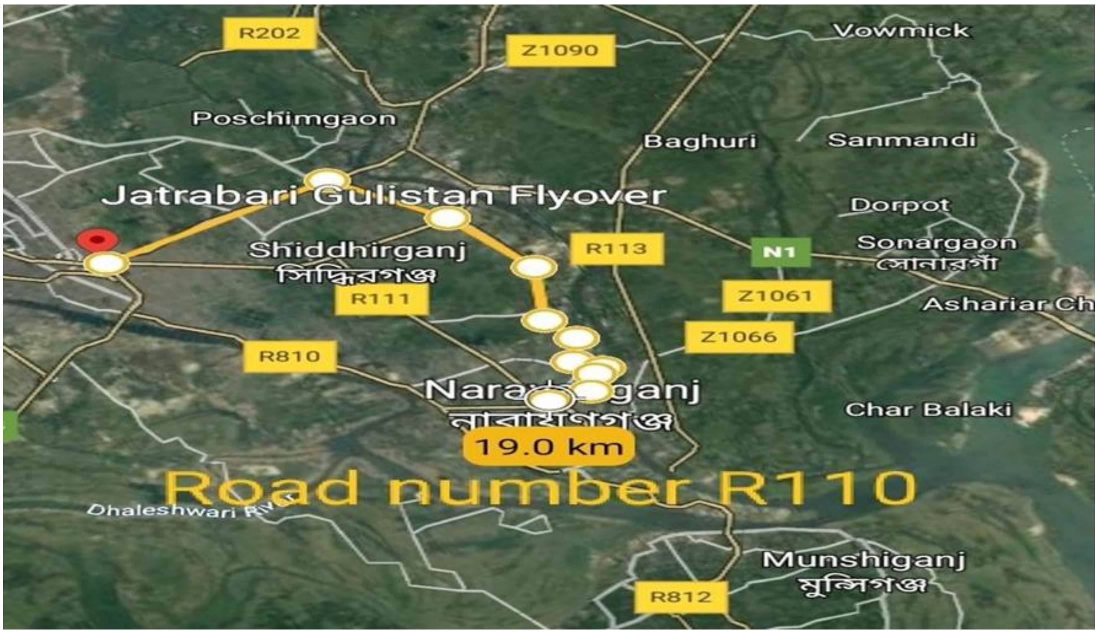

Figure 3.5: Google Map of R110

3.3.1.6 Site Description of R112:

Basic Information	
Road Number	R112
Road Name	Narayanganj (Signboard) – Demra – Amulia –Rampura Road
Class	Regional Highway
Length (km)	8.508
Starts at	Signboard
Ends at	Rampura
Traffic and Other Information	
Traffic (AADT)	5761 (Motorized: 3598; Non-Motorized: 2163)
Average Width (m)	6.08
Number of Bridges	4
Number of Ferry Ghats	0
Location	
Division	Length (km)
Dhaka	8.51

Figure 3.6: Google Map of R112

3.3.1.7 Site Description of R370

Basic Information	
Road Number	R370
Road Name	Mymensingh (D.C Office) – Raghurampur-Netrokona – Mohongonj – Jamalganj – Sunamganj Road
Class:	Regional Highway
Length (km):	131
Starts at:	Mymensingh DC Office
Ends at:	Sunamganj
Traffic and Other Information	
Traffic (AADT):	8726 (Motorized: 6003; Non-Motorized: 2724)
Average Width (m):	4.92
Number of Bridges:	60
Number of Ferry Ghats:	0
Location	
Division	Length (km)
Mymensingh	21.23
Netrokona	52.64
Sunamganj	57.13

Figure 3.7 Google Map of R370

3.3.2 Site Description for Evaluating Overloading Impact on Pavement Life:

Forevaluating the impact of rampant overloading on pavement life, the axle load station at Bathuli, Dhamrai, Dhaka was selected, which is situated on the Dhaka-Aricha Highway. The stations are operated for controlling overloading truck traffic by government-approved mechanisms to preserve the national road networks from the damaging effect of overloading. The station has AxleLoad Measurement installation on both sides of the Highway for opposite traffic. On each side, the 600m long installation includes two HSWIM (High-speed Weigh-in-Motion) equipment and one LSWIM (Low-speed Weigh-in-Motion) equipment with integrated traffic sensors, video cameras, signs, signals, terminals, computing & communications equipment, connections, nodes,and compatible suits of software; control building and annexes, approach roads comprising acceleration & deceleration lanes, laybys, gates, fences, barriers, truck parking area, lighting, generator, and other related features required for the functioning of the station. The approach roadscomprised of flexible pavement, rigid pavement, and a modern subsurface drainage system requiring careful maintenance. The constructing contractor Regnum Resources Limited performsthe Operation and Maintenance (O&M). The construction contractor is also responsible for the general maintenance of the stations. However, they are responsible for maintaining structures/installations constructed/included by them/any other entity but the constructing contractor, being approved by competent RHD authority, from the beginning of their services.

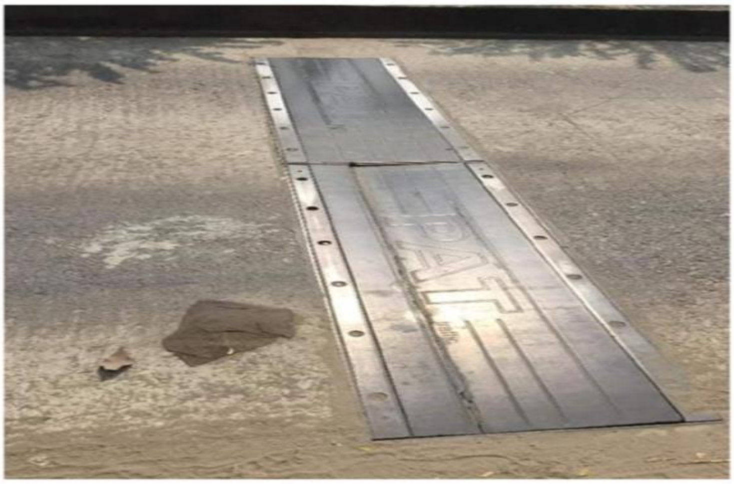

Figure 3.8: Traffic Sensor Loops

Figure 3.9: Signal Light & Weigh Board

3.3.3 Site Description for Life Cycle Cost Analysis of Rigid and Flexible Pavement:

For determining the life cycle cost of both flexible and rigid pavements, case studies are made on three road sections, as mentioned in the previous article of this chapter viz., the Debogram-Progoti Sharani Link Road Project, the Dhaka-Sylhet Highway

Restrengthening Project, and the Sylhet-Bholaganj Road Project. The Debogram-Progoti Sharani Link Road or Purbachal access road is a proposed project constructed by RAJUK as a flexible pavement, and the Dhaka-Sylhet highway has already been constructed as a flexible pavement. In this cost comparison analysis, both road sections are analyzed as flexible pavement and then again as rigid pavement with the same data (soil condition, traffic, etc.). The Sylhet-Bholaganj road project has both flexible and rigid pavement work, and the project is in progress at this moment.

For observing whether the proper method is followed in the construction of flexible pavement, data is collected from two overlaying construction sites in Dhaka city. These two-construction works were undertaken by Dhaka City Corporation (DCC), engaging local contractors. These two road sections had different geometric features and traffic loading patterns.

