WOLAITA SODO UNIVERSITY

COLLEGE OF ENGNEERING

DEPARTMENT OF CIVIL ENGINEERING

Course Name: Road And Bridge Construction.

Code: CoTM 4202

Pre-requisite: Highway Engineering (CoTM 3201)

For 4th Year CoTM Students

CHAPTER ONE
INTRODUCTION TO HIGHWAY PAVEMENT

Before we directly go through the course content let us discus on the following important points:-

- **Why the gov't has constructing Highway? Even It is cost and expensive….**
- **What are the stages to have construct the Road (Highway)?**
- **What are the parties on constructing the Road? What are their role on each stages of the road construction?**
- **What is pavement?**
- **What will be happen if the highway is not paved?**
- **What is its function?**

Why the gov't has constructing highway? Even it is cost and expensive…

þ/c it is backbone for one's country dev't.. No highway no dev't,…

For military purpose…

Its Stages:-

1. Planning stage = reconnaissance survey, feasibility study , discussing with stake holders, political decision , local administration, finance,
2. Preliminary design = checking different options, corridors
3. Detail design = working drawings….
4. Right-of-way issue = land issue, compensation fee
5. Construction = Bid process, selecting contractors, mobilization of machinery, manpower…..

What are the parties on constructing the road?

- The client = the federal gov't, regional gov't, zonal or woredal gov't, the community, local authorities…..
- The consultant = local or international consulting company…..
- The contractor = local or international construction contractors. For mega projects international contractors…
- Financers =

What are their role on each stages of the road construction?

The client:- The word is more generally used for the organisation which need the end product and has the authority and the money to order and approve it. The client can be an individual, government organisation, group of people, etc.

Consultants/designers

These are professionals responsible for translating the client's requirements into reality.

Consulting engineers must be qualified by education and experience to provide competent engineering services.

The consulting engineer plays an important role in the private and public sectors of nearly all countries.

Consulting engineers furnish valuable professional services to various clients, which include governments, commercial organisations, individuals, etc.

Consulting engineers have continuing personal contacts with contractors, suppliers, manufacturers, government officials, financial organisations and others.

Contractors / the executors

these are people who undertake the physical construction as per the design and agreement with in allocated budget and time, who in many cases will be private contractors.

Financers

These are banks, insurance companies and other financing organisations who made the construction possible by financing the particular project.

What is pavement?

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, favorable light reflecting characteristics, and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel load are sufficiently reduced, so that they will not exceed bearing capacity of the sub-grade.

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Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Pavement grants friction for the vehicles thus providing comfort to the driver and transfers the traffic load from the upper surface to the natural soil.

Pavements are primarily to be used by vehicles and pedestrians. Storm water drainage and environmental conditions are a major concern in the designing of a pavement.

What will be happen if the highway is not paved?

- Deficient pavement conditions can result in increased user costs and travel delays,
- braking and fuel consumption,
- vehicle maintenance repairs and probability of increased crashes.
- Causes accidents of human fatality, property damage.
- High noise and environmental pollution.

Major defect types in pavements

Pavements are designed such that they provide a safe and comfortable driving surface to the public.

Major defect types that can be observed on pavements are:

- cracking,

- deformations,

- disintegration and wear.

Cracks in pavements occur because of different reasons. They might be traffic load associated or might develop because of thermal movements.

Due to low temperature.

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- alligator cracking and longitudinal cracking.
- Pot holes = Lack of maintenance has resulted in potholes which obviously result in a large decrease of driving comfort. The reason for the potholes is that pavement has cracked severely and small pieces of the surface layer have been driven out.
- It holds rain water and causes uncomfortable conditions for pedestrians on rainy season.

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Deformations in pavements can be divided in longitudinal and transverse deformations.

- are caused by settlements, swelling soils, frost heave etc.

The best known transversal deformation type due to traffic is rutting or permanent deformation that occurs in the wheel paths.

- Rutting can be the result of a densification process or as a result of shear failure of the asphalt layers.

Disintegration and wear

Raveling, bleeding and pothole formation can be rated as signs of disintegration and wear.

- Bleeding is a defect type that can be recognized as black, “fatty” looking spots on the pavement surface.

