Annual Report
2009-10









केन्द्रीय सड़क अनुसंधान संस्थान

CENTRAL ROAD RESEARCH INSTITUTE

New Delhi

CRRI

CRRI ORGANISATIONAL STRUCTURE

Research Council

Dr. S. Gangopadhyay
Director

Management Council

R & D Areas

Pavement Engineering and Materials (PEM)

Dr. Sunil Bose, Head, *Flexible Pavement (FP)*
Sh. B.M. Sharma, Head, *Pavement Evaluation (PE)*
Dr. Rumi Mathur, Head, *Rigid Pavement (RP)*

Geotechnical Engineering (GTE)

Shri Sudhir Mathur, Area Advisor & Head

Traffic & Transportation Planning (TTP)

Dr. Nishi Mittal, Head, *Traffic Engineering & Road Safety (TES)*
Ms. Anuradha Shukla, Head, *Transport Planning & Environment*

Road Development Planning & Management (RDM)

Dr. B. Kanaga Durai, Head, *Road Development Planning & Management*

Bridge and Structure (BAS)

Dr. P. Lakshmy, Head

Infrastructure

Estate Services (ESS)

Shri Jai Bhagwan, Head, *Civil Section*
Shri Subodh Kumar, Head, *Electrical Section*
Shri Ashok Kumar, In charge, *Horticulture*

R & D Support Services (RDS)

Dr. D. Mukhopadhyay, Head, *Computer Centre (CCN)*
Shri R.S. Bharadwaj, Head, *Mechanical Engineering Support (MES)*
Shri. Prasanna Kumar, Head, *Instrumentation (INS)*

HRD and Project Management (HRP)

Shri. Sudhir Mathur, Area Advisor
Dr. P.K. Jain, Head, *Planning, Monitoring & Evaluation (PME)*
Shri T.K. Amla, Head, *Information, Liaison and Training (ILT)*
Shri A. Saurikhia, Scientist I/c, *Technology Management & Business Dev.*
Ms. Kamla Masih, I/c, *Management Information (MIN)*

Documentation & Library Services (DLS)

Dr. Ashok Kumar, Area Advisor & Head

Quality Management

Shri R.S. Bharadwaj, Head

Maharani Bagh Staff Quarter (MBSQ)

Shri B.M. Sharma, Area Advisor
Shri A.K. Tripathi, Head, *M.B.S.Q- Maintenance*

Administration (ADM)

Shri Jitendra Panwar, Controller of Administration
Shri M.K. Jain, Controller of Finance & Account
Shri S.S. Verma, Controller of Store & Purchase (Acting)
Shri I.P. Indora, Finance & Account Officer
Ms. Sumedha Verma, Administrative Officer
Dr. Anang Pal Singh, In Charge-Rajbhasha
Shri Dharam Singh, Cafe Taker
Md. F.A. Siddiqui, Manager, Guest House

Annual Report
2009-10

केन्द्रीय सड़क अनुसंधान संस्थान
नई दिल्ली (भारत)

Central Road Research Institute
New Delhi (India)

Contents

CRRI
Annual Report
2009-10

Edited, Compiled & Produced by:
Information, Liaison & Training Division

Editing, Compilation & Production:

Sh. T.K. Amla, Scientist & Head
Smt. Anita Arora, Technical Officer,

Assisted by :

Sh. M.K. Meena, Scientist
Sh. P.R.N. Nair, Technical Officer
Sh. Rajbir Singh, Technical Officer
Sh. Ashok Kumar, Technical Officer

Overall Supervision:

Sh. T.K. Amla
Head
Information, Liaison & Training Division

Designed & Printed at :
Chandu Press
D-97, Shakarpur, Delhi-110092

Foreword

मुझे सीएसआईआर स्थापना दिवस पर संस्थान के वार्षिक प्रतिवेदन 2009-10 को प्रस्तुत करते हुए अत्यंत प्रसन्नता हो रही है। संस्थान ने वर्ष के दौरान यातायात एवं परिवहन आयोजना, सड़क सुरक्षा एवं पर्यावरण, सड़क विकास आयोजना एवं प्रबंधन, (भूस्खलन, ढाल स्थापित्व, भूमि सुधार आदि) से संबंधी भूतकनीकी पक्षों, दृढ़ एवं सुनम्य कुट्टिमों के लिए सामग्री तथा मिश्रणों के मूल्यांकन एवं निर्माण तकनीकी, सेतु डिजाइन, मूल्यांकन एवं पुनः स्थापन तथा सॉफ्टवेयर विकास के क्षेत्रों में अनुसंधान एवं विकास के कार्य प्रमुख रूप से जारी रखे।

संस्थान ने वर्ष के दौरान लगभग तीस प्रायोजित अनुसंधान परियोजनाएं आरंभ/संपन्न की है जिसमें हाई स्पीड कॉरिडोर के लिए अनुरक्षण, आयोजना एवं बजट हेतु प्रबंधन प्रणाली का विकास सम्मिलित है। परियोजना के द्वारा कुट्टिम अनुरक्षण के लिए सीमित बजट के अंतर्गत बजट की आवश्यकताओं एवं निधि के आबंटन के संबंध में आकलन करना संभव होगा। सड़क परिवहन एवं महामार्ग मंत्रालय द्वारा प्रायोजित राष्ट्रीय महामार्गों के लिए जीआईएस आधारित महामार्ग सूचना तंत्र एवं आंकड़ा आधार (डाटाबेस) पर समेकित अध्ययन आरंभ किया गया। इसके अंतर्गत जीआईएस वातावरण में महामार्ग सूचना तंत्र का विकास तथा तंत्र के प्राथमिक एवं द्वितीयक दोनों स्रोतों के महामार्ग से संबंधित जानकारी का संग्रहण एवं संयोजन सम्मिलित है।

सीआरआरआई ने नवीन एवं संशोधित सड़क प्रौद्योगिकियों पर अपनी दसवीं पंचवर्षीय योजना परियोजना को सफलतापूर्वक कार्यान्वित किया है। अध्ययन के

It is my proud privilege to present the CRRI Annual Report 2009-10 on CSIR Foundation Day. The main R & D inputs during the year continued to be in the area of Traffic and Transportation Planning, Road Safety and Environment, Road Development Planning and Management; Geotechnical aspect related to Landslide, Slope Stability, Ground Improvements; Construction Techniques and Evaluation of Materials and Mixes for Rigid and Flexible Pavements; Bridge Design, Evaluation & Rehabilitation and Software Developments.