3.3.3.1 Description of Site-1 :

Site-1 is a lightly traveled local road segment situated in the Khilgaon area near the Khilgaon flyover. It is a link road that connects two main roads. So, there was no disruption of vehicular movements during the time of construction. The construction work consisted mainly of resurfacing the deteriorated pavement and was implemented by using an on-site prepared paving mix and laying it manually. During day time, relevant data were collected.

3.3.3.2 Description of Site-2 :

It is a road section situated in Shahbagh in the vicinity PG hospital which is mainly used by mediumto heavy traffic. This site is a very busy arterial road of Dhaka City. Hence, it was not possible to carry out the resurfacing maintenance work during day time due to vehicular movements. At this site, construction work was done at night time and thereby experimental data had to be collected at late night. The construction work of this site also consisted mainly of resurfacing the deteriorated pavement and was implemented by using plant mix and paver.

3.4 Data Collection:

Data are collected according to the methods outlined in the Data Collection Chapter Chapter.

3.1.1 Pilot Survey:

For systematic way of collecting reliable data, a pilot survey is carried out before the final fieldwork is taken in hand.

Objectives of the pilot survey were:

- To trace the proper authority concerned for acquiring secondary data

- To find out the proper time of data collection.
- To determine suitable locations for data collection
- To assess the availability of relevant data for a particular environment
- To find out difficulties which may arise during the survey work

3.1.2 Final Survey:

Final survey work is conducted after sorting out problems which had arisen in the pilot survey.

3.4.2.1 Prediction of Actual Pavement Life:

In this research work, the actual pavement life is predicted using the survival curves. For creating the survival curves, the IRI values are converted to Pavement Condition Rating (PCR) values and the time since last overlay is made use as described in the methodology section in Chapter 3. The IRI values for the selected road sections as mentioned earlier in this chapter are acquired from HDM-Circle, Roads and Highways Department. The raw data collected from HDM-Circle are given in Appendix A. For obtaining the IRI data from RHD database a permission letter was written to the Chief Engineer, Roads and Highways Department on 16 October, 2016 through my thesis supervisor Dr. Md. Shamsul Hoque. After the Chief Engineer had issued permission on 23 October, 2016 the required data were acquired from the HDM-Circle in the form of a Portable Document Format (PDF) file. For predicting the remaining service life of pavement, the most important parameter to be considered is the time since last overlay on that pavement.

Table 3.2: Overlay History of Selected Road Sections

Road Number	Road Section Taken for Analysis		Time Since Last Overlay (Years)
	Chainage from (km)	Chainage to (km)	
N3	0	10	5
N5	21.987	34.087	1
	62,947	74.434	3
	181.907	210.007	5
N501	0	4.7	5
N504	0	4.811	3
R110	0	9.5	5
R112	0	8.486	4
R307	20.932	40.023	1

3.4.2.2 Evaluation of the Overloading Impact on Pavement Life:

Axle load data were collected from the weigh station at Bathuli, Dhamrai, Dhaka from Regnum Resources Limited who are the responsible party for maintaining the weigh station and collect tolls from the overloaded heavy vehicles authorized by Roads and Highways Department. The axle load data was acquired with the help of the Executive Engineer, Manikgonj Road Division, RHD. Axle weight of one thousand one hundred and fifteen (1115) overloaded heavy vehicles moving towards Dhaka were taken during the span of three days between 12 February 2017 and 14 February 2017 throughout the day for 24 hours. Also, axle weight of nine hundred and ninety-five (995) overloaded heavy vehicles moving towards Dhaka were taken during the span of three days between 12 February 2017 and 14 February 2017 throughout the day for 24 hours. The data collected are arranged in Appendix B. For calculating the percentage of overloaded trucks, data were also extracted from the monthly report for penalty amount against overloaded trucks at the axle load control station, Bathuli-Manikgonj. The monthly reports for the months November, 2016, December, 2016 and January, 2017 were collected from the office of Executive Engineer, Manikgonj Road Division, RHD for the analysis purpose. The raw data of these monthly reports are attached at the Appendix B. All these data were collected after physically inspecting and observing the axle load control station at Bathuli-Manikganj on 15 February, 2017 accompanied by the Executive Engineer, Manikgonj Road Division, RHD and other RHD officials.

3.4.2.3 Life Cycle Cost Analysis of Rigid and Flexible Pavement:

For performing life cycle cost analysis of rigid and flexible pavement, the pavement design data of Debogram-Progoti Sharani Link Road Project and Dhaka-Sylhet Highway Restrengthening Project were collected from the thesis paper titled "EVALUATION OF FLEXIBLE AND RIGID PAVEMENTS CONSTRUCTION IN BANGLADESH" by Mohammad Arifuzzaman Bhuyan. The pavement design data of both flexible and rigid pavement of Sylhet-Bholagonj Road Project were collected from the office of Technical Services Wing of Roads and Highways Department located at Elenbari, Dhaka on 26 October, 2016. For determining the cost associated with the construction and maintenance of rigid and flexible pavement, RHD Schedule of Rates 2015 was used. According to the Planning Commission Bangladesh, a discount rate of 15% was used to convert all the costs to Net Present Value (NPV) for comparing the life cycle costs of rigid and flexible pavement. The data of the three projects are summarized in the following section.

3.4.2.3.1 Design Data of Debogram-Progoti Sharani Link Road Project:

Functional Classification = National Highway Road Length = 13 km

Lane Width = 3.65 m

Road Type = Divided Four-Lane Estimated Traffic = 110 × 106 ESAL

Design flexible pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.10.

Pavement Layer	**CBR**	**Thickness (mm)**
Bituminous Carpeting	-	150
Aggregate Base, Type-1	>80%	225
Sub-Base	>25%	300
Sub- Grade	>8%	400

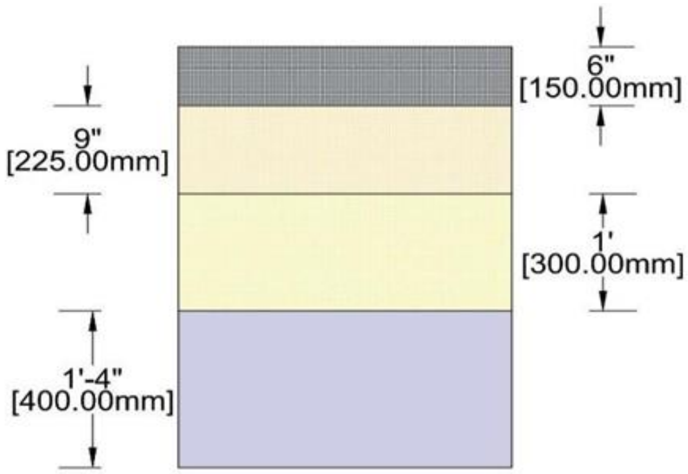

Fig: 3.10 Case-1 Design layer Thickness of Flexible pavement

Design rigid pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.11.

