12th Five Year Plan Network Project (ESC-0106)

"DEVELOPMENT AND APPLICATION OF TECHNOLOGIES FOR SUSTAINABLE TRANSPORTATION (SUSTRANS)"

STATE OF ART REPORT

(EXECUTIVE SUMMARY)

Nodal Laboratory

CSIR-CRRI, New Delhi

Participating Laboratories

CSIR-NAL, Bangalore

CSIR-CSIO, Chandigarh

CSIR-CLRI, Chennai

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EXECUTIVE SUMMARY

Background

Sustainable development is a holistic practice that includes efforts to mitigate negative effects on every part of the road infrastructure and transportation system which are generally ignored in traditional transportation system planning. Sustainable transportation system must consider the interconnected issues under social, economy and environment areas. Sustainable system considers social, economic and environment related parameters at the same time, then it would be a sustainable system. The need to plan for sustainable transport system is evident since global warming possesses significant challenges for cities. The transport sector alone accounts for 24% of CO_2 emissions worldwide. The energy consumption is about 75 to 80% by road transport and India's share is about 10% from all transport modes. The safety of road user is also a major concern towards achievement of sustainability. On Indian roads, about 1.4 Lakhs deaths occur in fatal accidents in a year. About 3% of GDP is wasted due to the fatal road crashes on Indian roads in a year. Moreover, the sources of natural mineral aggregates are depleting fast due to massive infrastructure development and road construction activities going on in India which consumes huge quantity of material (about 15,000 tonnes of aggregates/km of highway). Also, enormous amount of energy is consumed in the production and transportation of huge quantities of Hot Mix Asphalt (HMA) required for road construction (about 90,000 litres of diesel/km). Hence, there is an urgent need to develop technologies to utilize waste & marginal materials, innovative designs to achieve reduction in pavement thickness using high performance materials.

In view of this, there is a high need of conducting a research study on sustainable transportation covering transportation, road safety and road materials in order to develop some guidelines to design a sustainable transportation system. Considering these issues, the objectives of the present study should include, design symbiotic sustainable mass transportation system and sustainable non-motorised system applying appropriate ITS technologies along with development of indigenous driving simulator to evaluate the road users in terms of road safety. The study should also include innovative technologies for utilization of waste and marginal materials in road construction, improved design methods and materials/ mixes towards achieving reduced pavement thickness, superior performing bituminous technology for long lasting pavements, warm mix technologies for road construction, use of reclaimed asphalt pavement (RAP) in construction and maintenance of roads and estimation of carbon footprints in road construction process.

As the urban India is increasing rapidly, the proposed methodology and guidelines to develop sustainable transportation system for the cities in the present study would be an immense help to manage the future problems that are going to occur in these cities related to travel demands etc. The expected outcome of the present study includes the guidelines to design sustainable roads using waste, marginal materials and RAP and warm mix bituminous technologies, new design guidelines for reduced thickness of pavement and superior performing bituminous

technology for long lasting pavements leading to conservation of depleting aggregate resources and huge savings in construction cost and energy. Further, the developed indigenous Advanced Driving Simulator would play vital role in enhancing the safety on Indian roads, this will lead to reducing economic losses to the country.