The Institute handled about thirty sponsored research projects during the year including Development of a Management System for Maintenance Planning and Budgeting for High Speed Corridors, which would be capable of estimating the budget requirements and allocation of funds within constrained budgets for pavement maintenance. A Comprehensive Study on GIS based Highways Information System and Database for National Highways, sponsored by Ministry of Road Transport and Highway was taken up which involves the development of Highways information system in GIS environment and collection and collation of the highways related information from primary as well as secondary sources in the system.

CRRI has successfully implemented its tenth five year plan project on New and Improved Road Technologies. The study has culminated into development of a number of technologies such as Use of Waste Plastic, Ultra Thin

परिणामस्वरूप भारतीय सड़क कांग्रेस तथा भारतीय मानक ब्यूरो के लिए मानकों का विकास, अपशिष्ट प्लास्टिक का उपयोग, अति तनु श्वेत आस्तरण जैसी अनेक प्रौद्योगिकियां विकसित की गई हैं। सड़क परिवहन एवं महामार्ग मंत्रालय ने अभी हाल ही में सीआरआरआई को विस्तार संधियों के परीक्षण हेतु राष्ट्रीय परीक्षण सुविधा के विकास से संबंधित एक प्रमुख अध्ययन कार्य सौंपा है।

उत्तर-पूर्व क्षेत्र के समग्र विकास के लिए उपयुक्त प्रौद्योगिकियों का विकास करने के लिए प्रयास किए जा रहे हैं। सीआरआरआई इस क्षेत्र हेतु फोकस क्षेत्र के रूप में प्रयासरत है तथा नीस्ट, जोरहाट के सहयोग से सीआरआरआई केंद्र के रूप में अपनी उपस्थिति दर्शा रहा है।

वर्ष के दौरान संस्थान ने वैज्ञानिक सेवाएं प्रदान करने के लिए कुछ आधुनिकतम सुविधाएं तथा प्रमुख प्रयोगशाला अवसंरचनाएं प्राप्त की हैं। इसके अंतर्गत नेटवर्क सर्वे वाहन प्रणाली, रफोमीटर-II, पदाति परिच्छेदक, कार चालन सिमुलेटर, पेट्रोल हेतु ईंधन प्रवाह अन्वेषक, वाटर केमिस्ट्री प्रयोगशाला तथा ऑटो सैम्पलर एवं 'सुमा' कैनिस्टर्स सम्मिलित हैं। संस्थान ने एक राष्ट्रीय सुविधा-एक्सीलिरिटेड कुटिटम परीक्षण सुविधा आरंभ की है जो पूरे दक्षिण-पूर्व एशिया में अपूर्व है। इस सुविधा के द्वारा कुटिटमों की दीर्घावधि कुटिटम निष्पादन का पूर्वानुमान अत्यंत अल्प अवधि में लगाया जा सकता है। उदाहरणस्वरूप, 10-20 वर्षों की सामान्य यातायात परिस्थितियों की तुलना में यह कार्य 3-6 माह के दौरान संभव हो गया है।

संस्थान ने 'सड़क अनुसंधान और इसके उपयोग' विषय (एनजीटी 2010) पर राष्ट्रीय संगोष्ठी का आयोजन किया। प्रो0 समीर के ब्रह्मचारी, महानिदेशक सीएसआईआर एवं सचिव डीएसआईआर ने इस संगोष्ठी का उद्घाटन किया। एनजीटी 2010 के दौरान व्यावसायिकों एवं विषेशज्ञों ने सड़क विकास के विभिन्न बिंदुओं पर चर्चा की तथा अनुसंधान के प्रमुख क्षेत्रों पर उपयुक्त संस्तुतियां देने के साथ-साथ एवं सड़क परिवहन के क्षेत्र में अनुसंधान निष्कर्षों के अनुप्रयोग को रेखांकित किया गया।

उपभोक्ता संगठनों के साथ प्रगाढ़ संबंध के निर्माण एवं प्रभावोत्पादक प्रौद्योगिकी हस्तांतरण के उद्देश्य से संस्थान ने अनेक परामर्श कार्य संपन्न किए एवं प्रचुर नगद संसाधन का अर्जन किया। संस्थान ने महामार्ग एवं सेतु अभियांत्रिकी, यातायात अभियांत्रिकी, गुणवत्ता नियंत्रण, निर्माण तकनीक एवं अन्य संबंधित क्षेत्रों में पुनश्चर्या पाठ्यक्रम/प्रशिक्षण कार्यक्रम चलाने संबंधी गतिविधियों को पूरे वर्ष जारी

White Topping: Development of Specifications for Indian Roads Congress and Bureau of Indian Standards. The Ministry of Road Transport & Highways has recently assigned CRRI a major study to create National Test Facility for Testing of Expansion Joints.

For North-Eastern Region, efforts are being made to develop appropriate technologies for its overall growth. CRRI is putting its efforts as a focused area for the region and is showing its presence in the region in collaboration with NEIST Jorhat as CRRI Node.

During the year, the Institute has added some major laboratory infrastructures viz. State-of-the-art facilities for offering scientific services include; Network Surveys Vehicle System, Roughometer II, Walking Profiler, Car Driving Simulator, Fuel Flow Detector For Petrol, Water Chemistry Laboratory and Auto Sampler along with SUMMA Canisters. The Institute has commissioned a National facility-Accelerated Pavement Testing Facility which is unique in south-east Asia. It is a facility with which long term pavement performance of pavements could be predicted in a very short duration i.e., say 3-6 months as compared to 10-20 years needed under normal traffic conditions.

The Institute had the honour to organize National Get – together on Road Research and its Utilization (NGT 2010), which was inaugurated by Prof. Samir K. Brahmachari, DG CSIR and Secretary DSIR. During NGT 2010, various issues related to road development were discussed by the professionals and experts and come out with appropriate recommendation on thrust areas of research and application of research findings in the field of Road and Road Transportation.