Pavement Layer	**CBR**	**Thickness (mm)**
Concrete Slab	-	300
Sub-Base	>25%	80
Sub –Grade	>8%	300

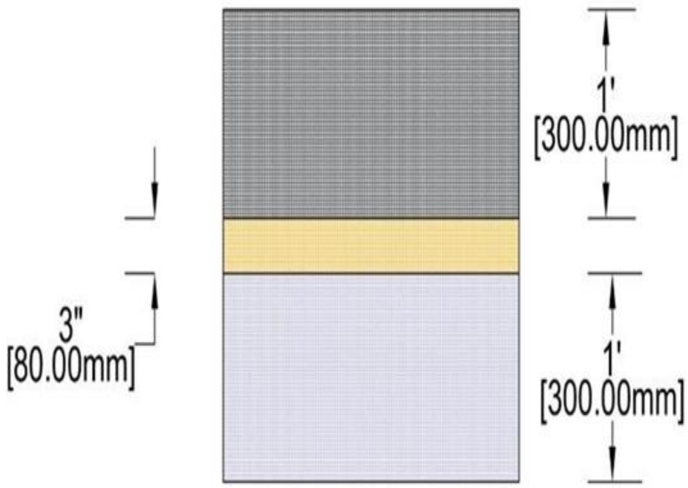

Fig. 3.11 Case-1 Design layer thickness of Rigid Pavement

3.4.2.3.2 Design Data of Dhaka-Sylhet Highway Restrengthening Project:

Functional Classification = National Highway High-way Type = Two-lane Single Carriageway Lane Width = 3.65 m
Estimated Traffic = 113 × 106 ESAL
Design flexible pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.12.

Pavement Layer	CBR	layer Thickness (mm)
Bituminous Carpeting	-	150
Aggregate Base, Type-1	>80%	240
Sub-Base	>30%	400
Sub-Grade	>3%	300

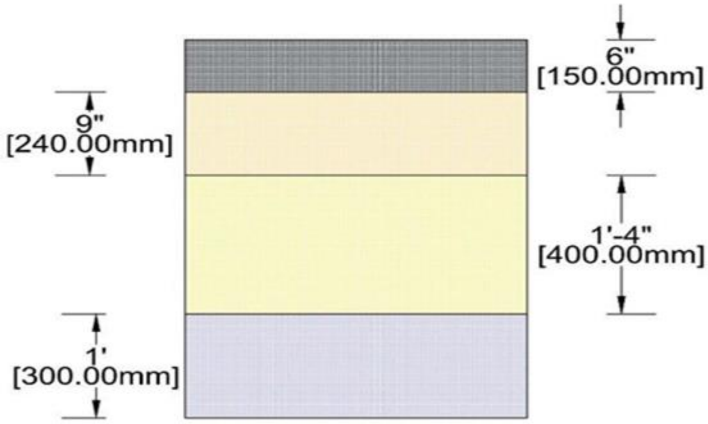

Fig: 3.12: case-2 Design layer thickness of flexible Pavement

Design rigid pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.13.

Pavement Layer	**CBR**	**Thickness (mm)**
Concrete Slab	-	300
Sub-Base	>30%	150
Sub -Grade	>3%	300

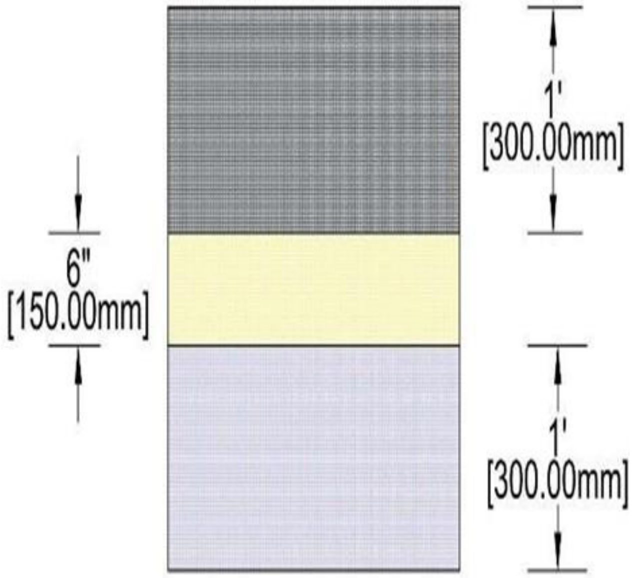

Fig. 3.13 Case-2 Design layer thickness of Rigid Pavement

3.4.2.3.3 Design Data of Sylhet-Bholaganj Road Project:

Functional Classification = National Highway Road Length = 32 km

Lane Width = 3.65 m

Road Type = Two-lane Single Carriageway Estimated Traffic = 109.15 × 106 ESAL

Design flexible pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.14.

Pavement Layer	CBR	layer Thickness (mm)
Wearing Course	**-**	**50**
Bituminous Binder Course	-	70
Aggregate Base, Type-1	>80%	250
Aggregate Base Type-2	>50%	300
Sub-Base	>25%	300
Improved Sub-Grade	>8%	300
Sub-Grade	>3%	-

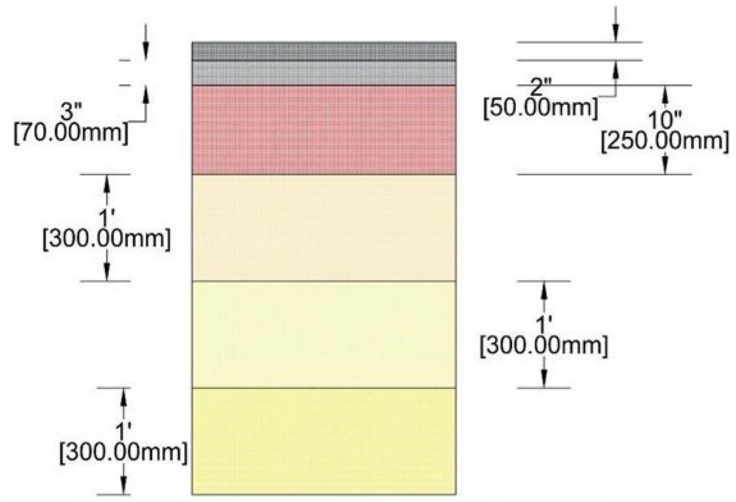

Fig: 3.14 Case:3 Design layer thickness of Flexible Pavement

Design rigid pavement layer thicknesses along with the corresponding CBR values are shown graphically in the figure 3.15.

Pavement Layer	CBR	layer Thickens(mm)
Concrete Slab (Class 35)	-	300
Concrete Slab (Class 20)	-	100
Sub-Base	>8%	150
Improved Sub-Grade	>3%	300

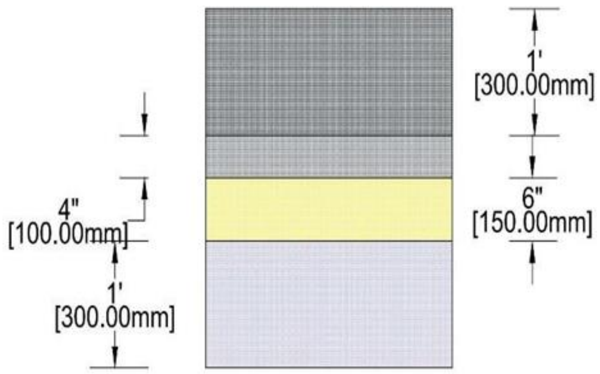

Fig: 3.15 Case:3 Design layer thickness of Rigid Pavement

The detailed design description of flexible pavement and rigid pavement is collected from the Technical Services Wing of Roads and Highways Department. In the flexible pavement design sheet, the design considerations are described briefly, such as the design subgrade CBR, design life, traffic growth rate, cumulative ESAL, phasing of construction, shoulder description, freeboard, predicted completion year etc. The general notes for flexible pavement design are:

• In this design, RHD Pavement Design Guide April/2005 & AASHTO/1993 Design Specification has been followed

• AADT collected from Sylhet Road Division of (Z-2801) Sylhet-Salutikar-Companiganj- Bholaganj Road on 2009

• Design Sub-Grade CBR = 5%

• Design Life = 20 years

• Traffic Growth Rate = 7%

• Cumulative ESAL = 109.15 million for 10 years Design Life and 323.81 million for 20 years Design Life. At present considering pavement Design and traffic growth rate, 60 mm overlay (As per Tentative Design) is to be provided after 10 years, i.e., in 2026. But finally, this should be done as per proper field investigation or need assessment report prepared by HDM circle.

