EVOLUTION OF HIGHWAY FAILURES AND THEIR MAINTENANCE

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ABSTRACT: A well-developed transportation infrastructure is essential for economic, industrial, social and cultural development of a country. Due to this need, human being has developed three modes of transport, i.e., by land, by water and by air. The road network has expanded from 4 lakh km in 1947 to 20 lakh km in 1993 and almost 55 lakh kms as on 31 March, 2015. India has less than 3.8 kms of road per 1000 people; including all its paved and unpaved roads. In terms of quality, all season, four or more lane highways; India has less than 0.07 kms of highway per 1000 people as of 2010. Inadequate maintenance of roads accounts to an act of disinvestment and sacrifice of past investment in roads. Roads have been receiving decreasing share of total Five Year Plan expenditure (decreasing from 6.7% in first plan to 3% in second plan). The Vehicle Operating Cost increases at a rapid rate as the condition of existing pavements starts deteriorating. The loss due to bad conditions of the main road network would be around Rs.12000 crore per annum. Pavement structure can be destroyed in a single season due to water penetration. Defects in flexible pavements is a problem of multiple dimensions, phenomenal growth of vehicular traffic (in terms of no. of axle loading of commercial vehicles), the rapid expansion in the road network, non-availability of suitable technology, material, equipment, skilled labour and poor funds allocation have all added complexities to the problem flexible pavements. Maintenance of a road network involves a variety of operations, i.e., identification of deficiencies and planning, programming and scheduling for actual implementation in the field and monitoring. The essential objective should be to keep the road surface and appurtenances in good condition and to extend the life of the road assets to its design life. The purpose of the proposed study is to discuss the possible causes of pavement failures, and recommends better ways to minimize and hopefully eliminate the causes of failures in pavements.

Key Words: Distress, Highway Failures, Maintenance and repairs.

1. INTRODUCTION

1.1 General

From the beginning of history, human sensitivity has revealed an urge for mobility leading to a measure of Society's progress. The history of this mobility or transport is the history of civilization. For any country to develop with right momentum modern and efficient Transport as a basic infrastructure is a must. **Transport** (British English) or **transportation** (American English) is the movement of people and goods from one place to another. The term is derived from the Latin *trans* ("across") and *portare* ("to carry").

A road network system is perhaps one of the most important necessities for the economic development of any country, particularly developing countries. Many of developing countries, therefore, invest huge amount on road construction, while many developing countries appreciate the necessity for huge investment in capital development of roads. Only a few give due importance to the road maintenance. It is found more glamorous to embark on new construction than to maintain what is already in existence. But unfortunately pavement structure can be destroyed in a single season due to water penetration. Maintenance activities may be required at intervals throughout the year, but their frequency varies with traffic, topography and climatic conditions, type of roads, grading and repairing pot holes and ruts for paved roads. They include repairing pot holes, surface patching, sealing of cracks and

Road surface marking. Transportation contributes to the economic, industrial, social and cultural development of any country. Transportation is vital for the economic development of any region since every commodity produced whether it is food, clothing, industrial products or medicine needs transport at production and distribution stages. The inadequate transportation facilities retard the process of socio-economic development of the country. The adequacy of transportation system of a country indicates its economic and social development.

India is a vast country having extreme variation in climatic conditions. North-Eastern region gets very heavy rainfall and annual rainfall as much as 600 cm per year has been recorded, whereas the deserts of Western India get very less rainfall. Even in a particular area the difference between maximum and minimum temperature of the year may be as high as 420c. North India experiences heavy snowfall during winter at altitudes above 2000m. These climatic conditions have great influence on the type of problems existing on the road as only 47% are surfaced roads, balance being earthen roads.

1.2 Introduction of roads in India

Roads are considered as the lifeline of any country. Some of the important roles roads in India's economy are:

1. Connection to villages.
2. Communication in hilly terrain.
3. Carriers of freight and passengers complementing the railways
4. Helps agricultural development
5. Administrative convenience, etc.