In its endeavor for effective technology transfer and building a close linkage with user organizations, the Institute handed a large number of consultancy assignments and earned a sizeable cash resource. The Institute also continued with its year round activities of conducting refresher course / training programme in the field of highway and bridge engineering, traffic engineering, quality control, construction techniques and other related aspects. An International training

रखा। एचडीएम-4 पर अंतर्राष्ट्रीय प्रशिक्षण पाठ्यक्रम भी आयोजित किया गया। इसके अतिरिक्त सुनम्य/दृढ़ कुट्टिम की आयोजना, डिजाइन, निर्माण एवं अनुरक्षण पक्षों पर इरकॉन, आरएंडबी, गुजरात सरकार, गांधीनगर, एचएसएएमबी हरियाणा एवं कर्नाटक सरकार के इंजीनियरों के लिए विभिन्न तदनुकूल निर्मित प्रशिक्षण कार्यक्रम चलाए गए।

संस्थान के मानव संसाधन विकास कार्यक्रम के अंतर्गत उच्चतर शैक्षणिक योग्यता पाने के लिए अनेक वैज्ञानिकों को अध्ययन हेतु प्रतिनियुक्त किया गया। साथ ही, चुनौतीपूर्ण कार्यों के बेहतर निष्पादन के लिए स्टाफ सदस्यों को उनकी विशेषज्ञता के क्षेत्र में प्रशिक्षण लेने के लिए प्रतिनियुक्त किया गया। इसके अतिरिक्त विभिन्न शैक्षणिक संस्थानों/विश्वविद्यालयों के 29 छात्रों (बी.टेक, एम.टेक, एमसीए) को उनके ग्रीष्म परियोजना/प्रशिक्षण तथा शोध-कार्य/शोध-प्रबंध इत्यादि कार्यों को पूरा करने के लिए मार्गदर्शन एवं प्रशिक्षण प्रदान किया गया।

सीबीआरआई के सहयोग से सीआरआरआई सामयिक प्रौद्योगिकियों के विभिन्न क्षेत्रों में इंजीनियरी ऑफ इन्फ्रास्ट्रक्चर एंड डिजास्टर मिटिगेशन पर संयुक्त रूप से दो वर्षीय स्नातकोत्तर शोध पाठ्यक्रम शुरू कर रहा है। इस कार्यक्रम को अनुसंधान एवं विकास अनुभव की दृष्टि से गहन ज्ञान एवं अभ्यास प्रदान करने तथा युवा इंजीनियरी स्नातकों को भावी प्रौद्योगिकी अगुवाओं के रूप में तैयार करने के लिए निर्मित किया गया है।

सीआरआरआई ने अपने प्रयासों को समेकित रूप देने के लिए तीन प्रमुख क्षेत्रों की पहचान कर कार्य शुरू किया। ये तीन क्षेत्र हैं- 'रोड़ी को बचाएं', 'यातायात भीड़ को कम करें' तथा 'सड़क सुरक्षा'। व्यवसाय के प्रति अपनी प्रतिबद्धता दर्शाने के लिए कारपोरेट प्रौद्योगिकीय उत्तरदायित्व पहल के रूप में कुछ प्रयास किए गए हैं।

मैं अपने सभी स्टाफ सदस्यों, सीएसआईआर, इस प्रयोगशाला में अनुसंधान एवं प्रबंध परिषदों के सदस्यों को उनके अमूल्य सहयोग, परामर्श एवं समर्थन के लिए सबका आभार प्रकट करता हूँ।

course on Highway Management and Development (HDM-4) was also organized. In addition, several customized training programmes were also organized on planning, design, construction and maintenance aspects of flexible pavement / rigid pavement etc. for the engineers of IRCON; R & B, Govt. of Gujarat, Gandhi Nagar; HSAMB, Haryana and Govt. of Karnataka.

Under HRD Programme of the Institute, many scientists have been deputed for studies to acquire higher academic qualification. Besides, Staff members were deputed to receive training in the area of their expertise to cope up with the challenging assignments. Further, thirty nine students (B.Tech, M.Tech, MCA) from different academic Institutions / Universities were provided guidance and training for accomplishing their summer project / training and thesis / dissertation works etc.

In collaboration with CBRI, CRRI is jointly offering two year PG Research Course on Engineering of Infrastructure and Disaster Mitigation in different areas of cutting edge technologies. The programme is designed to give in-depth exposure and hands on R & D experience to the Young Engineering Graduates to groom them as Future Technology Leaders.

CRRI has identified and launched three major areas to focus the efforts in consolidated manners. These are 'Save the Aggregate', 'Reduce the Traffic Congestion' and 'Road Safety'. Initiatives have been taken as Corporate Technological Responsibility initiatives reflecting our commitment to the professions.

I wish to gratefully acknowledge the support and cooperation of all my staff, CSIR, Members of Research and Management Councils of this laboratory, for their valuable assistance and advice.

डॉ० एम. गोपालस्वामी
निदेशक

OBJECTIVES

The scientific & technical objectives of CRRI are :

- To develop specifications and manuals for construction of low cost roads for different regions of the country.
- To carry out applied research for investigation, construction and maintenance of different types of roads and runway including studies on related materials such as aggregates, bitumen, cement, etc. with a view to effecting economy and achieving greater serviceability.
- To develop appropriate tools, machinery, equipment and instruments for adapting technologies as related to highway engineering and relevant to the country for indigenous use.
- To carry out research and development activities in all aspects of roads under varying climatic and traffic conditions.
- To carry out research and development in all aspects of road traffic and transportation engineering, including study of accidents, development of road safety measure, psychology of road users and transportation economics in relation to different forms of transport.
- To render technical advice and consultancy services to various organisation in roads and related fields to avoid import of foreign expertise.
- To train engineers through refresher courses, workshops and training programmes for wider application of indigenously developed technologies.
- To create and establish all the needed infrastructure, both equipment and expertise, in the various facets of highway and transportation engineering for investigation, planning, design, construction and maintenance as well as to achieve judicious solutions for special problems.
- To collaborate with other institutions for R&D studies concerning roads, road transportation and related practices particularly on regional problems.
- Publication of scientific and technical findings in journals, symposia, conferences, etc. devoted to research and development in related areas of highway engineering.
- Generation of intellectual property and its commercialization through technology transfer.

गुणवत्ता नीति

केंद्रीय सड़क अनुसंधान संस्थान (सी आर आर आई) सड़क व सड़क परिवहन के क्षेत्र में व्यवसायिक उत्कृष्टता का विकास करने तथा व्यवसाय के समक्ष उपस्थित विविध तकनीकी समस्याओं का उपयुक्त समाधान प्रस्तुत करने के लिए अनुसंधान एवं विकास कार्यक्रमों, परामर्श सेवाओं एवं मानव संसाधन विकास कार्यक्रमों को संपन्न करने हेतु कटिबद्ध है।

Quality Policy

The Central Road Research Institute (CRRI) endeavors to develop Professional Excellence in the area of Roads and Road Transport and to undertake Research & Development (R&D) Programmes, Consultancy Services and HRD Programmes to evolve appropriate solutions to the diverse technical problems faced by the profession.