• For hard shoulder wearing course is not applicable

• Free Board = 1.00 meter
• Completion year = 2017

• Detail Geometric Design is to be made by the respective field office

• Work should be done as per proper specification

For rigid pavement construction, the 28 days cylinder crushing strength of concrete, the yield strength of M.S bar, and the required compaction of sub-grade are correctly specified. The joint details of rigid pavement such as contraction joint, longitudinal joint, expansion joint, and corner reinforcement detailing are provided in the design sheet with neat illustrations. The general notes for rigid pavement design are:

• Rigid Pavement construction shall be done as per General Specification of RHD

• Traffic shall not be allowed within 28 days

• Curing should be done for 3 weeks

• Acute Corner should be reinforced

• Dowel bar should be placed on 6 mm dia

• Caps should be of PVC pipe in which Dowel bar will play during Contraction

• Joint of two concrete slabs will be filled by Bituminous san mixture

• Concreting should be done by using Batching Plant

For quick disposal of Rainwater, adequate drainage facilities should be provided the pavement design sheet collected from the Technical Services Wing of Roads and Highways Department with the cooperation of the Executive Engineer is given in the following pages.

3.5 Pavement Design (as national highway standard):

Name of Road: Road division sylhet

Name of Division: (Z-2801) sylhet - salutikar -companiganj - Bholaganj road (length =32.00 km) and osmani International Airpot By pass Road (length = 5.50 km)

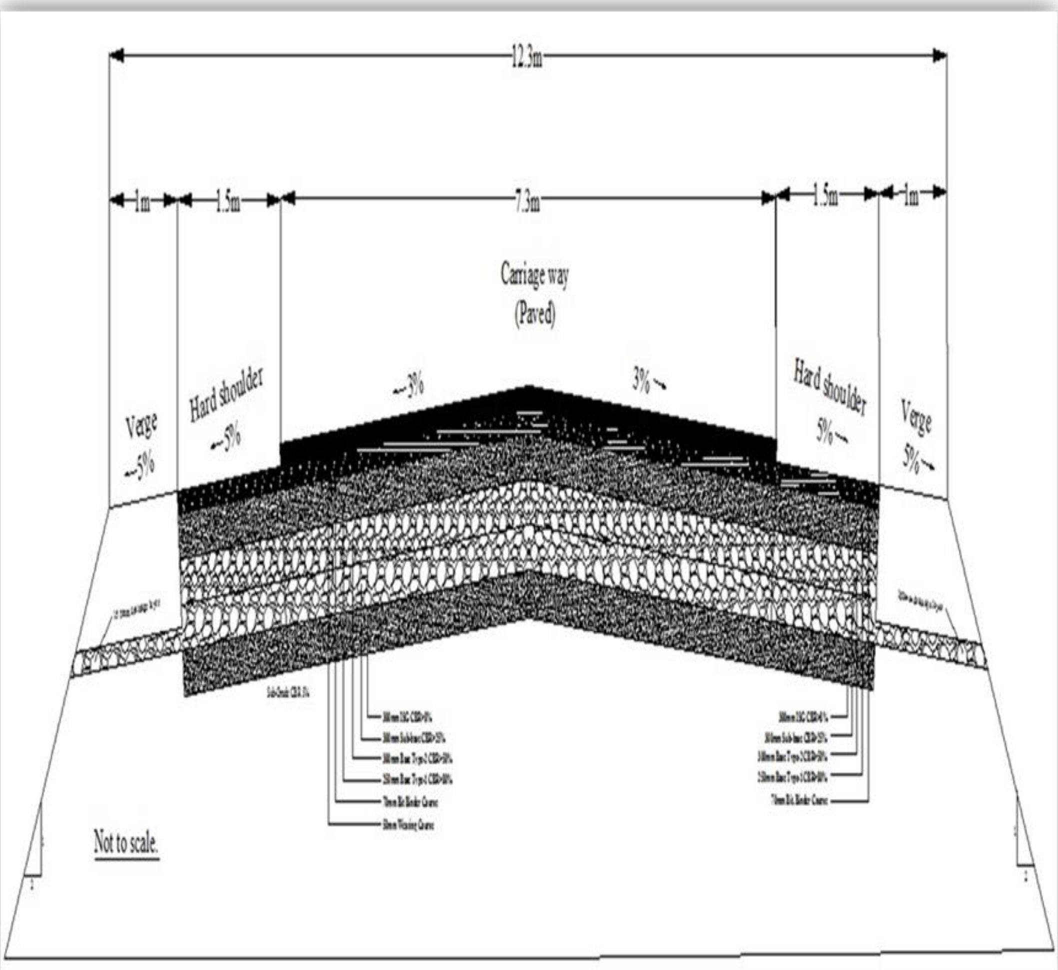

Figure: 3.16: Design of Flexible Pavement

10 years design period			Wearing course	Bit Binder course	Agg.Base type -1	Agg Base type -2	Sub-base	ISG	CAL. 10 YEARS SNc	Total thickness
Sub - grade CBR %	Design ESA Lo	10 years SNr	Thickness	Thickness	Thickness	Thickness	Thickness	Thickness		
5%	109.15 million	6.70	50	70	250	300	300	300	6.79	1270 mm

1.In this design RHD pavement design guideApril 2005 and AAHTO / 1993 design specification has been to allowed. 2.AADT collected from sylhet road divisionof (Z - 2801) Sylhet salutlkar - companigaj -Bholaganj. 3.Design sub - grade CBR = 5% road in2009. 4.Design life = 20 years. 5.Traffic growth Rate = 7 % 6.Cumulative ESAL = 109.15 million for 10 years design life and 323.81 million for 20 years design life. At present considering pavement design and traffic growth rate 60 mm overlay (as per tenlative design) is to be provide after 10 years i. e on 2026.But finally this should be done as per proper field investigation or need assessment report prepared by HDM circle.	1.For hard shoulder wearing course is notapplicable. 2.Free Board = 1.00 meter. 3. Completion year = 2017. 4.Detail geometric design is to be made by therespective field office. 5.Work should be done as per properspecification

