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GREEN HIGHWAYS-A SUSTAINABLE APPROACH

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Abstract
Several infrastructure developmental activities lead to change in the natural environment and sometimes it leads to excessive environmental degradation. Unplanned management of natural resources is already limiting the development in some areas, resulting in growing scale of economic activity and subsequently posing serious challenges for environmental management. Environment- friendly methods and technologies are essential in today's scenario of global issues such as climate change, global warming, energy depletion and other environmental concerns which have led to the emergence of the green concept in India. The policymakers and researchers strongly believe that the increase in green technologies will result in sustainable societies and economic development. Considering economic development and environmental sustainability in roads and the highways sector, it is necessary to adopt the green concept.

The objective of the study is to present the concept of green highways, the available green practices, technical aspects, further benefits and implementation of such practices and the possible challenges in the Indian context. It is an integrated partnership planning program to promote environmental sustainability.

Keywords
Green Highways concept, economic development and sustainability practices.

Introduction

Roads and Highways make a vital contribution to economic growth and development. The road transport sector is providing access to employment, social, health and educational services and act in fighting against poverty. Over the next several years, developing countries will be substantially expanding and restoring their infrastructure networks. Asia is going to construct many new roads and highways to stimulate economic and social development. Every infrastructure project requires a sustainable practice that needs further consideration and consciousness efforts. As part of sustainability practices, the concept of ecofriendly or green highway technologies are to be adopted in the recent world scenario of combating global warming and climate change.

Most of the road construction projects lead to loss of surrounding natural resources due to the construction or expansion works. Therefore, the restoration of the natural environment in the project area is necessary for considering environmental requirements throughout the stages of planning, designing, and execution. Road construction projects must be met with the dimensions of economic, social and environmental considerations. Green Road construction practices will meet human needs and at the same time minimize the usage of natural resources to support nature for the present and future perspective.

Factors influencing Green Highways

There are certain reasons which can affect the implementation of the concept of green technologies in the construction industry to become an emergence in India. They are:

Unawareness- not aware of nature, its importance and sometimes any knowledge about conservation techniques and the actual process of renewable and non-renewable resources.

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Inattentiveness - Non-protecting the environment means that it is given less priority, leading to direct effects on human health and environment. Many construction projects release pollutants and use excessive natural resources, which shows an ineffective way of implementation practices.

Non-Performance activities - Many times road development comes at the cost of disturbance to ecological balance; loss of vegetation is an unavoidable consequence in road construction projects. Lack of Planning and continuous monitoring of environmental components is a major concern in developmental projects.

Pollution burden -All stages of highway projects i.e. construction, maintenance, and operation stage require energy-intensive inputs that are derived from the burning of fossil fuels [1]. This results in the release of a massive amount of greenhouse gases and other ambient air pollutants.

Additional Cost -Traffic Congestion in cities and towns is increasing widespread all over the world. The enormous and growing cost caused by it in terms of loss of time, vehicle operating cost and degradation of environmental quality necessitate to find out ways for sustainable practices.

Concept of Green Highways

The concept of Green Highways is relatively new and is derived from "Sustainable Development principles" which emphasizes the coexistence of global development with the environment and ecology, which is gradually taking hold around the world. The Green highway initiative is an effort to design eco-friendly highways and to promote environmental sustainability throughout the stage of project cycle through integrated partnerships, rewards, and market-based solutions [2].

The green concept was initially implemented in the USA through a public private-partnership known as Green Highway Partnership program[3]. The GHP is a social group and has identified the characteristics of Green Highway as well as a green rating system for roads and Highways. The partnership program aims by providing conditions that are "better than before". GHP has developed some principles to develop a green highway which are to:

- Achieve goals through voluntary participation and public/private partnerships,
- Utilize market-based approaches and economic incentives,
- Provide communication and support network to avoid duplication and help streamline business practices and processes among those organizations supporting and enabling the "Green Highways" philosophy,
- Promote collaborative approach for conservation and integratedwatershed management that leverages efforts of all levels of government and the private sector to maximize benefits
- Promote innovative storm water protection
- Promote use of recycled materials
- Prevent cutting/ felling of avenue trees by adopting various design alternatives wherever necessary and implement the tree transplantation measures to preserve trees
- Recognize and encourage existing environmental stewardship practices among transportation agencies by promoting them among a broader stakeholder universe
- Remove barriers to achieving innovative and positive results
- Leverage transportation and environmental resources (public and private) to multiply benefits and maximize results, and
- Support and stimulate applied research and training to remove barriers identified by partners and stakeholders.

