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Design of Highway Pavement

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Abstract:
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 subgrade. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. This chapter gives an overview of pavement types, layers, and their functions, and pavement failures. Improper design of pavements leads to early failure of pavements affecting the riding quality. Highway and pavement design plays an important role in the DPR projects. The satisfactory performance of the pavement will result in higher savings in terms of vehicle operating costs and travel time, which has a bearing on the overall economic feasibility of the project. This paper discusses about the design methods that are traditionally being followed and examines the "Design of rigid and flexible pavements by various methods & their cost analysis by each method". Flexible pavement are preferred over cement concrete roads as they have a great advantage that these can be strengthened and improved in stages with the growth of traffic and also their surfaces can be milled and recycled for rehabilitation. The flexible pavements are less expensive also with regard to initial investment and maintenance. Although rigid pavement is expensive but have less maintenance and having good design period. The economic part is carried out for the design pavement of a section by using the result obtains by design method and their corresponding component layer thickness. It can be done by drawing comparisons with the standard way and practical way. This total work includes collection of data analysis various flexible and rigid pavement designs and their estimation procedure are very much useful to engineer who deals with highways.

Keywords: Design of flexible pavement, Design of rigid pavement, Cost analysis, Estimation.

I.INTRODUCTION

A highway is a public road, especially a major road connecting two or more destinations. Any interconnected set of highways can be variously referred to as a "highway system", a "highway network", or a "highway transportation system". The history of highway engineering gives us an idea about the roads of ancient times. Roads in Rome were constructed in a large scale and it radiated in many directions helping them in military operations. Thus they are considered to be pioneers in road construction. The modern roads by and large follow Macadam's construction method, use of bituminous concrete and cement concrete are the most important developments. Various advanced and cost-effective construction technologies are used. Developments of new equipments help in the faster construction of roads. Many easily and locally available materials are tested in the laboratories and then implemented on roads for making economical and durable pavements. Scope of transportation system has developed very largely. Population of the country is increasing day by. The life style of people began to change. The need for travel to various places at faster speeds also increased. This increasing demand led to the emergence of other modes of transportation like railways and travel by air. While the above development in public transport sector was taking place, the development in private transport was at a much faster rate mainly because of its advantages like accessibility, privacy, flexibility, convenience and comfort. This led to the increase in vehicular traffic especially in private transport network. Thus road space available was becoming insufficient to meet the growing demand of traffic and congestion started. In addition, chances for accidents also increased. This has led to the increased attention towards control of vehicles so that the transport infrastructure was optimally used. Various control measures like traffic signals, providing Roundabouts and medians, limiting the speed of vehicle at specific zones etc. were implemented. With the advancement of better roads and efficient control, more and more investments were made in the road sector especially after the World wars. These were large projects requiring large investment. For optimal utilization of funds, one should know the travel pattern and travel behaviour. This has led to the emergence of transportation planning and demand management.

II.MODERN SOIL STABILIZATIONTECHNIQUES

The stabilization of naturally-occurring or native soil has been performed by millennia. The Mesopotamians and Romans separately discovered that it was possible to improve the ability of pathways to carry traffic by mixing the weak soils with a stabilizing agent like pulverized lime stone or calcium. This was the first chemical stabilization of weak soils to improve their load-carrying ability. Successful modern soil stabilization techniques are necessary to assure adequate subgrade stability, especially for weaker and wetter soils. It is widely recognized that selection between cementations stabilizing agents cement and lime is based on the Plasticity Index (P I) of the primary soil type being improved.

2.1 STABILIZATION WITH CEMENT

2.1.1 CTB (CEMENT TREATED BASE)

According to the PCA (Portland Cement Association), CTB (Cement Treated Base) has provided economical, long lasting pavement foundation. These structures have combined soil and/or aggregate with cement and water which compacted to high density. The advantages of cement stabilization are several:

1. Cement stabilization increases the base material strength and stiffness, which reduces deflection due to the traffic loads. This delays surface distresses such as fatigue, cracking and extends pavement structure life.
2. Cement stabilization provides uniform and strong support, which results in reduced stresses to the sub-grade. Testing indicates a thinner cement-stabilized layer can reduce stresses more effectively than a thicker un-stabilized layer of aggregate. This reduces sub-grade failure, pot-hole formation and rough pavement surface.
3. Cement stabilized base has greater moisture resistance to keep water out; this maintains the higher strength of the structure.
4. Cement stabilization reduces the potential for pumping of sub-grade fines.
5. Cement stabilized base spread loads and reduces sub-grade stress.

