Role of Nanotechnology in Bituminous Road Pavements

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Abstract. Recently, nanotechnology is an emerging area of research in almost all branches of science and engineering. Nanotechnology deals with structure having dimension 1nm to 100 nm, plays vital role in improving the properties of the materials used for several applications. Recently nanotechnology has been effectively used in the field of bituminous road pavement treatments. The important objectives of the road pavements are to provide safe surface on which vehicle can travel easily and more safely. Pavements are mainly exposed two type of load namely travel and environment. Large number of vehicle running on the road due to their load gets affected. Similarly due to environment conditions also the road gets affected. Good pavements can be constructed using existing treatment and technique. Nanotechnology can be effectively used in bituminous road pavements towards longevity and safety of road pavements. Road pavements are of microscopic structure and nanotechnology deals with nanostructure material. In this paper we through light on the nanoscale how can affect the microscopic properties and behaviour in the bituminous road pavements.

1. Introduction

Pavements are complex structures involving number of factors viz. type and quality of materials, construction methods and maintenance cost climate/environment conditions [1]. Therefore, in order to design and build the pavement these factors must be taken in to consideration. Also, the better maintenance of pavement is to be taken in to consideration. The problems related to pavement maintenance are not so simple due to the dynamic nature of the road pavement [2]. The elements used in the pavement design are consistently changing, can be added or removed. These elements affect the deterioration of the pavements. In the recent years highway pavement construction and their maintenance cost are increasing tremendously [3]. It is essential for good quality of pavement to utilise various tools and approaches. Pavement deterioration process starts directly after opening the roads to traffic. The process in the beginning starts very slowly and therefore cannot be noticeable [4]. But with increase of duration, the process of deterioration gets accelerates and lastly it becomes worst. The process of pavement deterioration can be minimize for which it is necessary to use the best practices available [5]. A care must be taken in planning, designing, construction and maintenance of the road. To overcome this problem, it is necessary to examine the pavement that have field permanently. Such a pavement element/ materials should not be used in the future. One of the reason of the failure of structure in the inadequate structure and inefficient evaluation programs [6]. It is important to find out the method to minimise the maintenance cost under a limited budget. Materials used in the structural layers of pavements are assists to the collective conditions. Various materials like asphalt mixture bituminous etc. are used for the road pavement [7]. The mechanical properties of the bituminous materials vary with temperature, loading time and mixture type. If the analytical design of flexible
payment, elastic module of bituminous materials is adapted as one of the input parameter [8]. The important objectives of road pavements is to provide a crucial safety and long life durable surface on which vehicles can be travel smoothly, while protecting the underlying layers of the material during all environmental conditions. The pavements consist of a combination of layers of engineered materials that generally provide all-weather access to vehicles to travel in a safe and economical way. The layers of materials used are selected and engineered to provide a structure which can withstand the applied vehicular loads under a range of environmental conditions for a defined minimum life. It is the intention of a good pavement design to enable vehicles to travel safely and economically.

2. Pavement materials

**Improved materials**: Better resistance to applied traffic load and environment (resistance to load-related damage and moisture and temperature related damage). This includes bituminous, cemented and granular materials and combinations [9]

**Smart materials**: Materials that can sense inputs (i.e. traffic or environmental) and either address these actively or store the information to be obtained at a later stage for active input repairs (as a normal sensor/data acquisition system unit) [10].

Typical pavement materials can be summarized as bituminous, cemented and natural soils and gravels. Each of these types of materials has specific properties and applications in a pavement structure.

3. Bituminous Materials

Bituminous materials consist of a selection of aggregates mixed with specific bitumen to form asphalt (bitumen typically termed asphalt and the asphalt mixture termed asphalt concrete). Asphalt is typically used as a surfacing layer, but can also be used as base material [11]. Temperature changes have a major influence on the properties of asphalt materials, as the bitumen is a temperature sensitive viscous material. Water does affect the behaviour of these materials causing stripping of the bitumen from the aggregate [12].

4. Types of road pavement failure

The four major categories of the road pavement failure are:
1. Cracking,
2. Surface deformation,
3. Disintegration,
4. Surface defects.

5. General causes of the bituminous road pavement failure [13]:

Following are some of the general causes;
1. Improper road drainage
2. Insufficient crust of the sub-based materials
3. Upgradation in standard of road
4. High density of traffic
5. Intense road fall
6. Climatic and environmental factors
7. Lack of planning and management etc.
8. Defects in original construction
9. Poor quality base and sub-base materials
10. Leakage of petrol, diesel, oil from vehicles
11. Bitumen binder properties

6. Role of nanotechnology
Nanotechnology is the branch which connects science and engineering to make the materials of improved quality. It deals with the structure between 1 nano meter to 100 nano meter dimension [14]. At this scale, the materials exhibit very unique and interesting properties due to their nanoscale dimension, large surface to volume ratio and greater stability [15]. The nanomaterials exhibit novel and improved properties such as high strength, higher conductivity, high reflectivity, higher magnetic properties etc [16]. Owing to the improved properties of nanomaterials, nanotechnology has an application in various fields such as medical science, high frequency applications, environment, agriculture etc [17]. The application of nanotechnology in various applied fields is receiving widespread attention. It is important to ensure that these applications address real questions to allow the technology to improve general well-being of the public, especially when evaluating application in the area of civil engineering. Recently, nanotechnology plays an important role in civil engineering in particular road pavement [18]. They focus on the ability of nanotechnology research in various areas to measure, manipulate and model highway matter at the nano-scale. To give an example of role of nanotechnology in road pavement, nano-sensors have been embedded in the structure of underline pavement layers. The abilities of nano-scale materials to bind with pollutants and thereby improve air quality around transportation facilities have already proved to be viable. The improved characterization of both new and recycled materials through nano-characterization procedures can also lead to more optimal use of these materials [9]. Four long-term anticipated effects of the use of nanotechnology in highway research include the development of novel structural materials that can withstand both traffic and environmental loads better, the incorporation of functions such as the ability to generate and transmit energy into pavement structures, improved vehicle-pavement communication regarding road conditions[19].

7. Conclusion:
It is important to construct high quality of bituminous road pavement for the safe travel of the vehicles which can sustain to any kind of causes. The nanotechnology is an important area research and plays an important role in tackling in general the civil engineering problems in particular road pavement.

8. References
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