Geotechnical Engineering

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report
2009-10

Project Team Members of Geotechnical Engineering Division

Engineering of Structures against Natural and Other Disasters

This project has been taken up as a network project coordinated by SERC, Chennai. In order to study natural disasters, three sites, one under the heavy flood and the other two large landslide affected areas were chosen. Under the heavy flood area, field visit was made to West Bengal to study impact of Cyclone Aila on road network Fig. 1(a & b). Discussions were held with officials from Ganga Flood Control Commission, WBIWD and DST, Govt of India. Various remedial measures being taken up were studied and recommendations for improving the same were provided.

Under the large landslide affected area, two landslides namely Patalganga and Kaliasaur landslides have been selected for detailed investigations. At Patalganga landslide on National Highway-58, Uttarakhand, sixty five numbers of specially designed steel pedestals have been installed in the landslide body for monitoring the dynamic behaviour of the landslide and their original position has been fixed by using DGPS (Differential global positioning System). Earlier, twenty five numbers of steel pedestals were surveyed to measure the shift in their position, if any, so that magnitude and direction of movement may be assessed. The movement of the pedestals is attributed to the movement of the blocks (formed by dilational and shear fractures in the main body) resting on the slip surfaces on which pedestals were installed. The sixty five numbers of additional pedestals which were installed in the year 2007 have been monitored for the movement and it was found

(a)

(b)

Fig. 1 (a & b) A view of heavy flood in West Bengal

that the shifting of position (Fig. 2 (a & b) of some of the pedestals ranges from 0.31 to 8.26m. Monitoring of Patalganga landslide depicts that it has shallow kind of movement. Current monitoring of the slide reveals that the movement ranges from 0.31 to 8.68 meters. Movement of lower magnitude has been observed in the upper parts of the landslide area whereas higher magnitude movement has been recorded in the lower parts of landslide

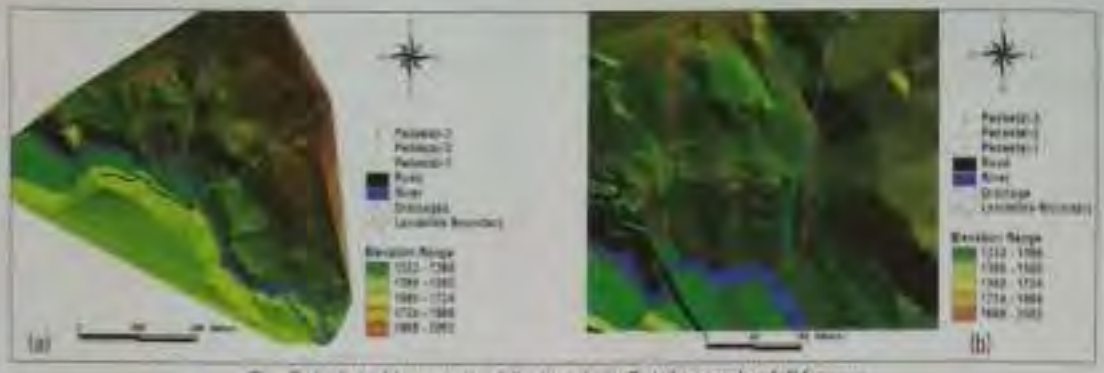


Fig. 2 (a & b) Movement of Pedestals in Patalganga landslide area

area. It depicts the erosion in toe parts during rainy season. Most of the movement of the pedestals trend towards SW and WNW direction. Monitoring will be continued in the future as well. The project is currently under progress.

Detailed Geological, Geotechnical Investigation, Instrumentation and Monitoring of Amparav Landslide

As reported earlier (Annual Report 2008-09) the study on Amparav landslide has been sponsored by the Department of Science and Technology (DST). The Amparav slide is located on the Kathgodam – Nainital road, 4 km. before Jyolikot on NH-87 in Nainital District of Kumaun Division, Uttarakhand State. Detailed geological and geotechnical studies were carried out. For this purpose, large scale mapping done at 1:500 scales with 2 m contour interval. Large scale mapping include all topographical, manmade features and also the dimension of landslides. It was found that study area is highly venerable for slope instability. Mainly, three different types of failures namely, plane/block failure, talus failure on higher reaches and rotational failure at lower reaches are affecting the NH-87 (Fig. 3). Further, studies revealed that there were natural as well as anthropological factors playing important role, causing instabilities in the area. These factors are given in Table – I. Proposed remedial measures are given in Fig. 4. Project report has been submitted to DST.

Table – I Causative Factors Identified at Amparav Landslide

Natural Causative Factors		Anthropological Causative Factors
Geology	Weak Lithology	Deforestation
	Structure Domination	Excessive Irrigation in Agriculture Fields
Steep Slope		Improper Drainage
Land Use and Land Cover		Inadequate Maintenance of Old Existing Remedial Measures
High Weathering		Construction of Concrete Bridge with Low Ground Clearance
Presence of Mud Stone Layers		
High Seismic Zone / Close to MBT		

Fig. 3 Different modes of failure of Amparav landslide

Fig. 4 Proposed remedial measures in Amparav slide area

Investigation, Instrumentation and Monitoring of Kaliasaur Landslide on National Highway-58

As reported earlier, (Annual Report 2008-09), the project has been sponsored by Departement of Science & Technology (DST) to suggest remedial measures for longterm stability of Kaliasaur landslide on NH-58. The study was initiated four years ago. The final report along with suggestion of long-term remedial measures for slope stability is submitted to DST. Important deliverables from the project work include topographic map of the area on a scale of 1:500 that served as the base map for many studies such as: large scale geomorphological, geological and structure map. It helped in creation of various data layers such as lithology, structure, rock mass and slope mass classes etc. and their geo-referencing with the base map and creation of digital terrain model from base map on a scale of 1:500. Draping the various data layers on the terrain model facilitated the virtual navigation, flight simulation and 3-D work for understanding the terrain better, derivatives of terrain model (slope distribution map, aspect distribution map, water flow line analysis map). The geomorphic analysis and maps of the landslide area of different time frames by acquiring base maps from various sources, rock mass and slope mass characterization of the landslide area, rock mass and slope mass zonation maps of the landslide area based on the analysis of rock mass and slope mass characterization, stability analysis of main slide have been integrated for designing suitable remedial measures. The upward extension of the slide boundary has been shown in Fig. 5 indicates 20m extension from 1984 to 2008.