Need for the Project

The current trend of infrastructural development in India has led to increased number of private vehicles and reduced trips of public transport, indicating that priority settings for sustainable modes and road infrastructure have not been considered effectively. Traditional transportation system planning mainly focuses on the current and future demands in the limited areas and cannot cope up with the dynamic changes in the system. In contrast, sustainable systems are capable of describing the function for the foreseeable future without collapse or depletion of the resource based upon which they depend. Sustainable development is a holistic practice that includes efforts to mitigate negative effects on every part of the road infrastructure and transportation system which are generally ignored in traditional transportation system planning. Sustainable transportation system considers social, economy and environment issues and the interconnections among these. The urban India is increasing with rapid growth and transportation needs are increasing exponentially in these cities. The need to plan for sustainable transport is evident since global warming poses significant challenges for cities. Design of appropriate NMT which has high potential towards sustainable transport system with suitable road infrastructure would cause the shift to these sustainable transport modes. Moreover, the sources of natural mineral aggregates are depleting fast due to massive infrastructure development and road construction activities going on in India which consumes huge quantity of material and enormous amount of energy. To cope up with this situation, there is an urgent need to develop technologies to utilize waste & marginal materials, innovative designs to achieve reduction in pavement thickness using high performance materials. Accordingly, the estimation of carbon foot prints from such technologies is also very much essential to consider the sustainability aspect. Hence, it is very much necessary to carry out this proposed study and the outcome of the study would finally lead to increase in GDP of the country from the huge savings in the construction cost, reduction in traffic congestion, emissions, energy and accidents and the conservation of depleting aggregate resources.

Objectives and scope of the proposed research

The objectives of the present research are conceived under following two modules:
(i) Transportation Module: The work packages in this module are:

a) Quality enhancement of public transport system
b) Feeder transport system and parking facilities at public transport terminals
c) Advanced public transport information systems using ITS technologies
d) Design and Development of Desktop Car Driving Simulator
e) Sustainable Non-Motorised Transport (NMT) system
f) Policy level sustainable strategies to restrict/ control usage of private vehicles

g) Sustainable integrated mass transportation system
h) Evaluation of sustainable transportation system (environment, social and economy)

(ii) Road Module: The work packages in this module are:

a) Innovative techniques for utilization of waste and marginal materials in road construction
b) Conversion of Chromium containing solid waste generated in leather industry into pavement materials
c) Improved Design Methods and Materials/ Mixes towards achieving Reduced Pavement Thickness
d) Technology SUperior PERforming Bituminous PAVEments (SUPERPAVE)
e) Warm mix technologies for road construction
f) Designs for using reclaimed asphalt pavement (RAP) in construction and maintenance of roads
g) Estimation of carbon footprints in the road construction process

The city of Delhi and NCR regions (shown in Figure 1) would be considered as the study area for the conceptual development of a sustainable transport system.