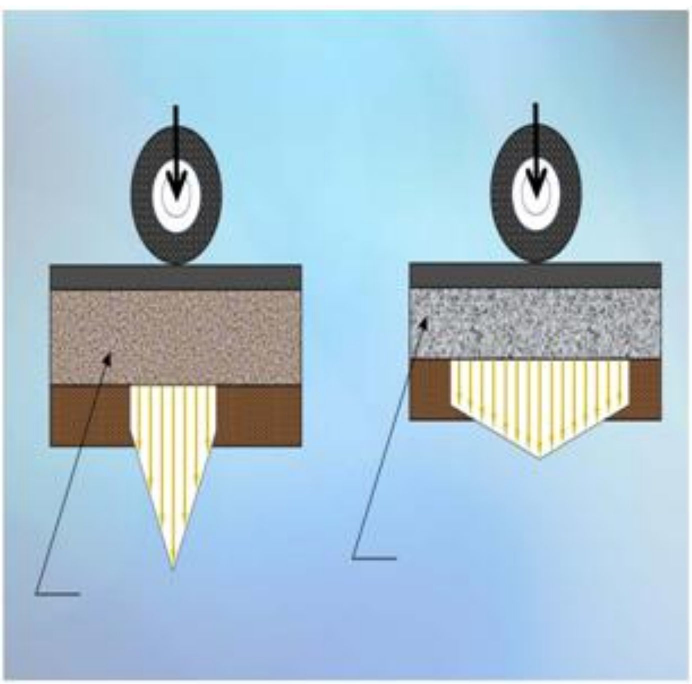

Figure.1. Load Distribution
(Source:http://www.scribd.com/doc/38589165/1-Cement-Treated-Bases-Abdo)

2.1.1.1COMPOSITION AND CONSTRUCTION

The mixture shall be composed of existing sub-grade, base course and surface course materials, and/or an imported soil aggregate, with Portland cement and water added. The mixture shall contain not less than 4% cement by volume of compacted mixture, 1420 kg (94 pounds) of cement being considered as 1 cu m (1 cubic foot). At least 30 days before the beginning of stabilizing operations, adequate quantities of soil and cement shall be supplied to the Materials Division for determination of cement requirements. The Engineer will specify, based on laboratory tests, the exact percentage of cement to be used. Specimens of soil aggregate, cement, and water shall develop a compressive strength of a least 2.7 M Pa (400 psi) in 7 days.

Figure.2.Mixing of soil-cement for sub-grade stabilization
(Source: http://www.cement.org/ pavements/pv_sc_ ctb_dulles. asp)

MATERIALS

The materials used shall comply with the following requirements:

(a) WATER

Water used in mixing or curing shall be clean and free from injurious amounts of oil, salt, or other deleterious substances. Where the source of water is relatively shallow, it shall be maintained at such a depth and the intake so enclosed as to exclude grass, vegetable matter, or other foreign materials.

(b) CEMENT

Fly ash may be used as a partial replacement for the cement. Replacement amounts, not exceeding 25% by weight, shall be determined through trial batch investigations using the specific materials proposed for the project. Mixtures with fly ash shall meet the same requirements as mixtures without fly ash. All trial batches required by this specification shall be accomplished by the Contractor, observed by the Engineer, and approved by the Engineer of Materials. Fly ash will not be allowed as a substitute for high early strength or blended cements. For in-place stabilization, the fly ash and cement shall be blended to form a homogeneous mixture before application on the roadway. The use of cement salvaged from used or discarded sacks will not be allowed. Cement placed in storage shall be suitably protected. Any loss of quality occurring during the storage period will be cause for rejection. If the cement furnished shows erratic behaviour under the field conditions incident to the mixing and placing of the mixture, or in the time of the initial or final set, the Contractor will at once, without notice from the Engineer, cease the use of that brand of cement and furnish material of such properties as to ensure quality work conforming to these specifications.

2.1.1.2 CONSTRUCTION REQUIREMENTS

Sufficient equipment shall be available so that the work may proceed in proper sequence to completion without unnecessary delay. Equipment, tools, and machinery used shall be maintained in a satisfactory working condition. The application of cement and mixing of the cement and soil aggregate will be allowed only on an approved sub-grade, free of excess moisture. No work will be allowed on a frozen sub-grade. The operations shall be such as to prevent the drifting of cement or dust off the right-of-way.

(a) PREPARATION OF THE ROADBED

Prior to other construction operations, the existing roadbed, including the shoulders, shall be brought to line and grade and shaped to the typical cross section of the completed roadbed and compacted to sufficient density to prevent rutting under normal operations of construction equipment. All soft areas shall be corrected to provide uniform stability.