Due to the high bitumen content, the mixture suffers probably from lack of stability at higher temperatures and high traffic loads might squeeze out the bituminous mortar.

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Another reason might be that because of the low void content, there is not enough space for the bituminous mixtures when it expands with increasing temperatures.

- Raveling is the loss of aggregate from the surface layer.

Raveling develops because of cohesive failure in the bituminous mixtures or adhesive failure in the interface between aggregate and bituminous mixtures.

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What is its function?

Why keep roads in good condition? The economy of any area depends on shipping and receiving products and materials; trucks are the most common form of transport. The condition of area roads directly affects the speed, efficiency, and ultimately the costs of transportation.

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- To safely transfer vehicle wheel loads and another vertical stress to sub components.
- To prevent the damage of sub base materials
- Reduce noise
- Minimize environmental pollutions.
- Reduce accidents
- Time saving (speed traveling)
- Fuel consumption saving
- Quality and comfortable riding (smooth surface)
- To minimize the maintenance cost of gravel road

Pavement design process

Pavement Design is a project level activity where detailed engineering and economic considerations are given to alternative combinations of subbase, base, and surface materials which will provide adequate load carrying capacity at the lowest possible cost during its life. Factors which are considered include: Materials, traffic, climate, maintenance, drainage, and life-cycle costs.

The design of flexible pavement is based on load distributing characteristic of the component layers

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- The basic elements of the paving structure include the surfacing, base course; stabilized or unstabilized, and subbase courses as required.
- Pavement structures are divided into two general classifications – **flexible and rigid** based on the type of pavement structure. Flexible pavements have some type of bituminous surfacing and rigid pavements have a surfacing of Portland cement concrete (PCC).
- The two main types of pavement in common use are flexible and rigid pavements. The difference between the two is the manner in which they distribute the applied load to the subgrade.

Characteristics of highway pavements

1. Friction services.

Several factors affect highway safety including pavement friction, road geometry, traffic conditions, vehicle speed, and environmental conditions. Safety data show low friction in conjunction with wet conditions directly correlates to increased number of skid related crashes. Thus, from a pavement engineering perspective, friction is a key factor in highway safety.

Is applied to existing pavement surfaces to significantly increase skid resistance at locations where friction demand is highest, such as at curves and near intersections.

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2.Smoothness services

Pavement smoothness directly affects ride comfort. The public demands good ride quality, agencies want good pavement smoothness specifications, and contractors want to do the best job possible to lower their bids and/or maximize incentive.

3.Noise services

Traffic noise can be a major environmental concern for many roads and highways. In many cases, the dominant source of traffic noise is tire-pavement noise, that is, sound produced by the tires rolling on the pavement. Sound walls or barriers are a common method of reducing traffic noise.

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4. Splash and spray services

Splash and spray is a surface characteristic that directly affects road safety. Generation of both splash and spray begin with the same basic mechanism: as a vehicle drives down a wet road, the water beneath the tire will be displaced. Some of this water will be ejected in bulk – as an airborne wave or jet of water termed splash.