3.6 Design of rigid pavement:

Name of Division: Sylhet road division

Name of Road :(Z -2801) sylhet Bholagoni Road

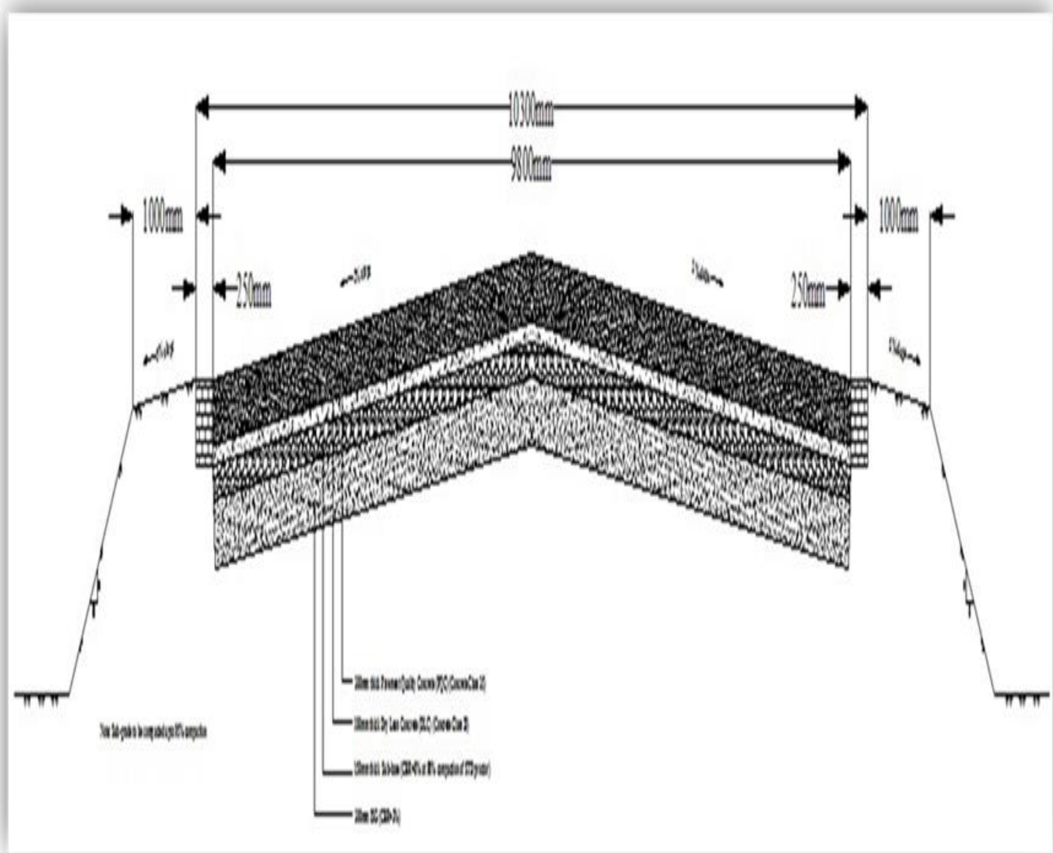

Fig: 3.17: Design of Rigid Pavement

NOTE: Sub - grade to be compacted up to 95 % compaction

NOTES:

1) All dimension are in millimeter unless otherwise mentioned.
2) 28 days cylinder crushing strength of concrete f'c =35 map equivalent to 5075 psi.
3) Yield strength of M.S bar fy = 60000 psi.