(b) PULVERIZING

After shaping and compacting the roadbed, the material to be processed shall be scarified and pulverized before application of cement. Pulverizing shall continue during mixing operations until a minimum of 80% by weight of the material, exclusive of coarse aggregate, will pass a 4.75 mm (#4) sieve. Material retained on a 75 mm sieve and other unsuitable material shall be removed.

(c) APPLICATION AND MIXING OF CEMENT

The application and mixing of cement with the aggregate material shall be performed according to one of the following methods:

(1) TRAVEL PLANT METHOD

The specified quantity of cement shall be applied uniformly on the material to be processed, and shall not exceed that which can be processed the same working day. When bulk cement is used the equipment shall be capable of handling and spreading the cement in the required amount. The moisture content of the material to be processed shall be sufficiently low to permit a uniform and intimate mixture of the aggregate material and cement. Mixing shall be accomplished by means of a self-propelled or self-powered machine equipped with a mechanical rotor or other approved type of mixer that will thoroughly blend the aggregate with the cement. Mixing equipment shall be so constructed as to assure positive depth control. Care shall be exercised to prevent cement from being mixed below the depth specified. Machines designed to process less than the full width of base at a single pass shall be operated so that the full width of base can be compacted and finished in one operation. Water shall be uniformly added and incorporated in the mixture. The water supply and distribution equipment shall be capable of supplying the total required amount of water to the section being processed within 3 hours. If more than one pass of the mixer is required, at least one pass shall be made before water is added. Mixing shall continue after all water has been applied until a uniform mixture of aggregate, cement, and water has been obtained for the full depth of the course. The aggregate and cement mixture that has not been compacted and remains undisturbed more than 30 minutes shall be remixed. In the event of rain adding excessive moisture to the uncompacted material, the entire section shall be reworked. Should the Contractor be unable to finish the section within the same day, the section shall be reconstructed and an amount equal to 50% of the original amount of cement added to the mixture at no cost to the Department.

(2)CENTRAL PLANT METHOD

When a central plant is used, the soil aggregate, cement, and water shall be mixed in a pug mill either of the batch or continuous flow type. The plant shall be equipped with feeding and metering devices that will add the soil aggregate, cement, and water into the mixer in accurately proportioned amounts as determined by the laboratory design. Aggregate and cement shall be dry-mixed sufficiently to prevent cement balls from forming when water is added. Mixing shall continue until a uniform mixture of aggregate, cement, and water has been obtained. The mixture shall be hauled to the roadway in trucks equipped with protective covers. Immediately before spreading the mixture, the sub-grade or foundation course shall be moistened and kept moist, but not excessively wet, until covered by the mixture. The mixture shall be placed on the roadbed in a uniform layer by an approved spreader or spreaders. No more than 60 minutes shall elapse between adjacent spreader runs and not more than 60 minutes shall elapse between the time of mixing and the beginning of compaction. The layer shall be uniform in depth and in such quantity that the completed base will conform to the required grade and cross section. Dumping of the mixture in piles or windrows will not be permitted.

(a) COMPACTION AND SURFACE FINISH

The moisture content of the mixture during compaction shall not vary more than ±5% from the optimum moisture. The surface of the treated roadway shall be reshaped to the required lines, grade, and cross section after the mixture has been compacted. It shall be scarified lightly to loosen any imprints left by the compacting or shaping equipment and rolled thoroughly. The operation of final rolling shall include the use of pneumatic tired rollers. The rolling shall be done in such manner as to produce a smooth, closely knit surface, free of cracks, ridges, or loose material, and conforming to the crown, grade, and line shown on the plans. The density, surface compaction, and finishing operation shallot require more than two hours. Water shall be added, if necessary, during the finishing operation to maintain the mixture at the proper moisture content for securing the desired surface. Areas inaccessible to rollers or finishing and shaping equipment shall be thoroughly compacted to the required density by other approved compacting methods and shaped and finished as specified.

(b) JOINTS

As soon as final compaction and finishing of a section has were completed, the base shall be cut back perpendicular to the centre line to a point where uniform cement content with proper density has been attained and where the vertical face conforms to the typical section shown on the plans. When the road mixes method issued, a header shall be placed against the vertical face of the finished section and securely staked in place. This header shall be left in place until all mixing operations on the adjoining section have been completed, after which the header shall be removed and the trench backfilled with processed material. This material shall be compacted so that a well-sealed joint is formed and a smooth riding surface is obtained. As an alternate to using a header, the subsequent day's operation may be started by cutting back into the previously placed course to the extent necessary to obtain uniform grade and compaction.

(c) SURFACE TEST

The finished surface of the treated base course shall conforms to the general surface provided for by the plans. It shall not vary more than 6 mm (¼") from a 3 m (10') straightedge applied to the surface parallel to the centre line of the roadway, nor more than 12 mm (½") from a template conforming to the cross-section shown on the plans. Excess material shall be disposed of as directed.