5. Texture services = environmental friend

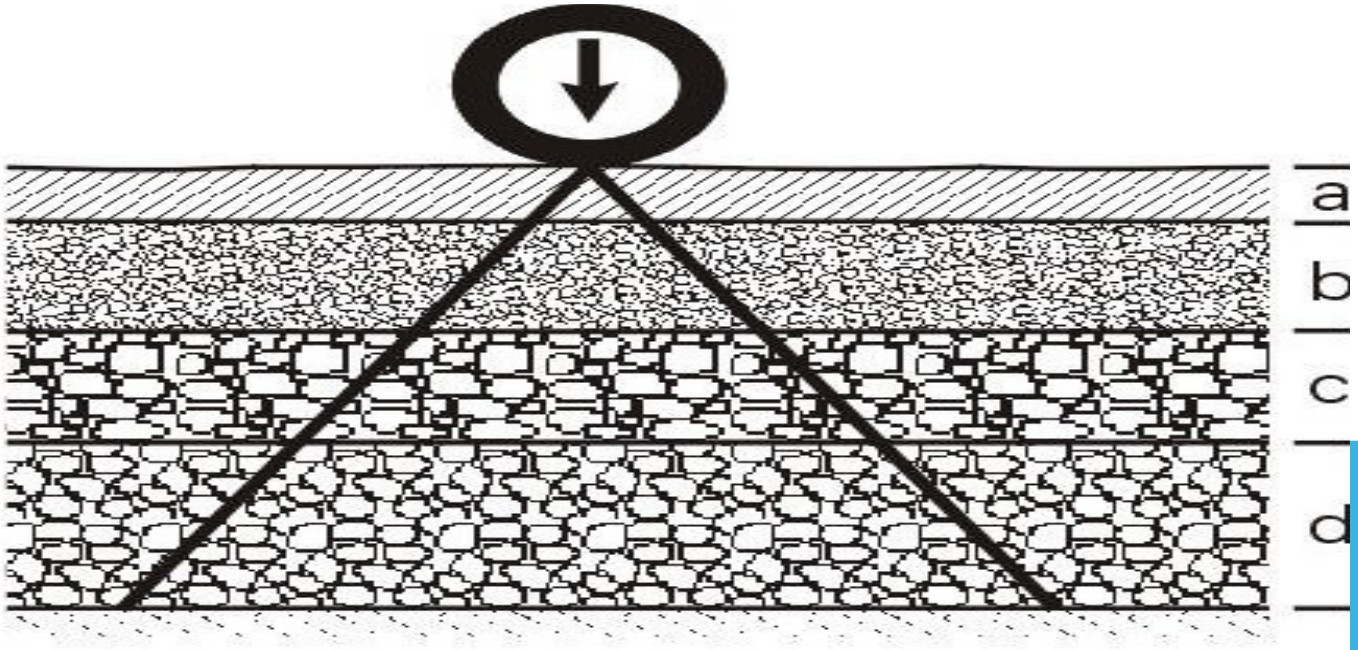
1.2 over view of pavement structures.

The pavement structure is the pavement layers designed to support traffic loads and distribute them to the roadbed soil or select embankment material.

Flexible pavements consist of layers of granular materials and/or asphalt bound materials (such as hot mix asphalt or asphalt surfacing) with lower rigidity and stiffness compared with rigid pavements. Such pavements generate their load-bearing capacities based largely on the load distribution characteristics of the individual layers. The strength of a flexible pavement is built up with thick layers. These layers distribute the applied loads over the subgrade. As a result, the design thickness of the pavement is influenced by the load distribution mechanism and the strength of the subgrade.

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For these reasons, the material properties comprising each layer, its thicknesses, the subgrade strength, and the loading level are critical design parameters.



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- HMA (bitumen's surface) = direct contact with wheel & transfer load to base course.
- Base course= supports asphalt & distribute load to sub base
- Sub base course= protecting water reaching to top layers
- Capping layer = if the sub grade CBR < 2%
- Sub –grade = natural soil

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The pavement has to be built on subgrade of known strength. For heavily trafficked roads the subgrade is improved as necessary and the sub-base form a stable platform for the construction of the bound structural layer and surfacing above. For the longer term the capping and/or sub-base prevent water reaching the bound layers and provide a platform on which to compact the bound layers.

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The foundation of road can be constructed of capping layer plus sub-base or sub-base alone. The choice of whether to use capping layer plus sub-base or sub-base alone can be made on economic grounds or other construction program considerations (unless the CBR is less than 2% in which case a capping layer is obligatory).

Capping layer can be formed from a wide range of materials including lime and cement stabilized subgrade soils, secondary aggregates and other quarry or demolition waste.

The capping layer is not expected to have the same stiffness as sub-base and so requires a greater layer thickness.

Sub-base materials are formed from cement stabilized soils, hydraulic bound materials and well graded granular material

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A rigid pavement, Portland cement concrete (PCC), due to its high rigidity and high stiffness (modulus of elasticity), tends to distribute the loads over a wide area of subgrade, resulting in the PCC slab carrying the majority of the load. Load distribution is considered the major factor in the performance of rigid pavements. This characteristic allows minor variations in the subgrade strength to have little effect on the structural capacity of the rigid pavement.

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- Portland cement concrete = rigid concrete, carries the load (stress) from wheel.
- Sub base = Is the layer of materials that lies immediately below the concrete pavement.
- Sub grade = Is the natural ground, graded and compacted; on which the pavement is built.