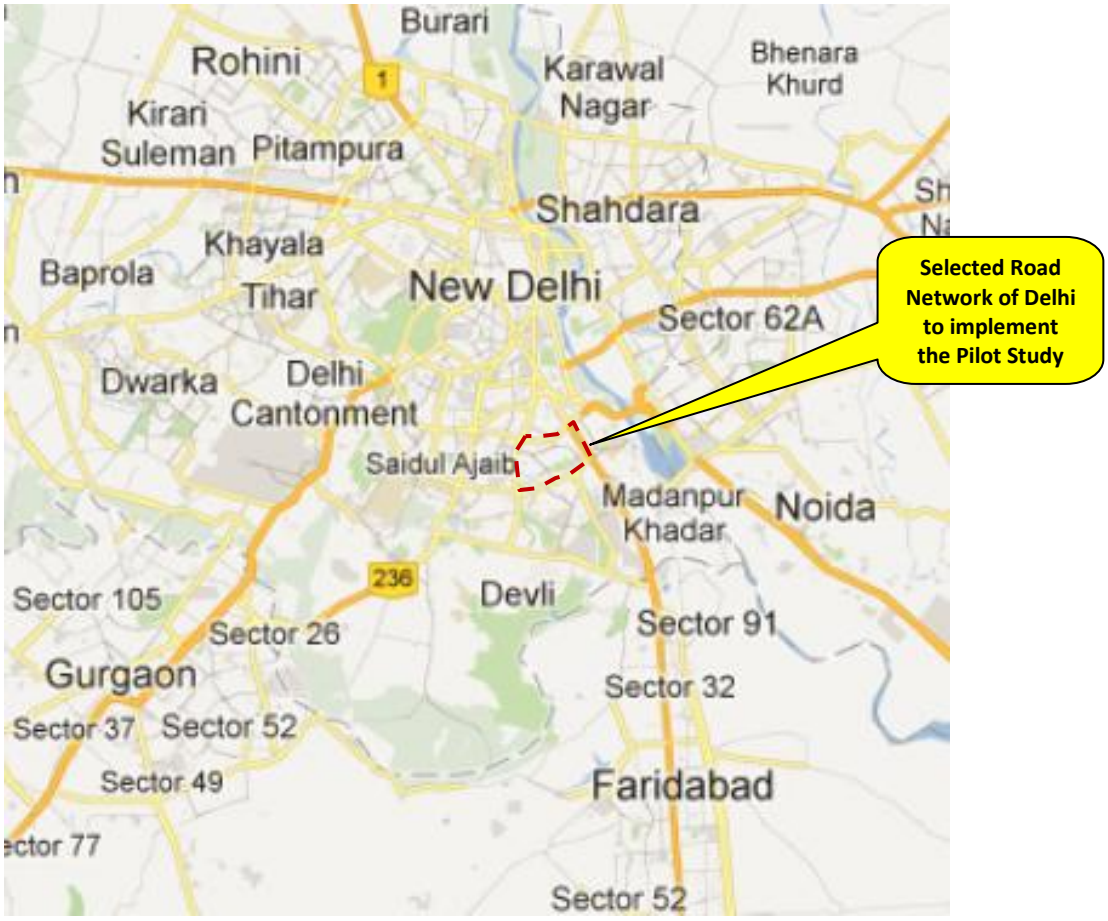

Figure 1: Selected Study Area of NCR of Delhi for the Conceptual Development of Sustainable Transport System

The developed sustainable transportation system would be considered to implement as a Pilot Study in a small road network of Delhi (shown in Figure 2) to demonstrate the benefits generated from the proposed sustainable system.

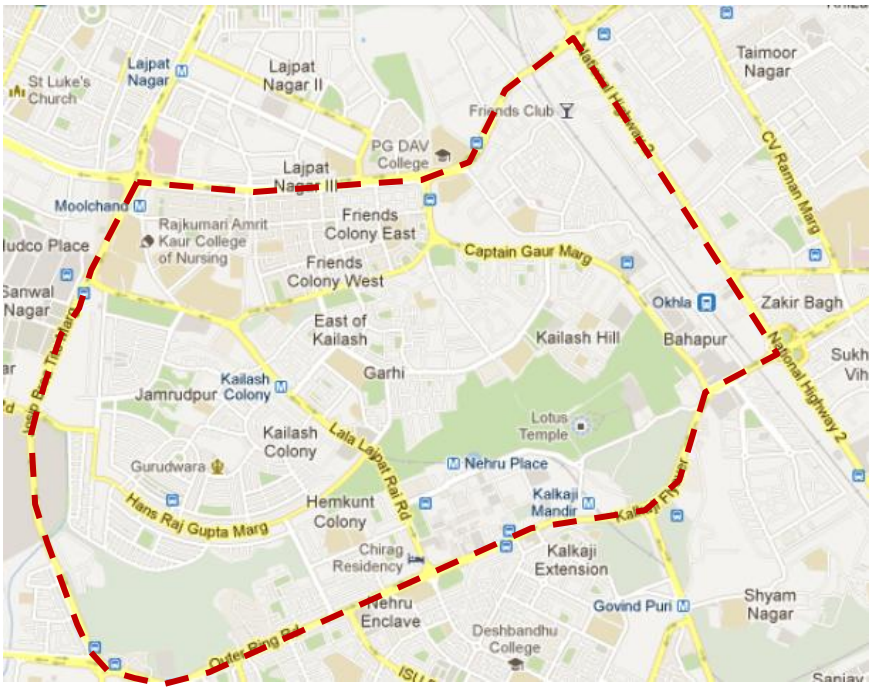

Figure 2: Selected Road Network of Delhi to implement the Pilot Study

The industrial waste and marginal materials will be collected from selected areas of the country for laboratory study. The proposed designs will be evaluated with APTF (Accelerated Pavement Testing Facility) available at CSIR-CRRI (shown in Figure 3) by constructing test tracks.