(d) PROTECTION AND COVER

Immediately after the rolling and shaping has been completed, the surface of the treated base course shall is covered by a protective coating of asphalt to prevent loss of moisture during the curing period and to serve as a prime coat for the later application of wearing course. The asphalt shall comply with the requirements listed herein and shall be applied by means of an approved pressure distributor at the rate of 0.4 to 1.1 L/sq m to provide complete coverage without excessive runoff. The actual rate of application will be determined by the Engineer. When used, emulsified asphalt shall be diluted with an equal amount of water before application. At the time of application, the base shall be in a moist condition. The protective coating of asphalt shall be maintained until the wearing surface is placed. If the condition of the protective coating is satisfactory, no additional prime coat will be required at the time of placement of the wearing surface. Furnishing and placing asphalt will not be paid for separately, but full compensation therefore will be considered included in the contract unit price bid for Processing Cement Treated Base Course. Finished portions of the roadway adjacent to construction that is travelled by equipment used in constructing an adjoining section shall be protected by means satisfactory to the Engineer. If earth covering is used on fresh bases, straw, hay, building paper or similar material shall be placed under the earth so that the covering may be removed without damage to the base.

2.2 STABILIZATION WITH BITUMEN

The basic principles in bituminous stabilization are water proofing and binding. By water proofing the inherent strength and other properties of the soil could be retained. In case of the cohesion less soils the binding action is also important. Generally both binding and water proofing actions are provided to soil. In granular soil the coarse grains may be individually coated and stuck together by a thin film of bituminous materials. But in fine grained soils bituminous material plugs up the voids between small soil clods, thus water proofing the compacted soil-bitumen.

Figure.3.Soil stabilization with bitumen

(Source: http://www.tradenote.net/keyword/235/)

The mechanics of asphaltic soil stabilization are discussed based upon the major four factors for any given soil material: (1) soil status, (2) asphaltic material, (3) mixing, and (4) compaction and curing. A method of bituminous stabilization of soils is presented as related to soils developing appreciable degrees of cohesiveness when moist and which may be stabilized by the principle of waterproofing. this method is based upon the theory that soil, water, and bituminous material, including asphalt, may be placed in such independent relative positions within a compacted mass of mixture so that a definite system exists or tends to predominate. The system consists essentially of soil-water mixtures which are waterproofed by bituminous films held or absorbed on their surfaces. Stabilization by waterproofing may be accomplished with: (1) relatively small quantities of bitumen, (2) a minimum of mixer work and time, (3) utilization of the economies accruing from intermediate soil moisture contents during mixing and compaction, and (4) the more complete utilization of soils in situ due to the greater range of soils which may be successfully treated. The bituminous stabilization of soil utilizing supplementary admixtures was investigated by the use of Portland cement, lime, and aqueous solutions of certain heavy metal salts. data presented indicate that stabilization of soil with materials as cement, consist of two separable and distinguishable functions, one an alteration of soil character reducing the sensitiveness of the soil to physical changes induced by water, the other a cementation of the altered particles of soil into a water- tight coherent mass. The first function may be produced by small quantities of cement, and the second by bitumen, yielding a dual or composite form of stabilization possessing high strength, flexibility, and high immunity to action of water and temperature. These principles were applied in two processes, one a pre-treatment of soil with cement which included mixing, wetting, curing, and repulverization, while the other method consisted of mixing, in consecutive order, the materials soil, cement, water, and bitumen, forming a mixture capable of being immediately laid and compacted. The effects of different types of cement upon the changes induced in soil were discussed. The character of the reactions induced in soil by both cement and lime were discussed. The efficiency of lime as an admixture material for bituminous stabilization was studied. The economic practicality of the use of cement and lime as bituminous stabilization adjuncts was discussed with attention to the method of soil dilution by aggregate as an alternative.