Difference between flexible and rigid pavement

1. Flexible pavement differ from rigid pavement in terms of load distribution. In flexible pavements load distribution is primarily based on layered system. While, in case of rigid pavements most of the load carries by slab itself and slight load goes to the underlying strata.
2. Structural capacity of flexible pavement depends on the characteristics of every single layer. While, the structural capacity of rigid pavements is only dependent on the characteristics of concrete slab. This is so, because of low bearing soil capacity of underlying soil.

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3. In flexible pavements, load intensity decreases with the increase in depth. Because of the spreading of loading in each single layer. While, in case of rigid pavement maximum intensity of load carries by concrete slab itself, because of the weak underlying layer.
4. In flexible pavement deflection basin is very deep, because of its dependency on the underlying layers. While in case of rigid pavement, deflection basin is shallow, this is because of independency of rigid pavement on the underlying layers.

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5. Flexible pavement has very low modulus of elasticity (less strength). Modulus of elasticity of rigid pavement is very high, because of high strength concrete and more load bearing capacity of the pavement itself. Than compared to flexible pavements.

6. In flexible pavements, underlying layers play very important role. Therefore, more role are playing only underlying layers. In case of rigid pavements, slight function of underlying layers. Maximum role is playing by the top layer (that is slab) by itself. Therefore, minute part is taking by sub layers.

Comparison of flexible and rigid pavements

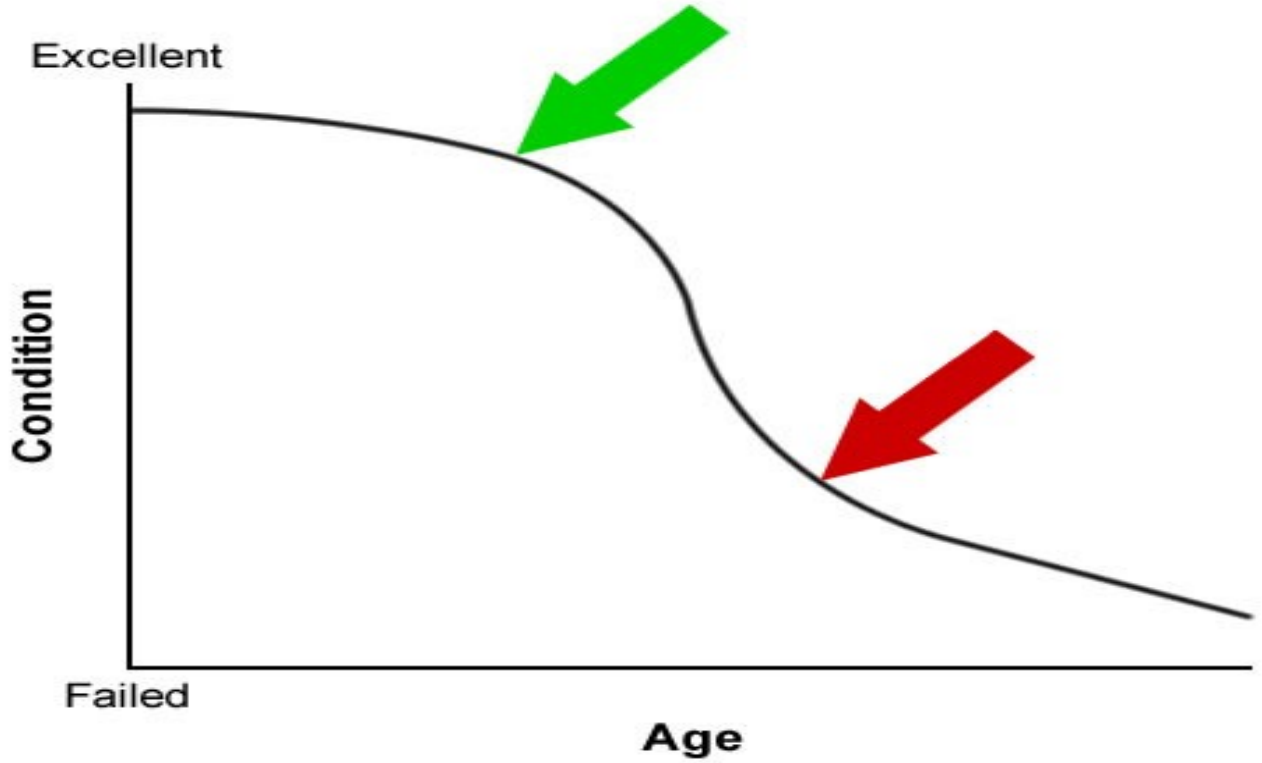
Flexible pavement	Rigid pavement
Deformation in the sub grade is transferred to upper layers	Deformation in the sub grade is transferred to subsequence layers.
Have low flexural strength	Have high flexural strength
Load transferred to gain to gain (layer to layer) contact.	No such phenomenon grain to grain loads transferred exist.
Have low completion cost (initial cost) but high repairing cost. 15-20 years life span	Have low repairing cost but high completion (initial cost). 30-40 years life span.
Damaged by oil and chemicals.	No damage by oil or Greece
Design based on load distribution factor.	Design based on flexural strength or slab action.