Figure 3: Accelerated Pavement Testing Facility to be used for evaluation of proposed designs of roads

Execution of the Project

Agencies involved in implementation of the project and their involvement
CSIR-CRRI, New Delhi: Being a nodal laboratory for this project, CSIR-CRRI is responsible for implementation of all the tasks of transportation module and road module (except the task of conversion of chromium containing solid waste generated in leather industry into pavement materials)
CSIR-NAL, Bangalore: It is responsible in implementing one of the tasks of transportation module of the project which involve in development of indigenous driving simulator by associating with CSIR-CRRI.
CSIR-CSIO, Chandigarh: It is responsible in implementing one of the tasks of transportation module of the project which involve in development of indigenous driving simulator by associating with CSIR-CRRI.
CSIR-CLRI, Chennai: It is responsible of implementing one of the tasks of road module of the project which involve conversion of solid waste discharged from leather industry into a road constructional material, this would yield a simultaneous solution for the (1) disposal of solid waste from leather industry (2) an alternate raw material for road construction.

Programme Schedule

The Schedule of the programme and target date for its completion (include Bar Chart) is given in Table 1.

Table 1: Schedule of the programme and target date for its completion

S. No	Name of the Activity	Schedule of the programme	
		Start	Completion
1	Development of framework for Sustainability of Transportation system and Road Infrastructure	September, 2012	March, 2013
2	Review on existing transportation system and road infrastructure facilities and Preparation of State of the Art Report	September, 2012	March, 2013
3	Development of Quality Enhanced Public Transport System	October, 2012	September, 2016
4	Development of Feeder Transport System and Parking Facilities at Public Transport Terminals	October, 2012	September, 2016
5	Advanced Public Transport Information Systems using ITS Technologies	October, 2012	September, 2016
6	Design and Development of Desk Top Car Driving Simulator	October, 2012	March, 2017
7	Development of Sustainable NMT System	October, 2012	September, 2016
8	Development of Policy Level Sustainable Strategies to restrict/ control usage of private vehicles and New Modes	October, 2012	March, 2016

9	Evaluation of Sustainable Transportation System (environment, social and economic)	October, 2012	March, 2016
10	Development of Sustainable Transportation System as Pilot Study	April, 2014	March, 2016
11	Framework and guidelines to design a sustainable integrated mass transportation system and NMT system for any given city	April, 2016	March, 2017
12	Innovative Technologies for Utilization of Waste and Marginal Materials in Road Construction	October,2012	March, 2017
13	Conversion of Chromium containing solid waste generated in leather industry into pavement materials	October, 2012	March, 2017
14	Improved Design Methods and Materials/ Mixes towards achieving Reduced Pavement Thickness	October, 2012	March, 2016
15	Development of Technology SUperior PERforming Bituminous PAVEments (SUPERPAVE)	October, 2012	March, 2016
16	Warm Mix Technologies for Road Construction	October, 2012	September, 2016
17	Use of Reclaimed Asphalt Pavement (RAP) in Construction and Maintenance of Bituminous Roads	October, 2012	September, 2016
18	Estimation of Carbon Footprints in Road Construction Process	October, 2012	March, 2016
19	Framework and guidelines to design a sustainable roads	April, 2016	March, 2017

Yearly Deliverables

The yearly deliverables of the project including the mile stones are shown in Table 2.