2.3 FLY ASH IN SOIL STABILIZATION

Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Stabilization can be used to treat a wide range of sub-grade materials from expansive clays to granular materials. Stabilization can be achieved with a variety of chemical additives including lime, fly ash, and Portland cement, as well as by-products such as lime-kiln dust (LKD) and cement-kiln dust (CKD). Proper design and testing is an important component of any stabilization project. This allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be used to achieve the desired engineering properties. Benefits of the stabilization process can include: Higher resistance (R) values, Reduction in plasticity, Lower permeability, Reduction of pavement thickness, Elimination of excavation - material hauling/handling - and base importation, Aids compaction, Provides "all-weather" access onto and within projects sites. Another form of soil treatment closely related to soil stabilization is soil modification, sometimes referred to as "mud drying" or soil conditioning. Although some stabilization inherently occurs in soil modification, the distinction is that soil modification is merely a means to reduce the moisture content of a soil to expedite construction, whereas stabilization can substantially increase the shear strength of a material such that it can be incorporated into the project's structural design. The determining factors associated with soil modification vs. soil stabilization may be the existing moisture content, the end use of the soil structure and ultimately the cost benefit provided. Equipment for the stabilization and modification processes include: chemical additive spreaders, soil mixers, portable pneumatic storage containers, water trucks, deep lift compactors, motor graders. High-calcium and low-calcium class C fly ashes from the Soma and Tuncbilek thermal power plants, respectively, in Turkey, were used for stabilization of an expansive soil. An evaluation of the expansive soil-lime, expansive soil-cement, and expansive soil-fly ash systems is presented. Lime and cement were added to the expansive soil at 0–8% to establish baseline values. Soma fly ash and Tuncbilek fly ash were added to the expansive soil at 0–25%. Test specimens were subjected to chemical composition, grain size distribution, consistency limits, and free swell tests. Specimens with fly ash were cured for 7 days and 28 days, after which they were subjected to free swell tests. Based on the favourable results obtained, it can be concluded that the expansive soil can be successfully stabilized by fly ashes.

2.4 STABILIZATION OF BLACK COTTON SOIL

Modification of black cotton soils by chemical admixtures is a common method for stabilizing the swell-shrink tendency of expansive soils. Advantages of chemical stabilization are that they reduce the swell-shrink tendency of the expansive soils and also render the soils less plastic. Among the chemical stabilization methods for expansive soils, lime stabilization is most widely adopted method for improving the swell-shrink characteristics of expansive soils. Lime stabilization of clays in field is achieved by shallow mixing of lime and soil or by deep stabilization technique. Shallow stabilization involves scarifying the soil to the required depth and lime in powder or slurry form is spread and mixed with the soil using a rotovator. The use of lime as deep stabilizer has been mainly restricted to improve the engineering behaviour of soft clays Deep stabilization using lime can be divided in three main groups: lime columns, lime piles and lime slurry injection. Lime columns refer to creation of deep vertical columns of lime stabilized material. Lime piles are usually holes in the ground filled with lime. Lime slurry pressure injection, as the name suggests, involves the introduction of lime slurry into the ground under pressure. Literature review brings out that lime stabilization of expansive clays in field is mainly performed by mixing of lime and soil up to shallow depths. The use of lime as deep stabilizer has been mainly restricted to improve the engineering behaviour of soft clays. Use of lime in deep stabilization of expansive soils however has not been given due attention. There exists a definite need to examine methods for deep stabilization of expansive soils to prevent the deeper soil layers from causing distress to the structures in response to the seasonal climatic variations. In addition, there exists a need for in-situ soil stabilization using lime in case of distressed structures founded on expansive soil deposits. The physical mixing of lime and soil in shallow stabilization method ensures efficient contact between lime and clay particles of the soil. It however has limitation in terms of application as it is only suited for stabilization of expansive soils to relatively shallow depths. Studies available have not compared the relative efficiency of the lime pile technique and lime-soil mixing method in altering the physico-chemical, index and engineering properties of expansive black cotton soils.

2.5 STABILIZATION OF DESERT SAND

There are large deposits of the desert sand in the regions of Rajasthan and other places in India. It is really a great problem to construct roads across the desert mainly because of non availability of other suitable materials. There is also acute scarcity of water in the desert regions. Hence a suitable stabilization technique seems to be the only economical solution. The desert sand deposits consist of fine grained uniformly graded sand with, rounded particles. This renders the desert sand with poor stability. The cement requirement for satisfactory stabilization is also very high in such soil. Due to scarcity of water, soil-cement stabilization is all the more difficult as considerable water is needed for soil cement base course construction. Use of hot sand bitumen would result in satisfactory mix, provided some material including filler can be added to give a proper gradation of the mix. In this connection mixing of locally available kankar dust has been found to give satisfactory result. However use of hot sand bitumen mix is not economical for sub base and base course construction. If cut back is to be used, the requirement of mixing water content would be considerable. The most promising bituminous material in desert region seems to be the emulsion. As the emulsion contains about 50% of water content, the additional quantity of water needed for mixing would be very less. During curing the water evaporates, the emulsion breaks down and the bitumen stabilizes the sand. The stability of the mix could be improved by the addition of kankar powder, and other material to improve the gradation.