The green highway concept has been used in the following ways (according to the Green Highway Partnership Program-(GHP) [4]:

Watershed driven Storm water Management method - The system holds runoff as well as treats in its natural way by holding it to reach the groundwater table. This technique protects runoff water in the way of treating and holding the water. This system also reduces the pollutants at the site and discharge into the adjacent drain through diverting the storm water runoff to areas where it can penetrate to reach the ground water table.

Resource Conservation Methods - Resource conservation method is the consumption of resources effectively by the method of reuse, recycle and replace the selected products/ material or technologies that minimize the overall use or consumption of natural resources.

Societal Benefits - Highways are an important asset for local economies. An aesthetically appealing highway design can attract more business into a community and supply local jobs [5]. The highway design options with safety aspects including provision for animal crossing shall decrease the accident rate.

Pollution free environment - The construction and operation activities involved during any infrastructure projects shall result in the emission of pollutants in the form of greenhouse gases. Monitoring the pollution levels and estimating the level of carbon footprint shall give an overall performance of the green highways.

Table 1: Important techniques considered in each component under GHP

Component	Techniques/methods	Description
Watershed/Storm Water Management Practices	Use of dry swales for stormwater recharge-	A simple drainage channel by selecting carefully, highly permeable soil (usually sandy loam), gravel bed or sandbags for developing small check dams along the roads and highways.
	Use of porous pavements in roadside facilities-	Permeable pavement surface facilities with a stone reservoir underneath that can store surface run-off before infiltrating it into the subsoil, thereby infiltrated directly into the soil, shall be used at parking areas, bus ramps, etc. Such pavements also help in noise reduction in some extend.
	Bio-retention techniques (landscape design system consists of a soil bed planted with suitable vegetation which will remove silt (mud/sediments) and the pollutants from surface water runoff)	Bio-retention is the process of collecting the stormwater run-off to remove contaminants and sedimentation and the treated water is allowed to reach the ground water table. Stormwater is collected into the Bio-retention area which consists of a grass buffer strip, sand bed, ponding area, organic layer, planting soil or plants. It is designed to retain stormwater before it discharges.
	Bio-retention techniques (landscape design system consists of a soil bed planted with suitable vegetation which will remove silt (mud/sediments) and the pollutants from surface water runoff)	Bio-retention is the process of collecting the stormwater run-off to remove contaminants and sedimentation and the treated water is allowed to reach the ground water table. Stormwater is collected into the Bio-retention area which consists of a grass buffer strip, sand bed, ponding area, organic layer, planting soil or plants. It is designed to retain stormwater before it discharges.
Resource Conservation Methods	Tree transplantation technique	It is to preserve the trees within 30 to 90 cm girth size or seven to ten years old tress where the trees to be cut due to laying new roads or road widening activities. The preserved trees shall be transplanted in an open area, where the less density of trees located such as School premises, Govt. building campuses and government open lands, etc. to increase the green cover on waste/open lands.
	The use of renewable energy (Solar lighting system)	To adopt the non-conventional energy sources, streetlights, parking lights, and lighting at junctions, etc. shall be considered.
	Reuse of Fly Ash	Fly ash is a residue generated by burning coal and is available in large quantities next to coal-based power plants. Fly ash poses health risks by way severe respiratory and skin problems and also takes up valuable landfill space. Hence, the use of fly ash in the construction industry is encouraged.
	Reuse of existing pavement material	The possible recycling option for pavement material in India is Hot Recycling. Stretches of existing bituminous pavements (road surface material) that are to be reconstructed, left out due to curve improvements or may get buried under flyovers or existing pavement can be milled off as a reclaimed asphalt pavement (RAP) that can be transported to hot mix plant for recycling.
	Resource-efficient construction technology	Presently most roads have bituminous surface constructed using naturally available road aggregates and bitumen at very high temperatures to produce hot mix asphalt (HMA). Heating of bitumen to very high temperatures is linked to environmental degradation due to air