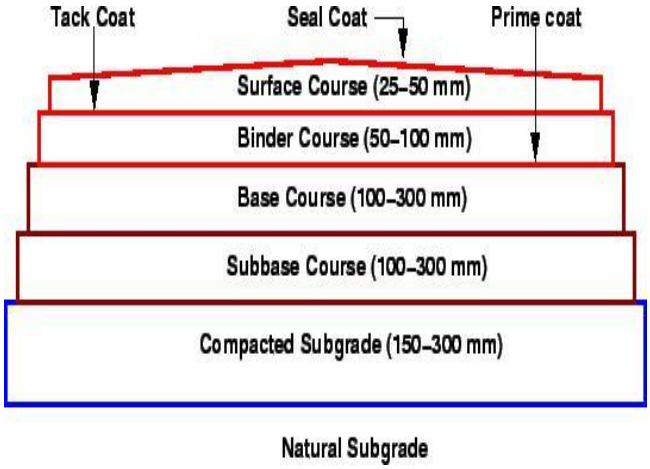
Engineers have been always with open mind to adopt any material available to them for its use for the construction purposes. It is logical to see that the purpose of highway construction is to provide a firm and even surface for the carriageway or the pavement which could stand the stress caused due to number of load applications.

1.3 Types of Pavements

The term pavement ordinarily means the surfacing layer only. But in highway design, it means the total thickness of pavement including surfacing, base and sub base if any. It is a hard crust constructed over the natural soil for the purpose of providing stable and even surface for the vehicles. It is therefore a structure consisting of superimposed layers of materials above the natural soil subgrade, whose primary function is to distribute the applied vehicle loads to the subgrade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance and low noise pollution.

From the point of view of structural performance, pavements can be classified as:

- Flexible
- Rigid
- Semi-rigid
- Composite



- **Figure 1. Pavement Layers**

2. LITERATURE REVIEW

Zulufqar Bin Rashid1, Dr. Rakesh Gupta emphasised on the parameters influencing the performance of pavements and to identify them. For efficient maintenance of road pavements, the deficiencies in our existing highway system need to be clearly understood. Proper design, regular inspection and maintenance of pavement is of utmost importance and in preserving the investment made on highway system and in providing comfort and safety to the road user.

DR. NDEFO OKIGBO studied the conditions of the roads in Nigeria and their effects to the citizen, government and the economy of the country. Some of the identified causes were; poor design and construction, poor maintenance of already built highways, use of low quality materials in construction, poor workmanship and poor supervision of construction work. Some of the recommendations to remedy the situation are; Use of the appropriate design of the roads, avoiding unnecessary congestion of the roads especially heavy traffics that were not meant for the roads in the first place, prompt maintenance of the roads, application of suitable construction material in the construction.

Mr. Devidas Chavade, Mr. Kedarnath worked on the on-going researches about the defects in Flexible and Rigid pavement and the maintenance in Flexible and Rigid pavements. The essential objective should be to keep the road surface and appurtenances in good condition and to extend the life of the road assets to its design life. Broadly, the activities include identification of defects and the possible cause there off, determination of appropriate remedial measures; implement these in the field and monitoring of the results.

Aaron Steinfield, BenedicteBougler, Dan Empey emphasise on snow removal and how it is critical for winter highway maintenance operations. However, it is subject to significant risk due to adverse operating environmental conditions such as total visual whiteout,

low tire/road traction, difficulty for detecting roadway boundaries and obstacles buried in or obscured by snow.

SurajoAbubakar Wada worked on road detoriation. Road deterioration is a critical situation for road sector because of the high cost for construction of new roads and maintenance of existing roads and routes. Therefore, better funding and management should be provided in order to keep the pavements in good condition and from getting damaged due to the aforementioned distresses.

3. HIGHWAY PLANNING & DESIGNING

Highway design is only one element in the overall highway development process. Historically, detailed design occurs in the middle of the process, linking the preceding phases of planning and project development with the subsequent phases of right-of-way acquisition, construction, and maintenance. It is during the first three stages, planning, project development, and design, that designers and communities, working together, can have the greatest impact on the final design features of the project. In fact, the flexibility available for highway design during the detailed design phase is limited a great deal by the decisions made at the earlier stages of planning and project development.