III. USE OF FLY ASH IN CONCRETE

Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipments before the flue gases reach the chimneys of coal-fired power plants, and together with bottomash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

Figure.4. Fly Ash In Concrete
(Ref:http://www.ashgroveresources.com/showcase4.html)

Toxic constituents depend upon the specific coal bed makeup, but may include one or more of the following elements or substances in quantities from trace amounts to several percent: arsenic, beryllium, boron, cadmium, chromium, chromium VI, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with dioxins and PAH compounds. Fly ash has been used as a pozzolanic admixture in concrete for more than 50 years. Earlier uses were largely confined concrete for more than 50 years. Earlier uses were largely confined to low-calcium ashes from hard bituminous or anthracite coals. However, increased demand for fly ash coupled with the declining availability of suitable low-calcium ashes has attracted a wider variety of fly ashes to the marketplace in recent years. Some of these ashes are characterized by very high calcium contents (for example. >25% CaO) and such materials affect the properties of concrete in a different manner than traditional fly ashes. The latest Canadian Standard covering fly ash for use in concrete divides fly ash into three categories strictly on the basis of its calcium content. This paper provides a rationale for this change in concept.

IV. RETAINING WALLS

A retaining wall is a structure designed and constructed to resist the lateral pressure of soil when there is a desired change in ground elevation that exceeds the angle of repose of the soil. The active pressure increases on the retaining wall proportionally from zero at the upper grade level to a maximum value at the lowest depth of the wall. The total pressure or thrust may be assumed to be acting through the center of the triangular distribution pattern, one-third above the base of the wall. Retaining walls serve to retain the lateral pressure of soil. The basement wall is thus one form of retaining wall. However, the term is most often used to refer to a cantilever retaining wall, which is a freestanding structure without lateral support at its top. Typically retaining walls are cantilevered from a footing extending up beyond the grade on one side and retaining a higher level grade on the opposite side. The walls must resist the lateral pressures generated by loose soils or, in some cases, water pressures.

Figure.5. Retaining wall
(Source: http://kshitija.wordpress.com/page/2/)

The most important consideration in proper design and installation of retaining walls is to recognize and counteract the fact that the retained material is attempting to move forward and down slope due to gravity. This creates lateral earth pressure behind the wall which depends on the angle of internal friction (phi) and the cohesive strength (c) of the retained material, as well as the direction and magnitude of movement the retaining structure undergoes. Lateral earth pressures are typically smallest at the top of the wall and increase toward the bottom. Earth pressures will push the wall forward or overturn it if not properly addressed. Also, any groundwater behind the wall that is not dissipated by a drainage system causes an additional horizontal hydrostatic pressure on the wall.

4.1 TYPES OF RETAINING WALLS

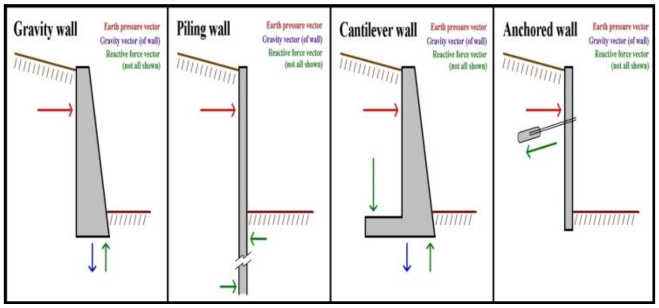

Figure.6. Types of Retaining Wall
(Source: http:// en. wikipedia. org/wiki/File:bRetaining_Wall_ Type _ Function.jpg)

(a)GRAVITY WALLS:
Gravity walls depend on the weight of their mass (stone, concrete or other heavy material) to resist pressures from behind and will often have a slight 'batter' setback, to improve stability by leaning back into the retained soil. For short landscaping walls, they are often made from mortar less stone or segmental concrete units (masonry units). Dry-stacked gravity walls are somewhat flexible and do not require a rigid footing in frost areas. Home owners who build larger gravity walls that do require a rigid concrete footing can make use of the services of a professional excavator, which will make digging a trench for the base of the gravity wall much easier. Earlier in the 20th century, taller retaining walls were often gravity walls made from large masses of concrete or stone. Today, taller retaining walls are increasingly built as composite gravity walls such as: geosynthetic or with precast facing; gabions (stacked steel wire baskets filled with rocks); crib walls (cells built up log cabin style from precast concrete or timber and filled with soil); or soil-nailed walls (soil reinforced in place with steel and concrete rods).

(b)CANTILEVERED WALLS:
Cantilevered retaining walls are made from an internal stem of steel-reinforced, cast-in-place concrete or mortared masonry (often in the shape of an inverted T). These walls cantilever loads (like a beam) to a large, structural footing, converting horizontal pressures from behind the wall to vertical pressures on the ground below. Sometimes cantilevered walls are buttressed on the front, or include a counter fort on the back, to improve their strength resisting high loads. Buttresses are short wing walls at right angles to the main trend of the wall. These walls require rigid concrete footings below seasonal frost depth. This type of wall uses much less material than a traditional gravity wall.