		pollution on account of an increase in emission of gases into the atmosphere. Low energy mixes such as warm mix asphalt (WMA) prepared and used at much lower temperatures than HMA are being extensively used in western countries to minimize air pollution, energy savings, etc. Production of WMA is at significantly lower the temperature between 100 to 140ºC as against HMA which is produced at high temperatures between 150 to 170ºC.
Societal Benefits	Safety provisions:	Pedestrian or Cattle crossing along and across the highways are common. Options for the safety of the pedestrian and cattle should be explored, like providing dedicated footpaths cattle underpass, cattle crossing with the provision of rumble strips, cattle crossings with other safety aspects to be considered.
	Solid waste management:	During the planning and design stage the reconnaissance survey should be conducted, based on the site visits locations should be identified for the requirement of solid waste management practices along the highways. Mostly at the settlement locations cleaning requirement due to lack of dust bins and improper maintenance or irregularity in the collection of waste etc., Hence, this practice is must be explored as the cleaning process is as part of sustainable practice and benefits of society.
	Quiet pavements:	Quieter pavement the pavement that produces less noise than another from during the movement of vehicles (traffic). Such pavements can be either asphalt or concrete pavement, but incorporating practices to make them quieter is important. A quieter pavement can be consideredat any location subject to any environment and any amount and type of traffic. Furthermore, quieter pavements of both asphalt and concrete can achieve the same level of cost-effectiveness, durability, and safety expected. It requires detailed study and research for further needful.
	Landscaping:	Landscaping along the highways is one of the key enhancement measures that are usually suggested while designing the highways. In general, landscaping shall be proposed along the RoW, parking area, road median, island, junction and oxbow land/incidental spaces. However, its size and extent will depend on the land availability.
Pollution free environment	During Project Construction:	The construction and operation activities involved during any infrastructure projects shall result in the emission of pollutants in the form of greenhouse gases; it should be minimized by using innovative techniques.
	During project Operation:	Gases emitted from the burning of fuel by the traffic plying on the highway after completion of road construction. This shall be avoided by using clean fuels or electric vehicles and efficient traffic measures.

Source: Ashoka Highway Research Centre-Research Activities, Nasik and Gujarat State Highways Project-II Report.

Present Practices on Green Concept

The initiation of green technologies is increasing slowly in India and other countries. Most of the Nations have already started with viable options. Now it is time to turn and follow the environment- friendly construction methods:

The Government of India and the Ministry of Environment, Forest and Climate Change has initiated the promotion of green technologies by framing various legislations and policies as statutory requirements and environmental clearances for highway projects.

The Ministry of Road Transport and Highways (MoRTH), Govt. of India launched a National Green Highway (Plantation, Transplantation, Beautification, and Maintenance) Policy, 2015 under National Green Highway Mission (NGHM). NGHM is a primary Authority to oversee the construction activities and focuses on inclusive growth and continuous innovation to make the project viable as well as beneficial to the environment [6].

India Roads Congress (IRC) published various manuals on Green Highways construction practices such as manuals for

environmental clearance procedures for highway projects, usage of eco-friendly material in highway construction, etc. [7].

The National Highway Authority of India (NHAI) planned to construct environment-friendly highways to reduce construction related carbon footprint. The authority also desires to explore carbon reduction measures orestimation of carbon credits, and develop a rating system for the national highways on their performance on environmental friendliness.

- India's first smart and green highway constructed near Delhi Eastern Peripheral Expressway, which was inaugurated recently in 2018.
- Another study carried out by NHAI for Lucknow-Muzaffar Green National Highway states that the concept of green highways aims for environmental mainstreaming and stewardship in all aspects of the highway project cycle.
- Research study has been carried out by CRRI-Central Road Research Institute, New Delhi, introducing about plastic waste technology particularly in mixing with bitumen for road construction; India already began deploying this technology with the use of plastic waste for road construction particularly in bitumen on a 1,000 km stretch in Bangalore.
- Assam State initiated the best use of green technology of road construction methods using cold bitumen emulsions, which takes less time and fuel consumption, andhas been approved byIIT-Guwahati and the Central Road Research Institute (CRRI) as ideal for the weather conditions of Assam.