3.1 The Stages of Highway Development

Although the names may vary by State, the five basic stages in the highway development process are: planning, project development (preliminary design), final design, right of way, and construction. After construction is completed, on-going operation and maintenance activities continue throughout the life of the facility.

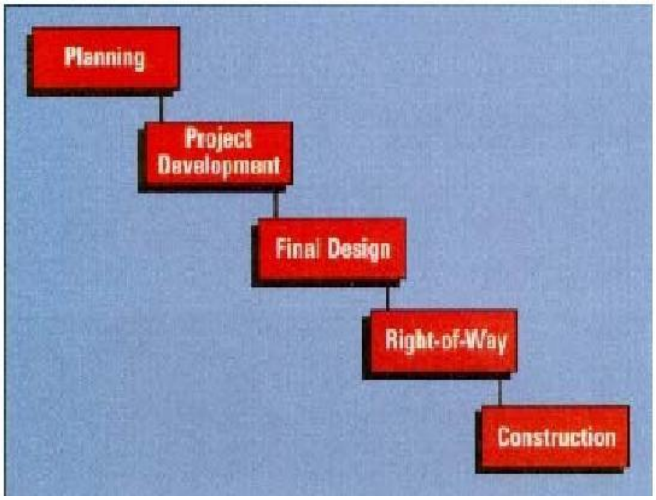


Figure 2. Process of Highway Planning

3.2 Geometric Design

Geometric design for transportation facilities includes the design of geometric cross sections, horizontal alignment, vertical alignment, intersections, and various design details. These basic elements are common to all linear facilities, such as roadways, railways, and airport runways and taxiways. Although the details of design standards vary with the mode and the class of facility, most of the issues involved in geometric design are similar for all modes. In all cases, the goals of geometric design are to maximize the comfort, safety, and economy of facilities, while minimizing their environ-mental impacts. This chapter focuses on the fundamentals of geometric design, and presents standards and examples from different modes.

The geometric design of highways deals with the dimensions and layout of visible features of the highway. The features normally considered are the cross section elements, sight distance consideration, horizontal curvature, gradients, and intersection. The design of these features is to a great extend influenced by driver behaviour and psychology, vehicle characteristics, traffic characteristics such as speed and volume. Proper geometric design will help in the reduction of accidents and their severity. Therefore, the objective of geometric design is to provide optimum efficiency in traffic operation and maximum safety at reasonable cost.

The planning cannot be done stage wise like that of a pavement, but has to be done well in advance. The main components that will be discussed are:

1. Factors affecting the geometric design,
2. Highway alignment, road classification,
3. Pavement surface characteristics,
4. Cross-section elements including cross slope, various widths of roads and features in the road margins.
5. Sight distance elements including cross slope, various widths and features in the road margins.
6. Horizontal alignment which includes features like super elevation, transition curve, extra widening and set back distance.
7. Vertical alignment and its components like gradient, sight distance and design of length of curves.
8. Intersection features like layout, capacity etc.

3.3 Factors affecting geometric design

Design speed: Design speed is the single most important factor that affects the geometric design. It directly affects the sight distance, horizontal curve, and the length of vertical curves. Since the speed of vehicles vary with

driver, terrain etc., a design speed is adopted for all the geometric design.

Topography: It is easier to construct roads with required standards for a plain terrain. However, for a given design speed, the construction cost increases multi form with the gradient and the terrain.

Traffic factors: It is of crucial importance in highway design, is the traffic data both current and future estimates. Traffic volume indicates the level of services (LOS) for which the highway is being planned and directly affects the geometric features such as width, alignment, grades etc., without traffic data it is very difficult to design any highway

Design Hourly Volume and Capacity: The general unit for measuring traffic on highway is the Annual Average Daily Traffic volume, abbreviated as AADT. The traffic flow (or) volume keeps fluctuating with time, from a low value during off peak hours to the highest value during the peak hour. It will be uneconomical to design the roadway facilities for the peak traffic flow.

Environmental and other factors: - The environmental factors like air pollution, noise pollution, landscaping, aesthetics and other global conditions should be given due considerations in the geometric design of roads.