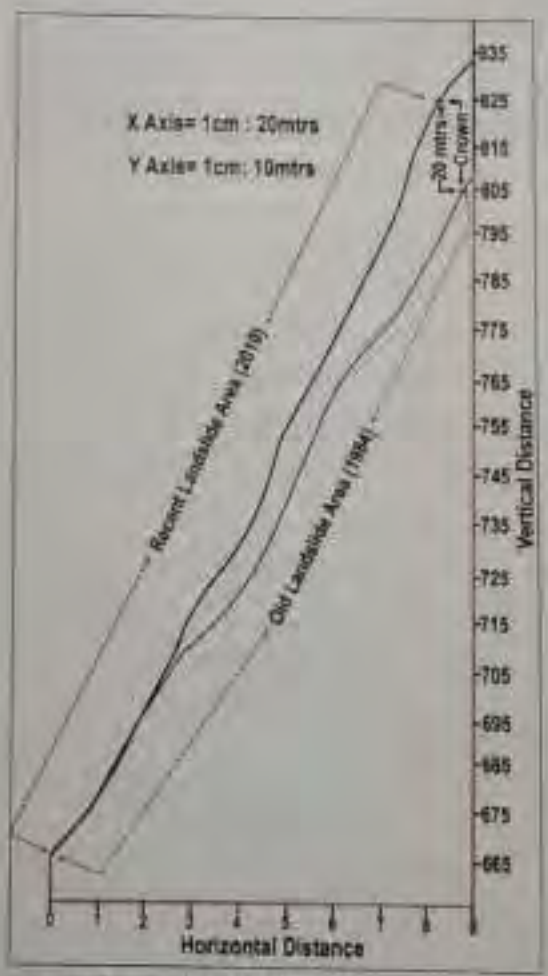


Fig. 5 Comparison of CBRI (1984) and CRRI (2010) Profiles of Kaliasaur Landslide Area on NH-58

Experimental Test track wi Cement Stabilization

This research project has been undertaken as an in-house research programme. In this study, design of road pavement is carried out using the cement stabilized materials in comparison with other available methods viz. South Africa method, Tanzanian method etc. to reduce the pavement crust thickness (saving of aggregates) and modify the present construction methodology of cement stabilization. Construction of experimental test track section of 60 m length (2 lanes) using cement stabilization is carried out on Amritsar-Wagha border road near Amritsar. In this construction, subgrade and GSB layers are stabilized with 2.5 per cent cement. Quality

check is carried out during the construction viz. quantity of cement, water content, mixing of cement, density etc. After construction of each stabilized layer, 7 days curing is carried out by covering the layers using next upcoming layer material. After 7days of curing, sample of stabilized subgrade materials were taken out from the site and compressive strength of the sample is determined in the laboratory. Fig. 6 shows some of the construction steps such as laying of cement, mixing of subgrade and cement, density determination after compaction.

Fig. 6 Laying of cement, mixing of cement & in-situ density determination

Pilot Project on Use of Jute Geotextiles in PMGSY Roads

As reported earlier, this project is being supported by Jute Manufactures Development Council (JMDC) as a sponsored research project with the objective to study efficacy of Jute Geotextile (JGT) for drainage, erosion control, capillary cut-off and subgrade improvement and hence performance monitoring forms an important component of this project. Under this project, construction of five PMGSY roads using different types of jute geotextiles has been completed in four states. Each of these PMGSY roads, comprises of several sub-sections in which JGT of different varieties (woven, non woven and open weave), of different strengths and rot treated as well as non treated varieties have been laid to study their relative performance. Control sections without JGT have also been constructed. A distinguishing feature of these test roads is the construction of reduced pavement thickness sections where in JGT as drainage improvement layer has been laid above subgrade. Presently the performance monitoring of these roads is under progress. The performance indicators which have been recognised for monitoring include – Benkelman Beam deflection studies, DCP tests at subgrade level, retrieval of JGT samples below pavement and tests on retrieved JGT samples and visual pavement surface condition evaluation for recording distress (Fig. 7 & 8). Performance

monitoring will be carried out for a period of 18 months.

Fig. 7 Exhuming JGT sample below the pavement

Fig. 8 DCP tests at sub-grade level

Guidelines for Soil and Granular Material Stabilisation using Cement, Lime & Fly Ash

The work of the preparation of guidelines was assigned by Indian Roads Congress. The revised guidelines encompass the review of soil stabilization which is the process whereby soils and related materials are made stronger and more durable by mixing with a stabilizing agent. Although many stabilizing agents can be used, cement and lime are by far the most important and the guidelines mainly concentrate on use of Lime, Cement, Lime-fly ash/Lime-cement fly ash as stabiliser. The guidelines include, general features of stabilization, guidelines for soil/ granular material stabilization, specifications and test requirements for stabilised materials, construction procedure, quality control and limitations on the use of stabilised materials. These guidelines have been made considering prevailing Indian and International practices. The guidelines have been approved by IRC Council.

Consultancy Assignments

Soil Nailing Technique for Facilitating Construction of RUB by Box Pushing Technique at Western Approach of Old Yamuna Bridge

Delhi PWD is constructing a bypass ring road from Salimgarh Fort to Velodrome Road as part of Commonwealth Games works. This road is proposed to pass under west end approach of old Yamuna Bridge (Railway cum Road Bridge) and a Road Under Bridge (RUB) was proposed to be constructed below the existing railway line. The approach to the railway bridge has been constructed by providing rubble stone masonry retaining walls and backfilling Yamuna sand in between the retaining walls. Two parallel railway tracks pass over this backfill.

The height of retaining wall at approach embankment is about 6 m. The railway line, stone masonry retaining walls and the bridge are about 135 years old. Sub-soil investigation revealed that backfill in-between retaining walls mainly consists of silty fine sand ($c = 0$, $\varphi = 29^0$) upto natural ground level (NGL). Below NGL, there is conglomerated soil upto 2 m depth and there after stratum consists of fine sand upto 6 m depth. In the absence of proper records, cross section of retaining wall at one location was explored by adopting GPR technique. This GPR study showed that retaining wall may have a battered face towards earth side having thickness more than 2 m.