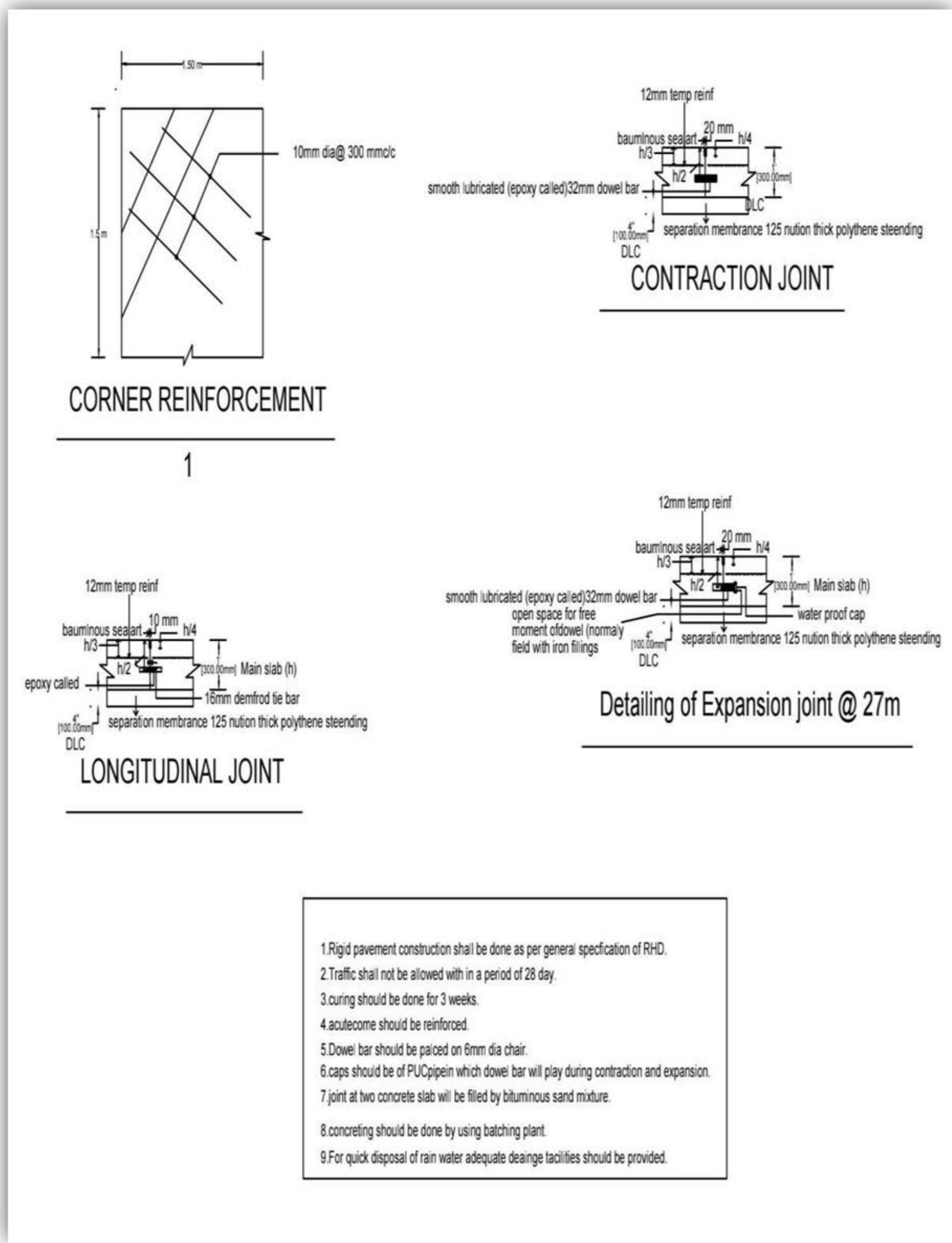

Fig: 3.18: Joint Details of Rigid Pavement

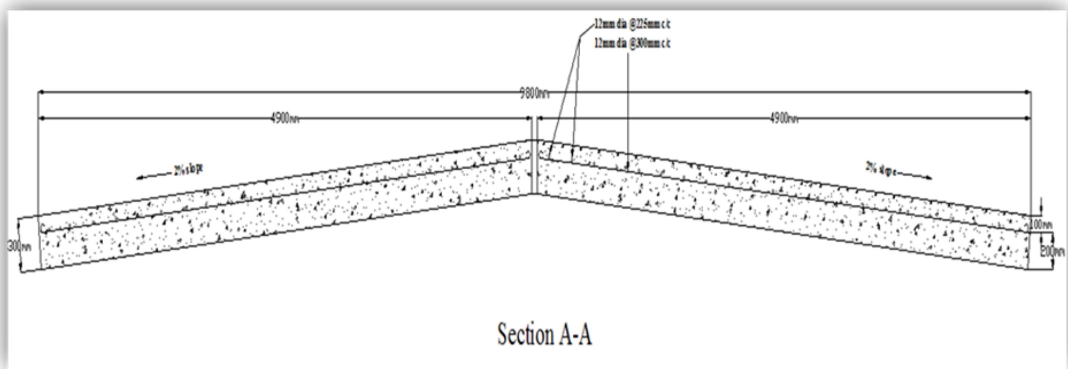

Fig. 3.19 Longitudinal and Transverse Reinforcement Spacing of Rigid Pavement

3.7 Field Data Collection for Performing Laboratory Experiment:

From the literature review it is understood that the construction of flexible pavements requires strict procedure in heating binder and aggregates at appropriate temperatures and mixing, laying, compacting operations are also need to be performed at specified temperatures. In order to assess the level of slackness in the construction of flexible pavements, field investigations were undertaken in the form of critically observing the construction procedures and measuring associated deviations from the specified standards, comparing strength parameters between samples prepared in the field using job mix and samples prepared in the laboratory with the materials collected from the construction sites. From the thesis paper titled “EVALUATION OF FLEXIBLE AND RIGID PAVEMENTS CONSTRUCTION IN BANGLADESH” by Mohammad

Arifuzzaman Bhuyan data obtained from the following tests made on the two selected sites as mentioned in Site Selection section of this chapter are used for analysis in this research work:

a) Gradation of aggregates

b) Properties of aggregates and bitumen

c) Marshall tests on both field prepared sample and laboratory prepared sample

d) Temperature check at different stages of flexible pavement construction

The test results obtained from performing different tests as mentioned previously are arranged in a tabular form in the following section.

Table 3.3: Properties of Bitumen (Virgin & Extracted) at Site-1

Properties	Test Method	Virgin Bitumen	Extracted Bitumen
Specific Gravity	AASHTO T228-93/ ASTM D 70-76	1.0168	1.048
Loss on Heating (%)	AASHTO T51-93/ ASTM D113-79	0.02%	0.07%
Penetration (1/10th mm,25^{0}C)	AASHTO T49-93 / ASTM D5-86	91	77
Softening Point (^{0}C)	AASHTO T47-8/ ASTM D6-80	55	48
Ductility (cm)	AASHTO T53-92/ ASTM D36-89	100+	95
Flash and Fire Point (^{0}C)	ASTM D 92/ T-48	250 &280	285 & 330
Solubility (% of insoluble)	AASHTO T-44	0.20%	0.212%

Table 3.4: Marshall Test Results of Specimens at Site-1

Marshall Method MixCriteria	Marshall Values for SpecimensPrepared in The Laboratory	Marshall Values for Specimens Prepared in TheField
No of Blows	35	35
Stability, N	2077	1526
Flow, 0.25 mm	15.9	6.5
Percent Air voids (%)	8.63	10
Percent Voids in Mineral Aggregate (VMA)	11.5	10.6
Percent Voids Filled with Asphalt (VFA)	44.73	35

Site-2: Road Section in Shahbag Near BSMMU (Medium to Heavy Traffic)

Properties	Test Method	Virgin Bitumen	Extracted Bitumen
Specific Gravity	AASHTO T228-93/ ASTM D 70-76	1.0165	1.035
Loss on Heating (%)	AASHTO T51-93/ ASTM D113-79	0.022%	0.02%
Penetration (110thmm, 25^0C)	AASHTO T49-93 / ASTM D5-86	89	83
Softening Point (^{0}C)	AASHTO T47-8/ ASTM D6-80	54	51
Ductility (cm)	AASHTO T53-92/ ASTM D36-89	100+	98
Flash and Fire Point (^{0}C)	ASTM D 92/ T-48	250 &280	265 & 330
Solubility (% ofinsoluble)	AASHTO T-44	0.20%	0.22%

Table 3.5: Properties of Bitumen (Virgin & Extracted) at Site-2

Item	Stage of Construction	Standard Values as per AASHTO	Temperature (Site-1) ManualMix	Temperature (Site-2) PlantMix
01	Dry aggregates (Stone chips)before mixing with bitumen	163°C	72°C	-
02	Heated Bitumen in the drum	163°C	> 300°C	-
03	Bitumen temperature at thetime of making mixture	135-163°C	199°C	-
04	Paving mixture temperature	139-163°C	123°C	121°C
05	Laying temperature of Pavingmixture over pavement	120-150°C	98°C	94°C
06	Compaction of the mixer	100-120°C	50°C	75°C

Table 3.6: Marshall Test Results of Specimens at Site-2

Marshall Method Mix Criteria	Marshall Values for SpecimensPrepared in The Laboratory	Marshall Values for Specimens Prepared in TheField
No of Blows	75	75
Stability, N	2205	1869
Flow, 0.25 mm	13.2	12.8
Percent Air voids (%)	13.2	12.8
Percent Voids in Mineral Aggregate (VMA)	12.6	13.0
Percent Voids Filled with Asphalt (VFA)	54.73	37.0

Analysis of these data are prepared in the next chapter "Data Analysis" and observations along with comments on the obtained results are made by comparing with the standard values.

3.8 Problems Encountered During Data Collection:

The problems that have been encountered during the collection of IRI data, axle load data, pavement design data and field investigation data are:

• For acquiring the IRI data from HDM-Circle, Roads and Highways Department, it was required to apply for permission from the Chief Engineer, Roads and Highways Department. The application was stuck in the Chief Engineer's office for seven days and it took another seven days to reach other divisions. So roughly two weeks were wasted before being able to collect the relevant data for this research work.

• The HDM-Circle do not perform roughness survey every year. So, the data of Roughness Survey performed in the year 2013 was used for carrying out the analysis work to achieve the objectives set out in the Chapter 1 for this research work.

• Management Services Wing of Roads and Highways Department do not preserve the data of the maintenance works that have been finished but they only keep track of the ongoing maintenance work. So, it was very difficult to find out the time since last overlay has been done on the selected road section for predicting the actual pavement life. So, the overlay history was traced with the help of verbal communication with the concerned officers of Roads and Highways Department.

• Majority of the axle load control stations set up by the Roads and Highways Department are not in action due to political reasons and oppression from the truck owners' association. So, the data source was very limited for evaluating the overloading impact on pavement life.

• Axle load data at Bathuli, Manikganj axle load station is collected by the Regnum Resources Limited under the supervision of Roads and Highways Department. This company could not provide monthly data of the axle loads for the previous months. They provided the axle load of three days only, hence the analysis was continued using the data of these three days only.

• For inspecting the quality control of pavement construction, a lot of time must be given in the field. But due to time and fund constraint in undergraduate thesis level, secondary data were acquired from the thesis paper titled "EVALUATION OF FLEXIBLE AND RIGID PAVEMENTS CONSTRUCTION IN BANGLADESH" by Mohammad Arifuzzaman Bhuyan.

• Due to fund constraint, it was not possible to carry out the roughness survey on the selected road sections by the researched himself. So, secondary data obtained from Roads and Highways Department had to be used for the analysis work.