4. HIGHWAY PAVEMENT FAILURE

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favourable light reacting characteristics, and low noise pollution. The major Flexible pavement failures are fatigue cracking, rutting, and thermal cracking. The fatigue cracking of flexible pavement is due to horizontal tensile strain at the bottom of the asphaltic concrete. The failure criterion relates allowable number of load repetitions to tensile strain and this relation can be determined in the laboratory fatigue test on asphaltic concrete specimens. Rutting occurs only on flexible pavements as indicated by permanent deformation or rut depth along wheel load path. Two design methods have been used to control rutting: one to limit the vertical compressive strain on the top of sub-grade and other to limit rutting to a tolerable amount (12 mm normally. Thermal cracking includes both low temperature cracking and thermal fatigue cracking.

4.1 Common Flexible Pavement Failure/ Distresses:

Various defects in flexible pavements have been seen and those are listed below:

1. **Cracks:**
- Alligator Cracking
- Longitudinal Cracking
- Block Cracking
- Edge Cracking
- Centre Cracking

2. **Rutting and Shoving:**
- Rutting Classification
- Shoving

3. **Pot Holes and Patching:**
- Pot Holes
- Patch Deterioration and Repairs

4. **Bleeding, Revelling and Weathering:**
- Bleeding
- Revelling and Weathering

5. **Miscellaneous Type of Defects:**
- Polished Aggregates
- Corrugations

4.2 Types of Distresses/Failures and Definitions:

1. Longitudinal Cracking: These are cracks parallel to the pavement centreline or lay down direction, which may eventually lead to moisture infiltration, roughness, and may indicate the possible onset of alligator cracking and structural failure. The possible ***causes*** include poor drainage, shoulder settlement, weak joints between adjoining spread of pavement layers or differential frost heave. The possible treatment depends on whether the pavement is structurally sound or unsound. Where the pavement is structurally sound, the cracks should be filled with low viscosity binder or slurry seal or fog seal depending on the width of the cracks. Unsound cracked pavements would need strengthening or rehabilitation treatment.

Figure 3. Longitudinal cracking on road

2. Fatigue Cracking: Cracks in asphalt layers that are caused by repeated traffic loadings. The cracks indicate fatigue failure of the asphalt layer. When cracking is characterized by interconnected cracks, the cracking pattern resembles that of an alligator's skin or chicken wire. Therefore, it is also referred to as alligator cracking.

Figure 4. Fatigue cracking on road

3. Block Cracking: These cracks appear as interconnected cracks forming blocks of square or rectangular shape on pavement surface. The size of the block cracking varies from 1000 sq.cm to 10000 sq.cm (1 sq.ft. to 10 sq.ft.). Block cracking is shown in photographs below.

Figure 5. Block cracking on road

4. Edge Cracking: Crescent-shaped cracks or fairly continuous cracks that intersect the pavement edge and are located within 2 feet of the pavement edge, adjacent to the unpaved shoulder. Includes longitudinal cracks outside of the wheel path and within 2 feet of the pavement edge.

Figure 6. Edge cracking on road

5. Rutting: Rutting is a longitudinal surface depression or groove in the wheel path. If the rutting is accompanied by adjacent bulging, it may be sign of subgrade movement. This phenomenon takes place when either pavement thickness is inadequate or there is heavy channelized traffic.

Figure 7. Rutting on road

6. Transverse Cracking: Cracks that are predominately perpendicular to pavement centreline and are not located over Portland cement concrete joints. Thermal cracking is typically in this category.

Figure 8. Transverse cracking on road

7. Reflection Cracking: Cracks in HMA overlay surfaces that occur over joints in concrete or over cracks in HMA pavements.