Maintenance and rehabilitation of pavements

Considering the huge cost of maintaining and rebuilding roads, local goverments have great incentive to protect pavements. Three elements work to cause road deterioration: traffic loads, the environment, and aging.

- pavement maintenance" can mean a lot of things, ranging from simple cleaning or restriping up to fixing severe distresses like potholes and washouts.
- maintenance activities is extending the life of the pavement.
- Using the right maintenance treatment at the right time will help you get the maximum benefit.

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- The graph shows the condition of pavement over time.

Preventive maintenance when a pavement is still in good condition (green arrow) is significantly less expensive than treatment after pavement deterioration has accelerated (red arrow).

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The worse its condition gets, the more expensive the treatment required to restore the pavement to good condition.

Pavement maintenance treatments do not significantly change the structural or load-carrying capacity of the pavement.

Categories of Pavement Maintenance

1. Preventive maintenance(Bituminous Surface Treatments

- seal coat or chip seal, is a thin protective wearing surface that is applied to a pavement or base course.
- retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity).

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2. Corrective maintenance:- treatments such as pothole repair and patching, along with joint replacement or slab replacement for rigid pavements.

- Patches are a common method of treating an area of localized distress of HMA. Patches can be either full-depth where they extend from the pavement surface to the subgrade

3. Routine maintenance:- Smaller activities like cleaning roadside ditches or crack filling.

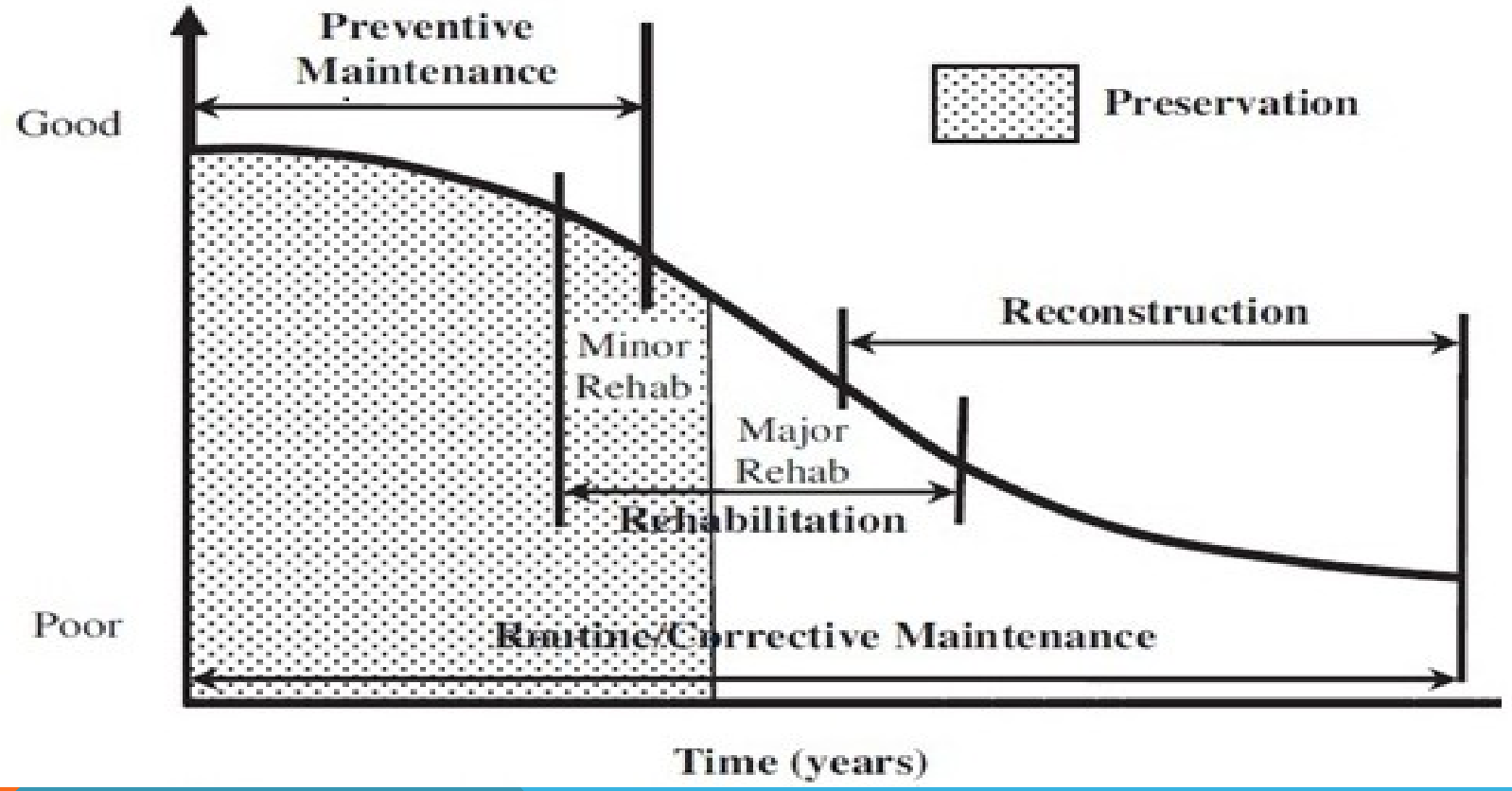
- Crack seal products are used to fill individual pavement cracks to prevent entry of water or other non-compressible substances such as sand, dirt, rocks or weeds.

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- **Pavement preservation:** Programs and activities employing a network level, long term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet road user expectations.
- **Pavement rehabilitation:** Structural enhancements that extend the service life of an existing pavement and/or improve its load-carrying capacity.

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Pavement reconstruction: Replacement of the entire existing pavement structure by the placement of the equivalent or increased pavement structure.



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What is pavement fatigue?

Fatigue is progressive damage from many (repeatedly) application of a load. Pavement usually breaks up from fatigue.

For example; if we bend a metal rod once; it won't break as soon as. But if we bend it many times and eventually it will break. It will take many more slight bends before it breaks than large ones.

