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Review

# Sustainable use of waste in flexible pavement: A review

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## HIGHLIGHTS

- Review of various studies pertaining to use waste material in flexible pavement.
- Review of recommendation various state transportation departments concerning use of waste in flexible pavement.
- Challenges and possible solutions regarding use of recycled material in flexible pavement.

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## ABSTRACT

Around the world flexible pavement is the most favored pavement structure to build road and highways. A massive amount of non-renewable materials and industrial products like aggregates, bitumen, cement, lime, and other additives are consumed during construction and maintenance of this pavement system. Extraction and production of these virgin materials is an unsustainable practice. Wastage of materials, environmental deterioration, depletion of resources, and the spike in material cost led researchers to search for alternative materials that can be used in flexible pavement. This paper provides an overview of such recycled materials that have been successfully used in different layers of flexible pavements. Studies have established that the use of secondary material not only provide an efficient waste disposal technique but also reduce demand for conventional material and reduce overall construction cost. Through this paper, an attempt has also been made to identify the reason because of which, despite having essential studies, their field implementation has been limited and suggest possible remedies by which use of recycled material in the flexible pavement can be promoted.



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## 1. Introduction

Sustainability is defined as meeting the needs of present age without compromising the well-being of future generation [1]. Sustainable development takes into consideration simultaneous economic, environmental and social growth [2]. This practice has become very important in today's reference as rapid growth has sidelined conservation and protection of the natural resources. Road and Highways sector is a significant part of construction industry where the exhaustive use of the natural resource has emerged as a severe threat to the environment [3]. The reason for this is that the material procurement for construction, their extraction, and laying, generates a lot of pollution and waste.

About 95% of world's roads are made of flexible pavements [4]. It is composed of four layers namely subgrade, subbase, base and surface course [5] as shown in Fig. 1. Sub-grade is natural soil over which other layers are laid. Many times it's found that existing subgrade is weak, or is of expansive nature, i.e., little change in moisture condition leads to substantial volume change within a short period [6]. In such cases, subgrade is modified using certain additives. This modified sub-grade is called subbase. Above sub-base lies base course which is a load-bearing layer composed majorly of high-quality aggregates of different sizes. Above it lies surface course, which is a mixture of aggregates, fines, filler, and binder. This layer is directly in contact with traffic load, hence using a superior quality material is an absolute necessity.

A significant part of flexible pavement is composed of aggregates which are procured from selected quarry sites. Their extraction process includes blasting, drilling, excavating and crushing. These methods are highly unsustainable as a massive quantity of waste produced during the process is either filled back at quarry site or disposed of abruptly, affecting ecological cycle in many hazardous ways [7]. Similarly, bitumen, which is used as binding agent in the surface course, also has an unfavorable impact on environment and health. It's mixed with aggregates at a temperature of 165–200 °C, releasing vapors and fumes into the atmosphere. These fumes contain greenhouse gas and aerosol components, which during occupational exposure cause irritation and carcinogenicity of skin and respiratory tract [8].

Despite all these impacts, construction of highways can't be restricted as they play a significant role in the development of a nation. Therefore, it's vital to search for resources which may provide a sustainable aspect by reducing consumption of natural resources, easing landfill pressure while maintaining structural integrity. Use of locally generated waste materials is a significant step forward in this direction. This review paper compiles the various wastes that are commonly produced around the world and their possible use in the flexible pavement.

## 2. Criteria required for waste to be used in flexible pavement

Every country has standards and specifications for a material to be used in pavement construction. Any recycled material to be used for construction purpose should be subjected to property test similar to that of conventional material. The product obtained using the waste material (used either as partial or full replacement of virgin material) should also comply with the minimum strength, stability, durability and other necessary specifications.

The basic material requirement is that it must be free from any contaminating element, organic impurities, and hazardous component. Tables 1–3 summarize the necessary parameters upon which materials to be used in the flexible pavement are evaluated for their suitability.

Around the globe, recycling of waste as pavement material has been in practice with varying degree of success. Few countries have formulated rules, regulation, suggestion, and restrictions which permit the respective transportation departments to utilize the locally available waste, while many are still in drafting phase to allow recycling of waste material in pavement construction.

In the USA, an average range of 15–20% of Recycled Asphalt Pavement (RAP) is allowed in wearing course. The Virginia center for transportation allows 30% RAP in blend phase as road base and sub-base material. Use of blended material is permitted if it satisfies the grading and particle size distribution of the mix design. The blending can be from multiple sources but once the batch is tested, verified and deemed suitable to use as pavement material, the addition of material to the stockpile is restricted. State of Nebraska permits using up to 50% RAP as pavement construction material, which makes it one the highest RAP using country in the world. The reason for this permissible specification is the provision that the contractor has to take the full ownership of the quality of material supplied. Florida Department of transportation permit use of RAP, recycled concrete aggregate (RCA) and construction and demolition waste (C&D) from existing concrete pavement to be used as subgrade and base material in highway construction. States's permissive specification allow the contractor to use a proportion of recycled material based on his or her judgment [9]. Similarly, Texas Department of transportation permit 20% percentage use of RAP and RCA in subgrade and base construction. This state department recommends that for a project, the material must be from the same stockpile, and along with gradation, the stock must not have maximum percentage loss from decantation higher than 5% and should also comply with state's non-hazardous recyclable material guidelines. The Department also permits the use of compost produced via aerobic decomposition as backfill ingredient. Only that compost is allowed for construction which is derived from agriculture residue, forest residue, bark, and paper. The waste must also satisfy particle size distribution where 95% of content is passing through 16 mm (5/8 in.) sieve, and at least 70% material is

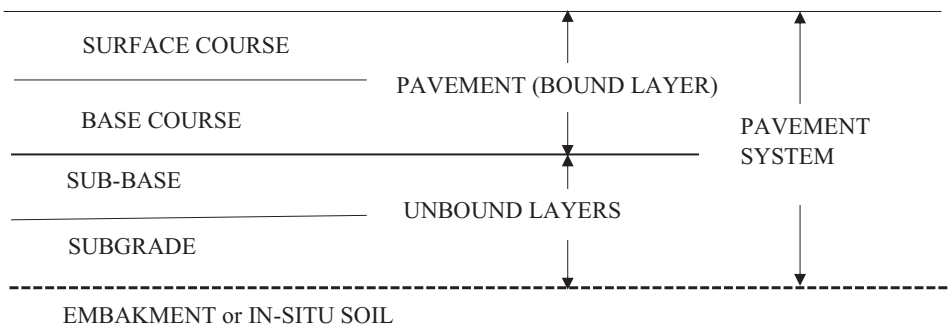


**Fig. 1.** Pavement system.