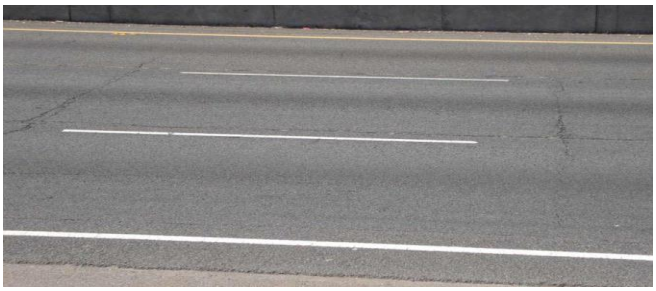


Figure 9.Reflections cracking on road

8. Corrugation: Transverse undulations appear at regular intervals due to the unstable surface course caused by stop-and-go traffic

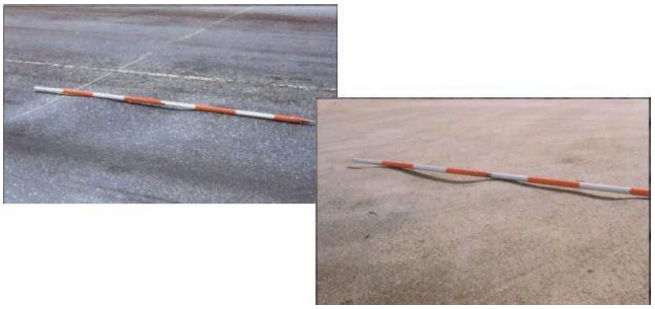


Figure 10. Corrugations on road

9. Shoving: It is a form of plastic movement resulting into localized bulging of surface. Shoving occurs characteristically at points where traffic starts or stops or at sharp curves. Shoving is shown in photographs.

Figure 11. Shoving on road

10. Depression: Small, localized surface settlement that can cause a rough, even hazardous ride to motorists.

Figure 12. Depression on road

11. Overlay Bumps: In newly overlaid pavements, bumps occur where cracks in old pavements were recently filed. This problem is most prevalent on thin overlays.

Figure 13. Overlay bumps on road

12. Delamination: Loss of a large area of pavement surface. Usually there is a clear separation of the pavement surface from the layer below. Slippage cracking may often occur as a result of poor bonding or adhesion between layers.

Figure 14. Delamination on road

13. Pot holes: These are bowl shaped holes of various sizes in the surface layer or extending into the base course. These are caused by localized disintegration of material and usually appear at water logged places or after rains.

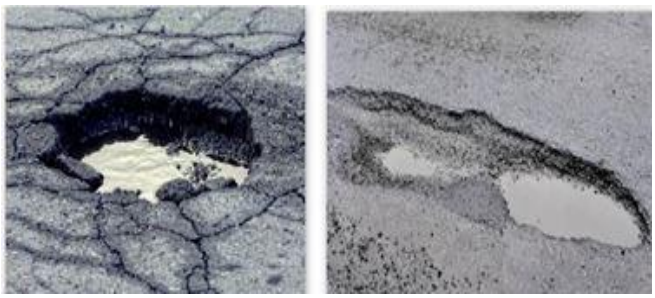


Figure 15. Pot Holes on road

15. Ravelling: Wearing away of the pavement surface in high-quality hot mix asphalt concrete that may be caused by the dislodging of aggregate particles and loss of asphalt binder.

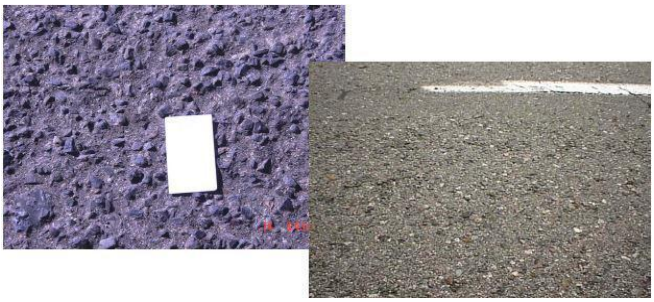


Figure 16. Ravelling on road

16. Stripping: The loss of the adhesive bond between asphalt cement and aggregate, most often caused by the presence of water in asphalt concrete, which may result in raveling, loss of stability, and load carrying capacity of the HMA pavement or treated base.

Figure 17. Stripping on road

17. Polished aggregate: Polished aggregate refers to the smoothness of the exposed aggregate. Bleeding and polished aggregate reduce the skid resistance of the pavement with resulting safety consequences. Bleeding is a film of bituminous material on the pavement surface, which creates a shiny, glass-like, reflecting surface that usually becomes sticky. It is caused by high asphalt content or low air void content. Since the bleeding process is not reversible during cold months, asphalt will accumulate on the surface and lower the skid resistance.