Fig. 9 Boxes to be pushed inside the retaining wall

Construction of RUB consists of pushing under existing railway track, two numbers of RCC Boxes with internal dimensions (opening) of 10.5 m x 5.75 m each and one number RCC box of 9 m x 4 m, under existing railway track. Width of the embankment between the retaining walls is 15 m. These precast box segments of RUB are to be pushed in highly unstable cohesionless sandy soil backfill in between retaining walls. Also rubble stone

Fig. 10 Casting of RCC boxes after dismantling the retaining wall

masonry retaining walls on the entry and exit ends of the box are required to be dismantled thereby exposing unsupported earth face of 7.5 m height which is prone to collapse. About 200 to 250 trains pass over this section daily, and there should not be any disruption to rail traffic in any case. To accomplish box pushing for construction of RUB, a novel methodology using 'Soil Nailing' has been adopted.

Fig. 11 Trains running smoothly after dismantling of retaining wall

Fig. 12 A view of retaining wall after dismantling

Soil Nailing consists of reinforcing the soil mass by the introduction of a series of thin elements called 'Nails' to resist tension, bending and shear forces. The reinforcing elements are made of steel round cross section bars called as nails. Dismantling of the retaining wall was taken up and at the same time, a series of driven and grouted nails were driven into the sand mass for retaining the same. Box pushing and gradual removal of backfill sand was then taken up and simultaneously driven nails were further pushed inside the sand mass. In this manner, RUB construction has now been successfully nearing completion. Different periods of construction at site are shown in Figs. 9, 10, 11&12.

Landslides on Dimapur-Kohima-Maram Road (National Highway-39) in Nagaland and Manipur States

National Highway-39 is the only connecting route between Dimapur and Kohima (The state capital of Nagaland) and had been suffering from slope failures at various locations. The investigation work required geomorphological, structural and geological analysis along with the evaluation of geo-technical properties

Fig. 13 A view of damaged road and traffic obstruction due to landslide (km 162 at NH – 39)

Fig. 14 Geomorphological map (km-174 at NH-39)

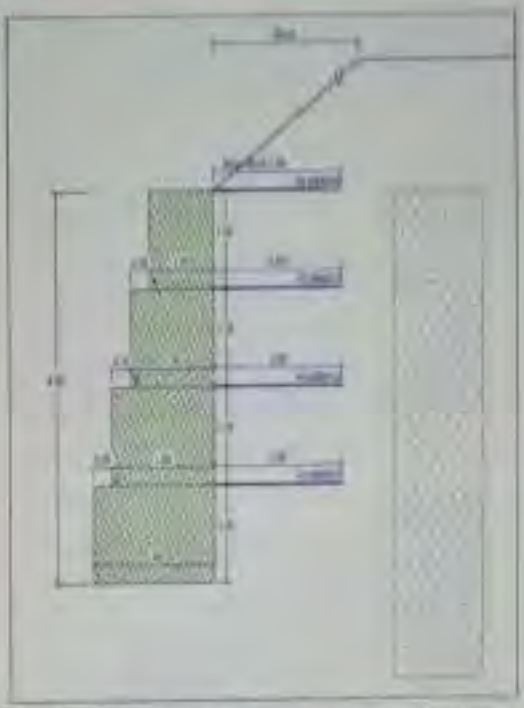


Fig. 15 Design of remedial measures suggested for NH-39

for designing suitable remedial measures to stabilize the slopes at various critical locations including km-162, 174, 179, 180 and 221 (Fig. 13) Topographic map of the area was prepared on a scale of 1:500. This map was used as a base map for the geological, geomorphological (Fig.14), and structural mapping. Geo-technical evaluation of slope materials was done to perform the stability analysis. Remedial measures were suggested for the different sites on the basis of geo-technical evaluation (Fig. 15). Final report has been submitted to Border Roads Organisation.

Protection of Unstable Cut slopes along Approach Roads and Railway Lines and Stabilization of the Proposed Dumping Sites

Konkan Railway Corporation Limited has sponsored a study for protection of unstable cut slopes along the approach roads and railway lines and to stabilize the proposed dumping sites on Katra-Qazigund Section of Udhampur-Srinagar-Baramula Rail Link in Jammu and Kashmir. The objectives of the study included to design suitable remedial measures for stabilization of muck yards for dumping the construction waste from the tunnels (where dumping is already done), design of suitable methods for stabilization of muck yards (where dumping is proposed) and demonstration of the design implementation at two sites. In addition, guidelines for stabilization of the cut slopes along the approach roads and railway line are also to be prepared and submitted to sponsor for implementation.

Field investigations of three of the dumping yards have been carried out and the measures for their stabilisations have been designed for implementation. The dumping yard investigated is shown in Figs. 16, 17, 18 &19.

Fig. 16 A view of dumped material towards hill slope

Fig. 17 A view of dumped material towards road side

Fig.18 Geology of Lamber.

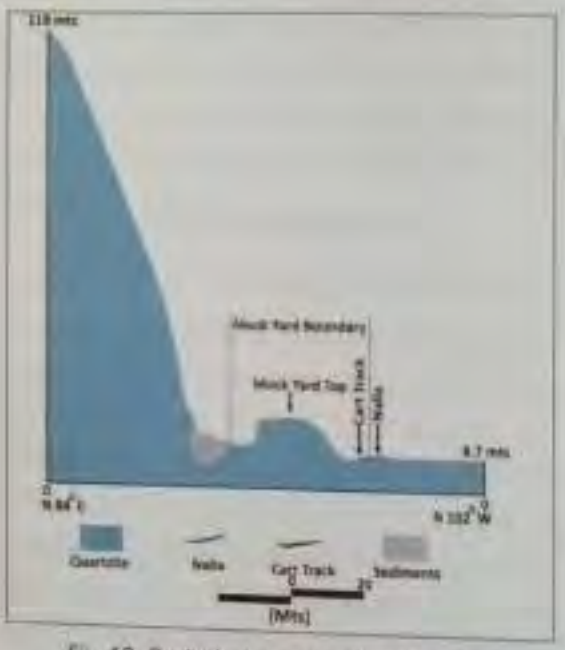


Fig. 19 Geological cross section of Lamber.