Table 2: Yearly Deliverables of the Project including the Mile Stones

S. No.	Deliverables	12-13	13-14	14-15	15-16	16-17
1 (a)	State of the Art Report (Transportation and Road Module)					
(b)	Interim Report on interpretation of collected data (Trans. and Road Module)					
2	Guidelines to Enhance Quality of Public Transportation System, Feeder Transport System and Parking Facilities at Public Transport Terminals					
3	Integrated Intelligent Dynamic Information System for Public Transport		**M 3.1**			
4	Guidelines on Modulus based design curves for various layers of pavement					
5	Advanced Public Transport Information Systems using ITS			**M 5.1**		

6	Travel Demand Model for Integrated Mass Transportation System and Sustainable NMT system			**M 6.1**		
7	Model for LCA of roads					
8	Design and construction guidelines for use of waste and marginal materials in road construction			**M 8.1**		
9	Integrated Double pyrolysis and oxygen infusion technology for conversion of Chromium containing solid waste into non hazardous residual ash			**M 9.1**	**M 9.1**	
10	New Design guidelines on new and cost effective design for reduced thickness of pavement		**M 10.1**		**M 10.2**	
11	Design guidelines for Superior Performing Bituminous Technology for Long Lasting Pavements		**M 11.1**		**M 11.2**	
12	Guidelines for use of warm mix in bituminous roads		**M 12.1**		**M 12.2**	
13	Design Manual/ Guidelines on the use of RAP in road construction		**M 13.1**		**M 13.2**	
14	Indigenous Advanced Driving Simulator for testing and evaluation of drivers			**M 14.1**	**M 14.2**	
15	Framework and guidelines to design a sustainable integrated mass transportation system and NMT system for any given city					
16	Framework and design guidelines to design a sustainable roads					

Note: M - Represents Mile Stones and the description is given below:

These milestones are described below:

M 3.1 - Database for all public transport information
M 5.1 - Installation of ITS Equipment to develop APTIS
M 6.1 - Travel Demand data for all the road users including NMT
M 8.1 - Characterization of waste and marginal materials from selected areas
M 9.1 - Characterization of chromium containing solid matrix
M 9.2 - Semi Pilot scale studies for the conversion of chromium containing solid waste
M 10.1 - Analytical properties of materials and mixes
M 10.2 - Design templates based on analytical properties and performance inputs
M 11.1 -Basic engineering properties of the materials
M 11.2 - Performance Monitoring by Instrumentation and data acquisition by APTF
M 12.1 - Warm mixes characterization
M 12.2 - Performance monitoring of test sections and control section
M 13.1 - Mix Design with varying RAP content and their characterization
M 13.2 - Performance Evaluation of the test section with APTF
M 14.1 - Design of the project with graphic experts
M 14.2 - Pilot testing of the simulator

Envisaged Outcomes and Outputs of the Project

The major outputs envisaged in the present proposal include:

- Framework and guidelines to design a sustainable integrated mass transportation system and NMT system for any given city

- Pilot Study to demonstrate the benefits quantified from Integrated Intelligent Dynamic Information System, Advanced Public Transport Information Systems using ITS, Sustainable NMT and Integrated Mass Transportation System
- Indigenous Advanced Driving Simulator for testing and evaluation of drivers
- Guidelines to design sustainable roads using waste, marginal materials and RAP and warm mix in bituminous
- New Design guidelines to reduce thickness of pavement and Superior Performing Bituminous Technology for Long Lasting Pavements
- Model for Life Cycle Assessment (LCA) of roads
- Publications in SCI Journals
- New Guidelines, Specifications & Manuals
- Patents for Developed New Designs for Pavement Construction and Materials with Indian Conditions

Since, very limited research has been carried out in the proposed area, the above envisaged outputs from the proposed research would place CSIR (India) in a leading position in terms of providing better performing transportation systems and roads for well being and overall economy of the country. Apart from that the proposed project will make the country to stand to gain in the Asian continent, since any move to develop and adopt such technologies can be used with equal dependency and reliability by any other developing neighbouring country.
The major outcomes envisaged in the present proposal include:

- Guidelines to design a sustainable integrated mass transportation system and NMT system and sustainable roads
- Indigenous Advanced Driving Simulator for testing and evaluation of drivers

The proposed research would place CSIR (India) in a leading position in India as well as in the Asian continent in terms of providing better performing transportation systems and roads for well being and overall economy of the country.