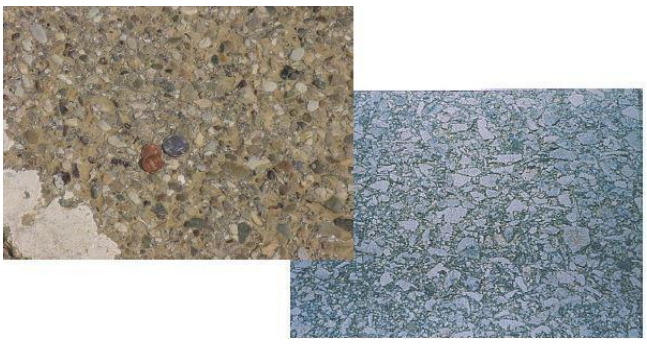


Figure 18. Polished Aggregate

18. Pumping: Seeping or ejection of water and fines from beneath the pavement through cracks.

Figure 19. Pumping

19.Segregation: Separation of coarse aggregate from fine aggregate as a result of mishandling of the mix at several points during mix production, hauling, and placing operations. Segregation leads to non-uniform surface texture and non-uniform density.

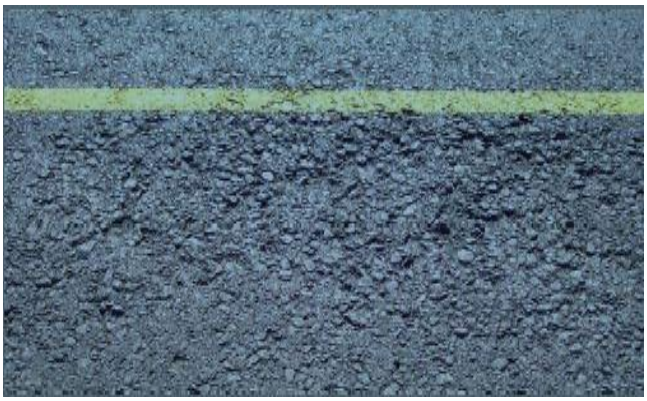


Figure 20. Segregation of Coarse Aggregate

20. Checking: Short transverse cracks, usually 1 to 3 inches in length and 1 to 3 inches apart, which occur in the surface of the HMA mat at some time during the compaction process. The cracks do not extend completely through the depth of the course, but are only about ½inch deep.

Figure 21. Checking on road

21. Bleeding/Flushing: Excess bituminous binder occurring on the pavement surface. May create a shiny, glass-like, reflective surface that may be tacky to the touch. Usually found in the wheel paths.

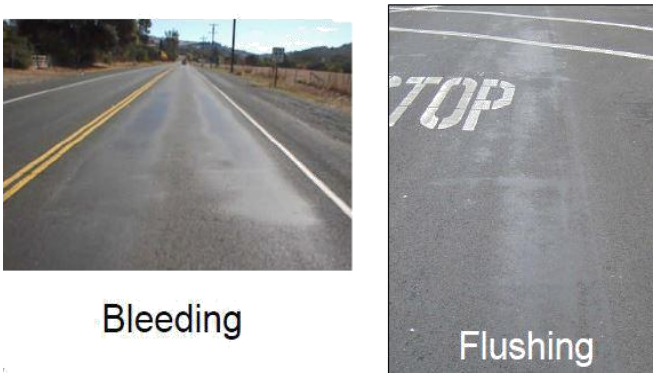


Figure 22. Bleeding & Flushing

22. Rock Loss: Wearing away of the pavement surface in seal coats.

Figure 23. Rock Loss

23. Bleeding/Fat Spots: Excess binder occurring on the surface treated pavements. May create a shiny, glass-like, reflective appearance. Fat spots are localized bleeding.

Figure 24. Bleeding on road

5. HIGHWAY MAINTENANCE

Preserving and keeping each type of roadway, roadside, structures as nearly as possible in its original condition as constructed or as subsequently improved and the operation of highway facilities and services to provide satisfactory and safe transportation, is called maintenance of Highways.