Design and Performance Monitoring of Test Road Constructed Using C&D Waste

CRRI had earlier carried out 'Feasibility Studies on Use of C&D Waste for Road Construction – as an Embankment Fill Material, in Base/ Sub-base layers, for Bituminous and Concrete Pavements' and had found this material to be useful for Base and Sub-base layers. Extending this laboratory work, test road construction of about 150 m length involving widening on both sides of existing road was taken up in

Fig. 20 Cement stabilisation of C&D waste for test road construction

Delhi. The project has been sponsored by IL&FS Ltd. The test road is presently under construction (Figs. 20, 21 & 22) and its performance would be recorded for evolving suitable guidelines for C&D waste usage in road works.

Fig. 21 Cement stabilised base course of C&D waste test road

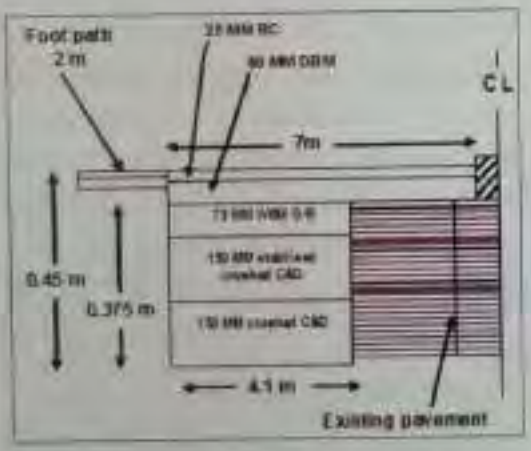


Fig. 22 Typical cross section of proposed C&D waste test road

Trials for Soil Compaction with Different Vibratory Rollers to Check their Compaction Efficacy

This study was entrusted to the Institute by JCB India Limited, Ballabhgarh, Haryana. JCB India Limited is one of the leading manufacturers of construction equipments in India, dealing in machines of various types including Soil Compactors, Tandem Vibratory Rollers etc. As a part of company's continuous efforts to provide their Customers, the best products & services, the company intended to carry out certain trials at one of its site near Pune (Maharashtra), for soil compaction with two different types of vibratory rollers to assess their efficiency in terms of compaction achieved. The soil samples were collected and characterized for their physical and engineering properties from the site where trials for compaction were proposed.

At site near Pune (JCB factory at Talegaon) the test bed were compacted at OMC/MDD with two different types of vibratory rollers. Field density tests after different passes of vibratory rollers were conducted on the trial stretches. The comparison of the efficiency of rollers in terms of degree of compaction achieved and communicated to the Client.

Design and Construction of Embankment and Pavement Layers using Copper Slag.

As reported earlier (Annual Report, 2008-09), this study has been sponsored by Sterilite Industries (I) Pvt. Ltd., Tuticorin (T.N) for the design and construction of experimental test track of one km length using copper slag stabilized with pond ash/soil. Construction of embankment and subgrade using copper slag + soil and copper slag + pond ash is carried out on four lane road of NH-45B, Madurai to Tuticorin expressway. During the construction, quality of construction of different layers of the embankment and subgrade is carried

out by evaluating different parameters viz. density, moisture, proper mixing, thickness of layers, side cover, slope of side cover etc. in the field. Plate load and dynamic cone penetrometer tests were also carried out at different locations on the constructed layers to determine the strength of pavement layers. Fig. 23 (a & b) shows the plate load test and dynamic cone penetrometer test in progress on constructed embankment. Modulus of soil reaction is determined from the result of Plate load test on copper slag + soil mix and copper slag + fly ash embankment. It is observed that modulus of soil reaction is more for copper slag + fly ash mix compare to copper slag + soil mix embankment. Further work is in progress.

(a)

(b)

Fig. 23 (a & b) Plate load and Dynamic cone penetration tests in progress

Feasibility study of Jarofix in the Construction of Embankment and Subgrade.

This project is sponsored by Hindustan Zinc Limited, Chanderia, Chittorgarh (Rajasthan) to study the potential of Jarofix as an embankment and subgrade material with or without stabilization (soil/bottom ash). Jarosite is a waste material produced during extraction of zinc from zinc ore concentrate by hydrometallurgy operations at Hindustan Zinc Ltd. The Jarosite is then mixed with 7 percent lime and 10 percent cement is termed as Jarofix. Fig. 24 shows the dumped Jarofix waste material nearby plant and Jarofix slope stabilised with grass. Detailed geotechnical investigation of Jarofix, soil and bottom ash is carried out. Also, the jarofix material was mixed with local soils and bottom ash in the range of 25 to 75 percent and their geotechnical characteristics were evaluated. Geotechnical parameters of jarofix, soil, jarofix:soil and Jarofix:bottom ash mixes are evaluated and compared with standard specifications of MORTH/MORD for the construction of embankment and subgrade. Geotechnical parameters of jarofix, soil and jarofix:soil mixes evaluated by the laboratory investigation is given in Table. II. The project is under progress.

Table II Geotechnical Properties of Jarofix, Soil and its Mixes with Standard Specification for Embankment

S. No.	Properties	Jarofix (100)	Jarofix:soil (75:25)	Jarofix:soil (50:50)	Jarofix:soil (25:75)	Soil (100)	MORTH	MORD
1	Maximum grain size (mm)	< 75 mm	< 75 mm	< 75 mm	< 75 mm	< 75 mm	< 75 mm < 2/3 of Compacted thickness	< 75 mm < 2/3 of Compacted thickness
2	LL (%)	59	47	39	35	34	< 70	< 70
3	PI (%)	16	17	18	18	18	< 45	< 45
4	Dry density (kN/m^3)	16	16	17.6	20	20	> 15.2 kN/m^3 upto 3 m height	> 14.4 kN/m^3 upto 3 m height
							> 16.0 kN/m^3 more than 3 m height	> 15.2 kN/m^3 more than 3 m height
5	FSI (%)	10	10 - 7	10 - 7	10 - 7	7	< 50	< 50
6	Remarks	Jarofix alone and mixed with soil may be tried for the construction of embankment						

Fig. 24 View of dumped Jarofix and slope stabilized with grass

Feasibility Study of Steel Slag Usage in Construction of Embankment and Pavement Layers

This project is sponsored by Goa State Pollution Control Board, Goa. The solid waste which is used in the study is generated as a by-product, during the melting process of mixed materials viz. steel scrap, sponge iron, pig iron, ferro-silicon, silico-manganese and Al-shots is termed as steel slag. Detailed laboratory investigation is carried out to investigate the feasibility of steel slag usage in the construction of embankment and pavement layers with or without stabilisation (local Goa soil). Laboratory investigation is carried out viz. grain size, Atterberg, FSI, Proctor density, Shear

strength test, CBR test, water absorption, AIV etc. It is observed that steel slag may be tried as an experimental basis in the construction of embankment, subgrade and replacement of aggregate in GSB layers. Fig. 25 shows the steel slag generated in the plant. Steel slag contains around 80 percent sand size particles. Laboratory investigation reveals that it has specific gravity of 2.75, Proctor compaction density – 23.5 kN/m^3, OMC – 8 percent, CBR – 70 percent and AIV – 40 percent.