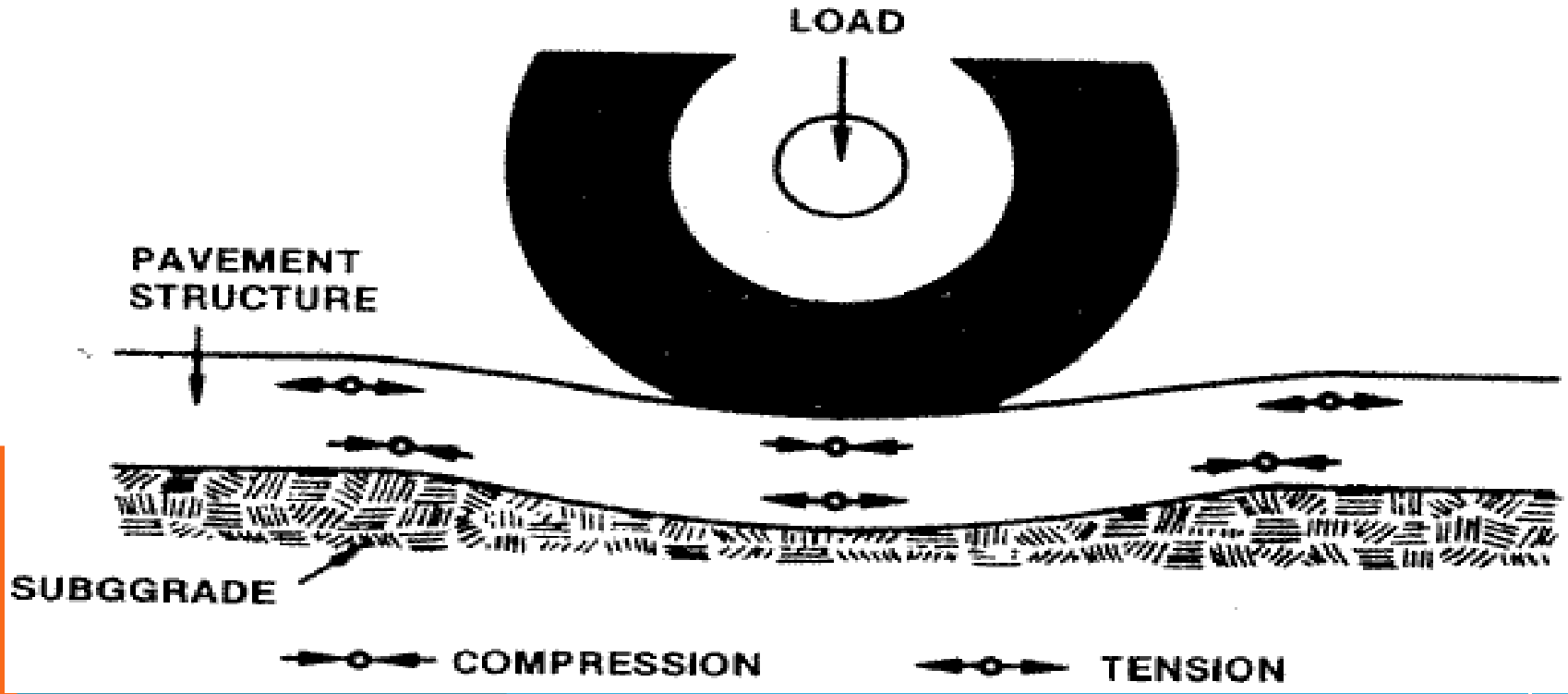
Flexible pavement = 15-20yrs. Rigid pavements = 30-40yrs

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Roads also bend under vehicle loads. As the pavement bends, its various layers are affected differently (see figure 1). Like the metal rod, the upper portion is compressed while the lower portion stretches. As bending causes fatigue, the pavement surfacing cracks allowing moisture into the pavement base and subgrade. This results in greater bending, further cracking and finally failure.

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Fatigue damage depends on the weight and arrangement of axle loads, the thickness of the pavement and the strength of the layers below(sub-grade, sub-base, base coarse)



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Changing seasons

Regardless of traffic, environmental effects will cause roads to need maintenance after about 15 years. Spring is the critical time of the year for a road. It is at its weakest during spring thaw. As frost leaves the ground, the moisture softens the soil causing it to lose its strength and ability to support loads. The amount soil weakens is related to its composition. Granular soil (sand), doesn't lose as much strength as a soil containing a lot of silt or

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Posting Roads

Since road strength varies throughout the year, roads may be posted for different load limits depending on the season. It is most important to change load limits in spring when the subgrade is the weakest. Local governments have the legal authority to post load limits

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Road posting and the use of truck routes are good management techniques to preserve pavements.

Assignment-1 (10%)

1. Discuss the role of Construction Technology engineering (CoTM) in construction of Road and Bridge. Why are you interested to study Construction Technology engineering (CoTM) ? Speculate on the future of Construction Technology engineering (CoTM) profession in Ethiopia.
2. How Vehicle Loads Affect Pavement Performance ?
3. What is the difference b/n maintenance and rehabilitation of pavements?
4. What are the party in construction of Highway pavement? In a tabulated form, discuss the functions of each party in construction works at each stage of highway pavement construction. Which party, do you think, is most important in executing a construction and Why?

Assignment-1

5. At what soil conditions and places (situation) the rigid pavement construction is recommended? Why?

Submission Date ……...