(c)SHEETPILING WALLS:
Sheet pile retaining walls are usually used in soft soils and tight spaces. Sheet pile walls are made out of steel, vinyl or wood planks which are driven into the ground. For a quick estimate the material is usually driven 1/3 above ground, 2/3 below ground, but this may be altered depending on the environment. Taller sheet pile walls will need a tie-back anchor, or "dead-man" placed in the soil a distance behind the face of the wall, that is tied to the wall, usually by a cable or a rod. Anchors are placed behind the potential failure plane in the soil.

(d)ANCHORED WALLS:
An anchored retaining wall can be constructed in any of the aforementioned styles but also includes additional strength using cables or other stays anchored in the rock or soil behind it. Usually driven into the material with boring, anchors are then expanded at the end of the cable, either by mechanical means or often by injecting pressurized concrete, which expands to form a bulb in the soil. Technically complex, this method is very useful where high loads are expected, or where the wall itself has to be slender and would otherwise be too weak.

V.NEW TECHNIQUES IN PAVEMENT

5.1 ASPHALT CHIP SEALS
Chip seals are applied in a three-part process. The asphalt emulsion binder is first sprayed onto the pavement. This is followed immediately by an application of rock chips. Finally, the rocks are pressed into the asphalt binder using a heavy roller. This process is more appropriate for use on roads than on parking lots. Service life is usually 5 to 7 years. The road takes on more of the colour of the rock used in the chip layer since it's not mixed together with the asphalt binder, so use of lighter coloured aggregate here can make more of a difference in cooling the road surface.

5.2 ASPHALT EMULSION SEALCOATS
Emulsion sealcoats are the familiar pre-mixed products often seen in shopping center parking lots or on driveways. They consist of a fine aggregate (rocks of small size) in emulsion (suspended in water) with an asphalt binder. Emulsion sealcoats are brushed on over existing pavements to seal small cracks and protect the surface. When used properly they're expected to last 3 to 5 years. These products are usually black but are occasionally made in gray or tan with the addition of zinc oxide, although this may cost a bit extra.

5.3 ASPHALT SLURRY SEALS
Slurry seals combine an asphalt emulsion with graded aggregate (rocks of special, even sizes). This mixture is then applied to existing pavement using a squeegee-like drag. Slurry seals are expected to last 3 to 5 years. Like the emulsion sealcoat, slurry seals are usually black but can be made gray or tan with the addition of zinc oxide.

5.4 ASPHALT SURFACE COATINGS
Asphalt surface coatings are painted or sprayed directly over clean asphalt. These coatings are decorative, while also serving to protect the asphalt underneath. They come in many colours, but the lightest colours have the highest solar reflectivity and stay coolest.

5.5 PAVEMENT TEXTURING
Pavement texturing is a process that uses standard asphalt to produce a decorative pavement in a variety of colours and patterns. These pavements are used in street paving, traffic calming, pedestrian areas, medians & boulevards, parking lots, playgrounds, and other applications. These pavements are less

labour-intensive to install, with the additional advantage of having no joints where water can infiltrate and weeds can grow. The construction process consists of first laying the asphalt, compacting it into a patterned form, and then finishing it with a polymerized cement coating. The resulting pavement can withstand extreme weather and traffic loading by combining the strength of concrete with the flexibility of asphalt. The choice of a lighter coloured coating is needed to make the surface more reflective and keep it cooler.

5.6 ROLLER COMPACTED CONCRETE AND SOIL-CEMENT PAVEMENT

Roller Compacted Concrete (RCC) combines cement with natural or graded aggregate to create a pavement suitable for heavy loads at low speeds, such as warehouses or airport taxiways. Soil-cement pavements combine cement with sand or alluvium material to construct pavement suitable for low-speed, low volume uses like hiking trails and bike paths. Both RCC and soil-cement pavements have a natural appearance, taking on the colour of the added aggregate or sand. Choice of lighter colours can keep the pavement cooler.

5.7 WHITE-TOPPING

This is a technique of covering existing asphalt pavement with a layer of concrete. Traditional white-topping with concrete added a 4 to 8 inch thick layer of concrete over an existing asphalt base. New concrete mixtures with fiber reinforcement, called ultra-thin white-topping, mean you now need only apply a 2 to 4 inch overlay of concrete to withstand normal loads on residential and low-volume roads. Special mixtures with higher cement content can also be used on surfaces that must be cured and ready for traffic within 24 hours. The white-topping construction process consists of four steps: 1) coring the existing asphalt to determine its depth, type and condition, 2) preparing the road surface by water or abrasive blasting, or milling and cleaning, 3) placing the concrete, and 4) finishing and texturing the surface, and curing and sawing its joints. The proper joint spacing is critical to control cracking of the concrete surface. Concrete pavements have a 1.5 to 2 times greater service life than asphalt pavements. Concrete pavements are naturally light gray in colour and need no further lightening. Concrete pavements can be periodically pressure-washed to remove dirt and stains and to help retain its reflective qualities.