Other countries have also initiated similar projects by addressing the concept of green highways and bridges through an international network:

- The Department of Commerce and Energy, along with the Washington Department of Commerce and Transportation planned to develop electric cars for the West Coast Green highway, a1350-mile strip starting from Mexico and ending in Canada.
- Switzerland has built vegetated overpasses called as green bridges, eco ducts.
- Germany has developed the landscape ecology where adjacent land use and land conservation as mitigation for highway development.
- Highway England department spends the money by setting aside the budget for a green retrofit. Fund allocation included for the improvement of air quality, cycling access, and the environment and ecology, other funds for innovation, housing and growth.
- Washington Department of Transportation started to promote the use of clean fuels and electric vehicles at the West Coast Green Highway, with this initiative, increasing the market demand for high efficiency, low carbon-emitting vehicles to reduce the transportation sector impact on the environment and dependency on foreign oil.
- Finland proposed world's first green highway by building a “carbon-neutral highway” that would include charging stations and biofuel stations.

However, it needs further involvement and innovation towards the implementation of green highways in a sustainable manner. Most of the State level projects follow only the traditional way of construction activities as of now. Itis necessary to turn out with the more encouraging way of doing with market-driven approaches of sustainable engineering designs of roadway construction practices.

Benefits of Green Highways

Green Highways will bebenefitted particularly in terms of reduction of carbon emissions, societal benefits, and improvement in health aspects. The technologies of green infrastructure are known to potentially replenish the ground water by triggering natural infiltration capabilities of the earth's surface runoff. This technology prevents transportation of pollutants to nearby waterbodies by infiltrating them at the source of generation itself.

The main aim of green highway approach is carbon sequestration by plantation and using soil techniques. Carbon sequestration is the process of capturing and eliminating carbon dioxide from the atmosphere by using geoengineering techniques and by natural process such as photosynthesis, etc. The concrete structures, emissions from vehicles, industries, air conditioners are contributing to the global warming and urban heat in addition to the forest displacement. Green infrastructure is the best option to combat the urban heat and energy demand.

The existence of trees & vegetation in an area enables removal of certain pollutants (majority of particulate matters) from the atmosphere through their leaf and canopy arrangement. If trees are planted widely in the entire habited areas, trees & plants can maintain cool temperature, create the peace-loving atmosphere through lowering down the ground-level concentrations of ozone and GHG emissions. Green infrastructure including vegetation & green space elevates the mental health which also actually leads to economic benefits.

Implementation Challenges in Indian Context

Implementation of Green Highways is initiated in various states of India; however, implementation practices are observed basically on a pilot basis study by choosing one component or based on selection criteria. The reason for adopting the pilot study could be the non-availability of practical experiences and not any further research and

development in highway construction projects. Few challenges or difficulties[8] in adopting the green highway concept fully as identifiedby literature study are categorized in the three aspects as follows:

Technical and Physical Barriers:

- High costs involved in removal of existing infrastructure/materials and installing new surfaces or replacement with ecofriendly material (E.g.: porous pavements)
- Limited studies and access to necessary materials (E.g.:usage of Fly ash, coco pit, etc.)
- Non-availability of land width along the roads and highways or at parking lots to install bio-swales or even rainwater harvesting structures or discharge pits, limiting local governments and public involvement choices of technology.
- Climate-resilient measures also present unique challenges to implementation
- Researchers are trying to prove benefits for the green highway. Further research on green initiatives will help in providing better guidelines or technologies that will be most appropriate for the different climatic zones.

Regulatory Challenges

- National government agencies are taking an active role in promoting the use of green transportation infrastructure, but paradoxically, those are not stringent to reach the local entities.
- The state and central Governments have been strong believers for green infrastructure projects; however, those are non-restrictive to implement.
- The program should be directed on a regional or state level, and regional project executives should be the decision makers over defining a green infrastructure technology.
- Local government's regulations or resolutions should restrict the approvals which discourage the use of innovative or ecofriendly way of technologies.