3.9 Overview:

This chapter includes the data collection phase which has been carried out according to the methods described in the Methodology chapter. Starting from the piloting survey for site selection to the final survey that have been performed for collecting relevant and reliable data for this research work have been neatly presented in this chapter. The data for prediction of actual pavement life, evaluating the overloading impact on pavement life, life cycle cost analysis of both rigid and flexible pavement, field investigation to observe the quality control in construction of pavement are summarized in this chapter and the source of raw data has been identified and linked to the attached appendices. The problems that have been faced while collecting the data are briefly described and the methods used to overcome these obstacles are also described in this chapter. Overall, this chapter includes all the data required for the analysis to be performed in the next chapter 4 named "Data Analysis" to achieve the objectives set out in the chapter 1 titled "Introduction".

CHAPTER 4
DATA ANALYSIS

4.1 Review on road section:

Here six road sections from four national highways of RHD, i.e., N3, N5, N501, N504, and threeroad sections from three regional highways, i.e., R110, R112, R307 of RHD, were selected to develop a pavement performance model. A brief description of the selected road sections is presented in table:4.1

Table: 4.1 Description of the selected road section

Road Number	Road SectionTake for Analysis		width(m)	AADT	Time Since LastOverlay (Years)
	Chainage from (km)	Chainage to (km)			
N3	0	10	8.19	18755	5
	21.987	34.087	7.17	8913	1
	62,947	74.434	7.17	8913	3
	181.907	210.007	7.17	8913	5
N501	0	4.7	7.33	11346	5
N504	0	4.811	7.32	6489	3
R110	0	9.5	8.60	15309	5
R112	0	8.486	6.08	5761	4
R307	20.932	40.023	4.92	8726	1

In Figures 1 and 2, the histograms represent the variation of deflection andIRI information concerning the chosen pavement sections, severally. The deflection values are found to be at intervals the vary of 2.2 to 24.7 mm, and also the IRI values varied between 0.26 to 1.61. From Figure 1, it may be determined that thedeflection worth principally varied from 2.2 to 11.2 mm, whereas Figure 2 reveals that the bulk ofthe pavement sections had an IRI value starting from 0.26 to 0. 8.