5.1 Surface maintenance of Roads:

Pavement maintenance and rehabilitation programs restore riding quality and maintain the structural integrity of the pavement over its full design life.

5.2 General surface maintenance:

- For maintenance of gravel roads blading and occasional resurfacing is required.
- For surface treatments of low type bituminous surface in maintenance of roads; Patching, seal coating or possible loosening oiling, re mixing and relaying are involved.
- For high type bituminous concrete and Portland cement concrete, the Removal and replacement of failure areas and resurfacing are approximate treatment methods for highway maintenance.
- Use same material and methods for road surface maintenance as far as possible.
- Highway Maintenance must be planned for rapid performance and to cause least possible disruption or hazard to traffic.

5.2.1Shoulders: Depend on the surface character of these areas:

- SOD shoulders must be moved and occasionally bladed down to the level of the roadway so that water is not trapped in the travelled way. Gross must be kept in good condition.
- Shoulders protected by bituminous blankets or surface treatments same as for roadway surface.
- Gravel and earth shoulders that leaves a drop off at the pavement edges creates a serious accidental hazard, hence, should be corrected by reconstruction, resurfacing or other appropriate means.
- Due to continuous wetting and drying of shoulder, edge joints result between lane and shoulder which may cause settlement of pavement due to entrance of water in sub grade soil. It can Repaired by filling the joint with sand and asphalt concrete.

5.2.2 Snow and ice control: Ice forming on the roadway reduces coefficient of friction between tires and surface, which makes vehicle control almost impossible. In highway maintenance we can apply abrasive to heavily travelled roadway and street. Suitable materials that can be used are clean and sharp sand, cinders and washed stone screening.

5.2.3 Bridge maintenance: Bridges maintenance is a major part of highway maintenance. Bridges can be maintained in good condition by following the below guidelines:

- Exposed steel work must be cleaned by sand blasting flame or other means followed by *repainting*.
- Deck joint may extrude or become filled with dirt so that cleaning and resealing is necessary
- Out of control vehicle, causing damage to guard rail, must be Repaired and strengthened.
- If bridge deck become rough resurfacing is required
- Remedial measures to correct serious scour around and under piers and abutments.

5.2.4 Traffic services: Include stripping, sign repair and maintenance (particularly needed for repair after stormy weather.

5.3 Surface treatment of highways:

Although the best type of surface course is pre-mix carpet for highway maintenance;

1. Intensity of traffic is not very high.
2. The pro-mix mixers are not easily available due to long transportation or technical reasons.
3. When the cost is high. The surface treatment methods are employed. The surface treatment may be single or multiple.

5.3.1 Single Surface Treatment: Is wearing course in which the bituminous material is sprayed and the aggregate is placed uniformly over the applied bitumen mineral. The thickness of such layer approximate the nominal size of aggregate used.

5.3.2 Multiple Surface Treatments :(Double or Triple) is a wearing surface in which a course aggregate is placed on bitumen coat (prime coat) already applied, followed by spraying of bitumen and then by subsequent application of finer aggregate over a second bitumen coat. Generally the minimum size of the smallest aggregate is one of the aggregate used in the preceding application usually thickness of single layer approximately maximum size of aggregate.

5.3.3 Function of surface treatment:

- To provide long lasting economical surface for granular base road having light and medium traffic volume.
- To prevent entry of surface water into old pavement that has been weathered or cracked.
- It improves the skid resistance of bitumen surface where the surface has polished under traffic.
- To provide temporary cover in case of delayed incomplete pavement.

In **Highway Maintenance,** for good surface treatment it is necessary to following the below rules.

- Base course is well prepared to its profile and is made freer from pot holes and ruts.
- Excellence of surface dressing depends upon the correct proportion of binder aggregate.
- Before laying that first surface dressing coat, the base should be made free from all dust loose soil etc.
- In all bituminous construction it is necessary that the newly surface possess a bond with the existing base at the interface. It is also necessary that the base is nearly impervious.