VI. PRESTRESSED CONCRETE PAVEMENT

The pressurising technique has been applied to the highway pavements in recent years. The pressurised pavement can be built in continuous length up to 120 m without joints. Elimination of joints without inducing cracks in the pavement could be considered advantageous, in view of the maintenance problems associated with the joints. To accommodate higher loads, there is obvious tendency of increasing the thickness. It may be realized that an increase in the thickness gives rise to a great temperature differential of the slab and also greater frictional resistance. A thick slab is therefore undesirable as well as costly. By providing a residual compressive stress to the slab by use of tendons etc, the total tensile stress can fairly be neutralized and thus same unit thickness of pressurised concrete pavement could support heavier loads than plain concrete pavement and can be built for longer without joints.

Following are few observations for the design:

a).Length: A length up to about 120 m can be prestressed for the pavement.

b).Width: A width of 3.6 m for prestressed pavement is desirable and a longitudinal a joint therefore should be provided.

c).Thickness: Because of the need to provide a required cover for tendons, the minimum recommended thickness is 15 cm.

d).Stress magnitude: A minimum value of 22 kg/cm^2 of prestressis recommended for 120 m long prestressed pavement slabs. A transverse prestress if required should be of 3 to 4 kg/cm$^{2.}$

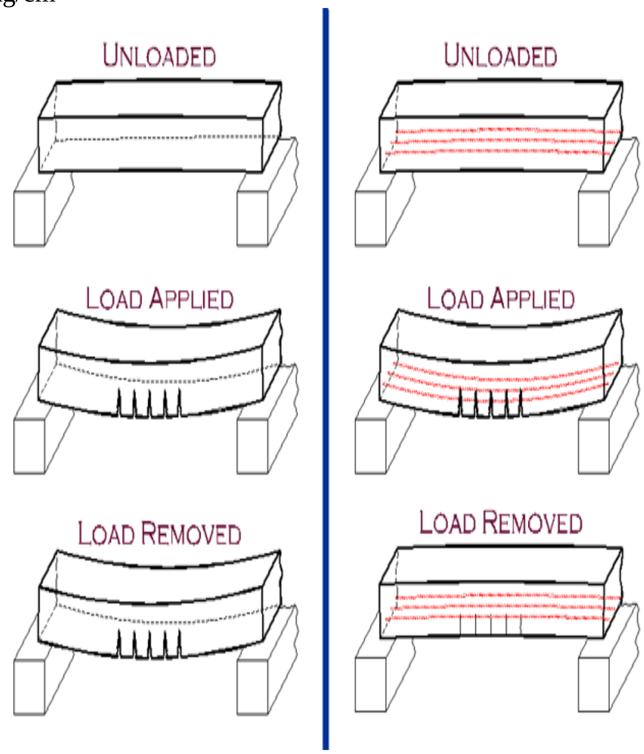

Figure.7. Prestressing Concrete Process
(Source:http://www.prestressedcasting.com/process)

Prestressing is applied either by pre-tensioning or by post-tensioning. For highway pavement, post-tensioning system has been used. Most of systems employ wire of 7.0 mm diameter with ultimate tensile strength of 142-173 kg/cm^2. The construction of pressurised concrete pavement is difficult job and needs a skilled team. Due to the long length of tendons, there is a great amount of energy stored in it and any failure of anchor could be very severe.

VII. CONCLUSIONS

Traditionally highways were used by people on foot or on horses. Later they also accommodated carriages, bicycles and eventually motor cars, facilitated by advancements in road construction. In the 1920s and 1930s many nations began investing heavily in progressively more modern highway systems to spur commerce and bolster national defence. India has an extensive road network of more than 3 million kms which is the second largest in the world, Roads carry about 60% of the freight and nearly 85% of the passenger traffic, Highways /Expressways constitute about 66,000 kms. The Government of India spends about Rs.18000 crores (US $ 4 billion) annually on road development. These new trends are initiative in the highway improvements. Now highways are well stabilized and more secure. The costs in the construction as well as in maintenance are reduced. These new trends are eco friendly because the use of fly ash is used as an important material and it is a residual of thermal power stations and in Free State, it is very harmful for the environment. So there is a great hope for the further improvement in these techniques.

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