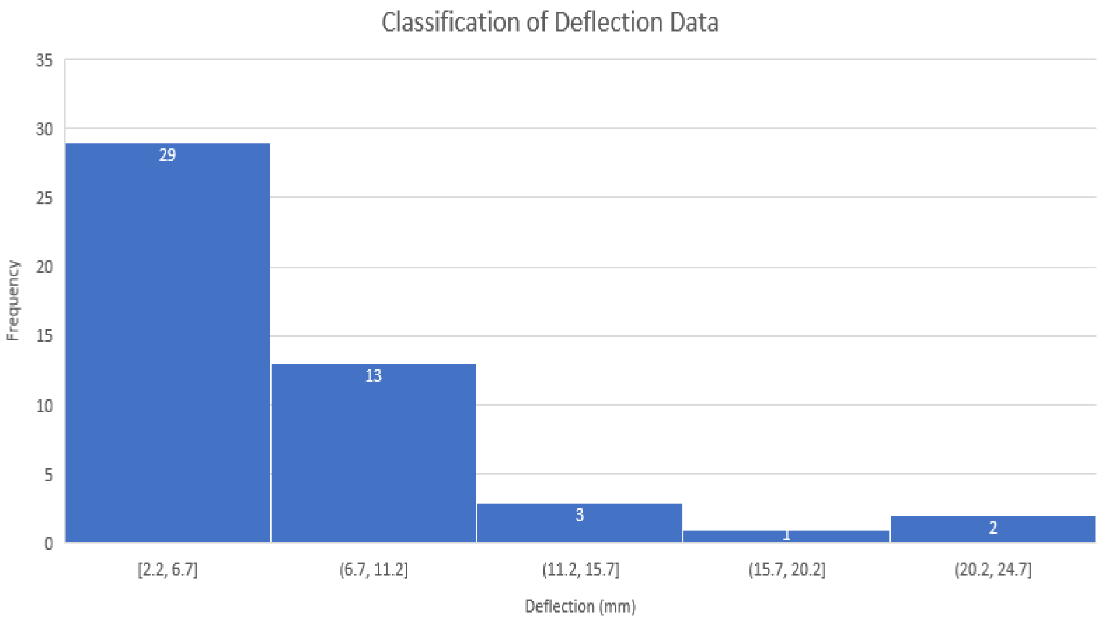

Figure 4.1 Classification of Deflection Data

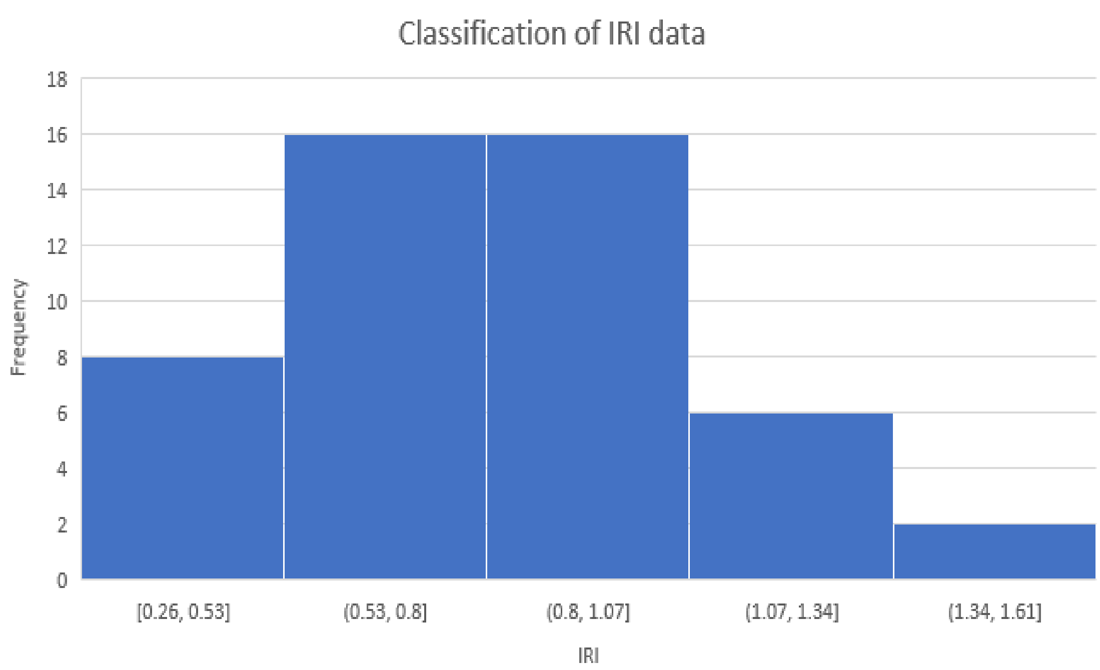

Figure 4.2 Classification of IRI Data

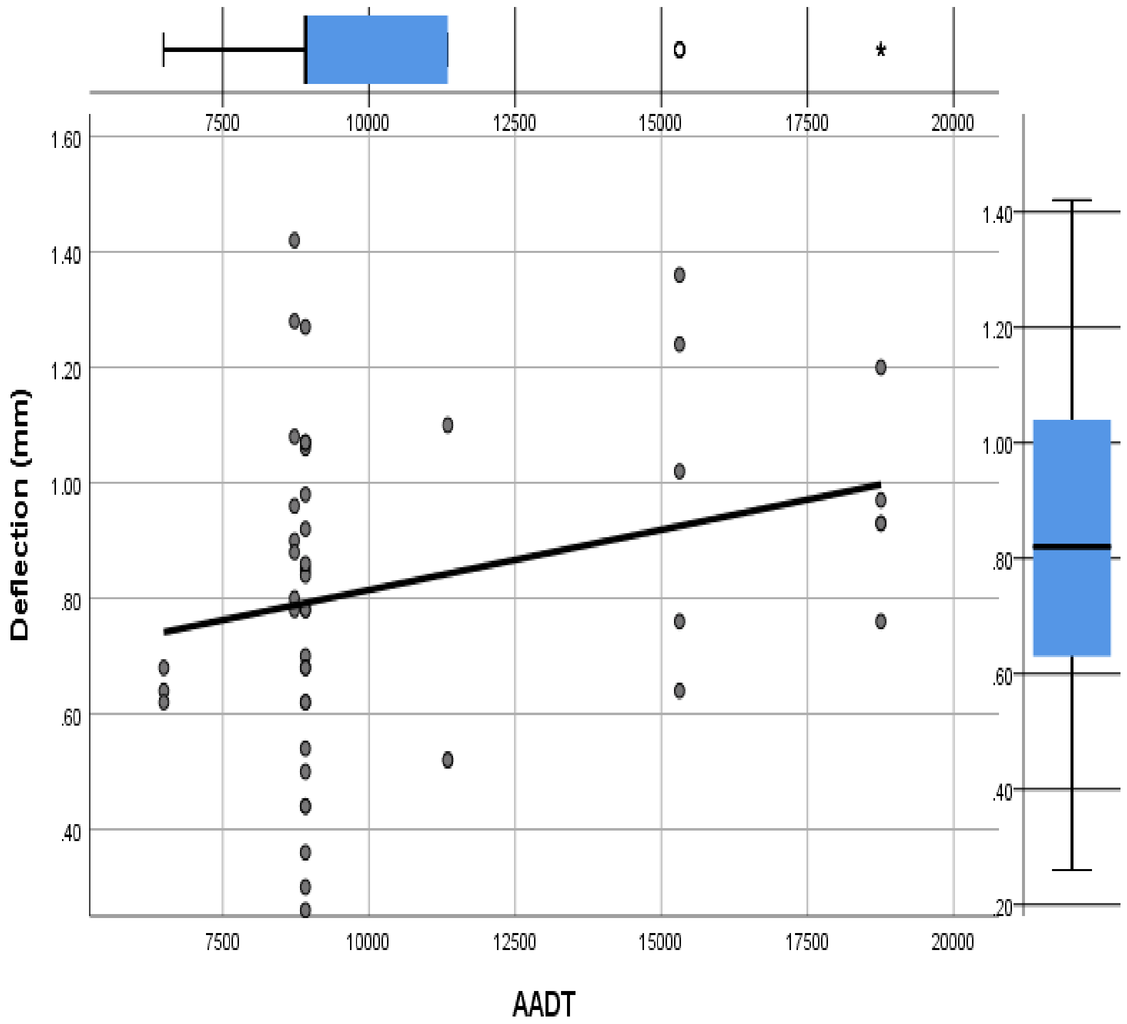

Figure 4.3 Deflection vs AADT

4.2. Analysis on IBM SPSS v.26 Software:

We did multiple linear regression using IBM SPSS v.26 Software and gets this model summary. Here depended variable was, ‘Deflection’. Predictors was: Width, Chainage(km), IRI, AADT, age.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.208	5	.242	4.162	.004[b]
	Residual	2.438	42	.058		
	Total	3.646	47			

a. Dependent Variable: Deflection (mm)

b. Predictors: (Constant), Width, Chainage (km), IRI, AADT, Age

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	99.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.229	.353		3.479	.001	.276	2.182
	Chainage (km)	.001	.001	.214	1.083	.285	-.001	.003
	IRI	.007	.008	.118	.885	.381	-.014	.029
	Age	.050	.043	.305	1.160	.252	-.066	.165
	AADT	4.405E-5	.000	.561	2.813	.007	.000	.000
	Width	-.161	.057	-.629	-2.849	.007	-.314	-.009

a. Dependent Variable: Deflection (mm)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.576[a]	.331	.252	.24093	.331	4.162	5	42	.004

a. Predictors: (Constant), Width, Chainage (km), IRI, AADT, Age

Figure 4.4 Model Summary

The multiple R and coefficient of determination (R^2) values for the developed regression model are given in Model summary. The R^2 value of 0.331 indicates that 33.1% of the variances in deflection can be explained by this regression model comprising of predictor variables, i.e., IRI and age. If other relevant factors are included, the model will be able to predict the deflection better, which can be a scope of future study. From model summary, it can be seen that the F valueis 4.162, which is significant at $p < .004$. Therefore, we can conclude that our regression model results in significantly better prediction of deflection than if we used the mean value of deflection. In other words, the regression model overall predicts pavement deflection significantly well. So, this model can be used as a pavement performance model for flexible pavements in Bangladesh.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.616	.109		5.656	.000					
	IRI	.013	.009	.224	1.573	.123	.212	.228	.224	.997	1.003
	Age	.034	.023	.212	1.486	.144	.199	.216	.211	.997	1.003

a. Dependent Variable: Deflection (mm)

4.3 Comments on Analysis:

This study found that IRI and age both have a significant positive effect on predicting deflection, while AADT and width both do not. A modified regression model was developed that only includes IRI and age as predictor variables, and it was found to be significantly effective in predicting deflection. The constant or intercept term, as well as the regression coefficients (B), for each explanatory variable included in the regression model, are presented in this table. The variables IRI and age have a statistically significant positive effect on deflection for a constant value of 0.616, suggesting that deflection increases with increasing IRI and age. The model indicates that for every unit rise in IRI, there will be an increase of 0.013 in deflection, and for every unit increase in age, there will be an increase of 0.034 in deflection, according to the model. When a result, as the pavement ages, an increase in IRI value and age corresponds to an increase in deflection, suggesting a loss of riding quality linked with structural inadequacy of the pavement as a result of aging. Furthermore, the standardized coefficients for IRI are higher than those for age, indicating that IRI has a better ability to predict deflection when compared with age.

CHAPTER 5
CONCLUSION

5.1 Conclusion:

In order to ensure the functional and structural performance of flexible pavements, it is critical to conduct regular inspections of the pavement. Using the IBM SPSS v26 software, a pavement performance model based on the dependent variable deflection and the predictors IRI, AADT, and pavement age data of flexible pavements created has been developed in this thesis study. The impact of pavement width and the average annual daily traffic (AADT) of the road segments have been found to be insignificant in predicting pavement deflection. IRI and pavement time, i.e., the amount of time that has passed since the last overlay, have been identified as major indicator factors for determining pavement deflection. Both IRI and age have been shown to be significantly associated with avoidance, demonstrating that an increase in IRI and age will increase the deflection of pavement. The most valuable variables for this model are age and IRI, which are the most important factors to consider. If the pavement's age and IRI grow, the pavement's deflection increases in this area. This regression model will assist in determining the most appropriate maintenance strategy based on the deflection value anticipated by IRI and the age of pavement region

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