5.4 Mowing

Vegetation along the right-of-way will be mowed for the following reasons:

- Eliminate obstructions to sight distance on curves.
- Control weed and brush growth.
- Reduce snow drifting on the roadway.
- Provide for unobstructed drainage.
- Reduce the fire hazard in some areas.
- Improve road aesthetics.
- Eliminate obstruction to signs.
- Increase the visibility of large animals on the right-of-way.

All high traffic volume highways will receive one shoulder cut in the late spring and an additional full right-of-way cut. All other provincial highways in Alberta will receive up to 2 shoulder cuts per year (as required) and a full right-of-way cut once every 3 years or as warranted for brush control purposes. The first shoulder cut will be 4.5 metres in width and should be completed during the early summer months. The second shoulder cut or full cut may be warranted in the late fall, depending on re-growth. Where required, trimming around all appurtenances located adjacent to the highway will be carried out during the second cut. In urban Areas the mowing of boulevards and raised medians will be the responsibility of the municipality. The department will discuss their area's mowing plans and arrangements with local municipal officials. Where possible, the department will try to coordinate their operations with that of the municipalities.

5.5 Drainage systems:

As flowing water can be one of the greatest natural destructive forces affecting a road, it is very important that all structures and other features of the drainage system are well designed and properly maintained. In

order to maintain a roadway in optimum condition, water must be kept from saturating the subgrade and also from eroding the roadway. Drainage systems include the following components:

- Ditches
- Culverts
- Ditch Blocks
- Curbs/Gutters
- Down Drains
- Subsurface Drains
- Bridges

Each spring, the department will update and prioritize the culvert maintenance program. This program will describe any drainage system deficiencies and identify what corrective action needs to be taken.

5.6 Traffic control devices

5.6.1 Signing: Signs are used to inform motorists of traffic regulations, warn of changes in the roadway characteristics or hazards, and to provide directional/distance information that is necessary to motorists.

All highways should be checked on a regular basis to ensure that all signs are properly in place, functional and conform to established standards. In addition to daytime inspections, night inspections should be carried out regularly to ensure that signs are reflective and legible during hours of darkness. Lighting which has been installed on overhead sign structures should be inspected regularly to ensure that all fixtures are operational. Signs larger than 3m2 should be placed on breakaway bases to minimize the potential for injury and vehicle damage if struck by vehicles leaving the roadway. Shear bolts should be checked periodically for proper torque so that the breakaway feature will function as intended.

5.6.2 Traffic signals: The function of a traffic control signal is to safely assign the right-of-way between the conflicting flows of traffic at an intersection. Standards related to the installations and operation of traffic control signals can be found in the Manual of Uniform Traffic Control Devices for Canada.

5.6.3 Livestock guards: Livestock guards are used to prevent domestic and wild animals from entering the roadway. Most livestock guards are installed on approaches to highways; however, there are a small number located on the main highway. The department will maintain and inspect all livestock guards located on the Provincial Highway System. The department shall inspect the guards to ensure that the guard is carrying out its intended function of preventing domestic and wild animals from entering roadway. Accumulated debris must be removed before it causes water drainage problems or builds to a height that it renders the guard ineffective. Repairs to guard and associated fencing are done as required.

6. CONCLUSIONS

Engineers have been always with open mind to adopt any material available to them for its use for the construction purposes. It is logical to see that the purpose of highway construction is to provide a firm and even surface for the carriageway or the pavement which could stand the stress caused due to number of load applications.

Following conclusions have been drawn based on the present study:

- Proper design, regular inspection and maintenance of drainage system is of utmost importance in preserving the investment made on highway system and in providing comfort and safety to the road user.
- The classifications of all types of distresses have been identified. The cause and treatment is different for different severity levels of each distress.
- The defects in existing highway system and in maintenance practices must be clearly understood and eradicated.
- The influencing parameters considered in this study are cracks and cracking pattern, roughness, pot holes and deflections. The above parameters have been classified according to their severity levels.
- Maintenance decision can be taken based on the criteria of reaching any one or all of the influencing parameters to their maximum acceptable limits.
- The small distress (cracking, potholes, shoving, rutting, etc.) must be repaired before any major maintenance (overlay, renewal coat) is done. Even reduced thickness of overlay will show better results if minor defects are repaired before overlays are done.

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