Social or cultural barriers

- The project executives have a tendency to not take risk in infrastructure projects and hence unwilling to adopt new technologies which may be considered as an experimental or unproven technology due to the assumption of high cost, non-reliability, high maintenance cost, or are unaware about the best products to use.
- Due to non-adoptability of green technologies leads to a shortage of trained contractors who can design and implementthe integrated systems, which makes it more difficult and costly.
- Many companies, non-profits, and industry organizations are into development of programs to promote environmental-friendly methods in construction technologies; however, it varies with the success levels.
- Demonstrating the market-driven techniques in infrastructure project are more attractive to consumers and an effective means of encouraging implementation as part of corporate citizenship programs.
- There is no particular research and development of green technologies and limited studies/resources for implementing practically.
- Overall, the green infrastructure is not a well-known term outside the environmental field, hence it can be used as the term of reuse or recycling methods in construction methodology to minimize the impact on environment.

Survey conducted

As a preliminary step, a quantitative research has been started by selecting survey method through questionnaire with an objective to get to know the awareness and importance of green highways among the people of India and to identify the challenges and gaps towards implementation. The questionnaire was finalized and circulated to all the stakeholders and road users, interacting with different departments. 125 out of 200 responses were received from various stakeholders belonging to different field of exposures, including government and private agencies, construction industries and academic institutions. The quick compilation was done with the responses received from the survey through Google forms. It was noted that 90 percent of the responses are in favor of the eco-friendly and sustainable way of construction management and 33 percent of responses revealed their opinion that due to lack of practical knowledge and lack of technology and research studies, implementation of a sustainable way of construction management is difficult. Only 22 percent of respondents have shown their response that they need more clarity on climate change and global warming and also expressed that more awareness among the people is important about material consumption and conservation of natural resources. On the basis of this survey authors are moving forward for both qualitative and quantitave research on study on green highways.

Summary and Conclusion

Green Highway Partnership (GHP) program has been launched with the aim of achieving a safe and efficient transportation system with an environmental stewardship and sustainability. The entire human community is moving towards greener practices. Green highway is a promising concept that involve socially desirable, economically feasible and ecologically viable practice to contribute to curb the global warming and environmental pollution. Applying all green technologies considered under GHP would not be possible to every highway construction project, each project highway will be unique to the extent of environmental impacts that can vary from project to project on basis of

climatic conditions. The analysis of the project area of environmental perimeters, social benefits are most important in the project planning stage.

This study will be one of the reference documents for highway concessions that may foresee, prevent and overcome possible difficulties for the issues relating to the development of green highway. This paper reviewed the literature on one of the highway constructions practices as a pilot green highway concept and other relevant publications from India and other countries to brief about the Green Highway Concept and to provide a clear view on implementation practices and challenges. The review of the literature study perceived the importance of green highways and sustainability practices with the concept of GHP that should begin from project preparation and its execution and maintenance of the entire project cycle.

Green infrastructure contributes a significant role in mitigating the impacts on the natural environment. Mandatory for green construction methodology is being noticed, explored, and realized for future sustainability. The study involves the contribution towards innovative eco-friendly techniques that are available and practically used in different countries or states and its applicability of selected component, at relevant project cycle that must be developed for sustainable highways.

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References

1. **Clark Williams** "Increases in GHG emissions from Highway –widening projects", 2007 Sightline Research Backgrounder, pp 1-9.
2. Gujarat State Highway Project Report (Pilot Green Highway), Roads and Building Department, Govt. of Gujarat-(World Bank funded project).
3. Project Report on Green Highway Programme (GHP), US Federal Highway Administration, 2008.
4. https://www.ahrc.in/green_highways.html (Ashoka Highway Research Centre, Nasik).
5. Special Report on Green Highways, environmentally and economically sustainably Concrete pavements, American Concrete Payments Association.
6. National Green Highway Mission under Ministry of Road Transport and Highways, Govt. of India (https://morth.nic.in/green-highways).
7. India Road Congress (http://www.irc.nic.in/index.aspx).
8. **Fatin Najwa Mohd Nusa** et al, "Challenges of Green Highway Concept towards implementation of Green Highway" *Applied Mechanics and Materials* 2015;747:3-6.