Fig. 25 View of generated slag

Design of Approach Embankment to Signature Bridge across Yamuna River, Wazirabad

The Government of Delhi has entrusted construction of Signature Bridge and its approaches at Wazirabad across River Yamuna to Delhi Tourism & Transportation Development Corporation Ltd. (DTTDC). The eastern approach of this bridge comprises of an embankment of about 1.8 km length and flyover at Khajuri Khas intersection. During September 2008, flooding of the Yamuna basin occurred due to torrential rains. A part of the stretch in which embankment is to be constructed, was still submerged in water even in March 2009. Water stagnation was particularly severe in the stretch nearer to Khajuri Khas intersection (Bhajanpura side) with standing water of about 2 to 2.5 m above ground level. DTTDC approached CRRI to provide design and construction methodology for approach embankment to Signature bridge across Yamuna river, Wazirabad. Detailed field investigations including SCP tests at the proposed site to obtain sub-soil strength profile has been carried out (Fig. 26). Samples of proposed fill materials like pond ash, local soil and Yamuna sand were collected and were subjected to various tests to determine their physical and engineering properties. The stability analysis for the approach embankment to Wazirabad Bridge was carried out using the stability analysis software available in CRRI. The stability

Fig. 26 SCP test being carried out at Signature bridge approach embankment site

analysis showed that embankment side slope of 1V:2.5 H with a berm of 4 m width to be provided at a height of 4 m from ground level would be the most appropriate choice.

A novel construction methodology involving back-dumping of pond ash directly into water pond was also devised. DTTDC has now taken up construction of embankment in water pond area. The embankment under construction successfully withstood floods in Yamuna River in Sep 2009. Presently the construction work is under progress. Typical cross section of proposed embankment is shown in Fig. 27.

Fig. 27 Typical cross section of the embankment proposed for construction at Wazirabad

Construction and Quality Control of Approach Embankment to Signature Bridge across Yamuna River, Wazirabad using Fly ash

The Government of Delhi has entrusted construction of Signature bridge and its approaches at Wazirabad across river Yamuna to DTTDC. The eastern approaches mainly comprise of an approach embankment starting from Khazuri Khas intersection. DTTDC entrusted the work of quality assurance to CRRI. Random checks on the quality of works are being carried out. Advice and guidance regarding quality of works/ construction are also being provided to DTTDC Fig. 28 shows the Flyash embankment construction in water logged area.

Fig. 28 -Fly ash embankment construction in water logged area

Design of Road Embankment in Submerged/Flood Affected Border Areas of Bhuj, Gujarat

The National Buildings Construction Corporation Ltd (NBCC) has been entrusted with the responsibility of constructing 'Border Fencing and Border Roads' along a part of our country's International border in Gujarat. India's International border in Gujarat is situated in Rann of Kutch where Arabian Sea water transgresses and regresses frequently leaving inland marshy and swampy, dotted with small to very large salt water bodies. During the monsoon of 2006, unprecedented rainfall occurred in the border areas of Gujarat and Rajasthan. As a result, large areas were inundated and floodwaters overtopped the border road and border link road at many locations causing heavy damage to the pavement, shoulders and embankment slopes. Due to marshy conditions, it was not even possible to reach these locations to make an assessment of site conditions till now. However,

with drying up of stagnant water over last three years, NBCC requested CRRI to undertake field visits and suggest suitable construction methodology along with embankment design/ slope protection measures for the areas which were hitherto inaccessible. A view of border road to be constructed is shown in Fig. 29. CRRI team carried out extensive field work, recording the damages to embankment and road pavement, site conditions and after analysis of data, design of erosion control measures was carried out. The remedial measures broadly comprise of energy dissipation armour system of gabions and geotextiles to prevent loss of soil. Methodology for construction of border road embankment in a patch of the stretch which is still submerged in water was also devised.

Preparation of Guidelines for Construction of Roads, Culverts and Bridges in Cyclone Prone Areas

Cyclone affected areas of our country are mainly lying in the Gujarat, and all along the eastern coast from West Bengal to Tamilnadu. In the cyclone affected areas, torrential rains follow the occurrence of cyclones, which usually results in floods. Cyclonic winds, which causes high sea waves inundate coastal region deep into the main land. Therefore, constructions of civil engineering structures such as roads, culverts, and bridges, which already need safety precautions in the coastal areas due to the marshy nature of land, further require extra measures to avoid damages due to the

Fig. 29 A view of the border road to be constructed through water logged area

cyclones. At the instance of National Disaster Management Authority, this project was taken up to prepare guidelines for construction of roads, culverts, and bridges in cyclone prone areas, which would be useful for the cyclone prone areas of our country. Compilation of guidelines is under progress.

Investigation and Design of Roads in Visakhapatnam Port Trust, Visakhapatnam

The work of investigation of four roads which were failing prematurely due to movement of heavy and multi-axle loaded trucks and poor bearing capacity of sub soil was sponsored by Visakhapatnam Port Trust. In addition to above, investigations were also carried out on sites where new roads were proposed. In order to carry out the field investigations and to assess the causes of failure, a team of scientists visited the site.

During the field investigations, test pits were made in the existing roads and their conditions were observed. The soil and material samples of the different pavement layers were also collected for detailed laboratory investigations. The sub soil samples (both disturbed /undisturbed) were also collected for determining their geotechnical characteristics. In addition to the pavement investigations, information was also collected regarding the traffic and drainage condition on the road. Similar types of investigations were also carried out on the new proposed roads. Based on the consolidation characteristics of soft subsoil, the estimated total consolidation was calculated and in order to minimise the time of consolidation, some ground improvement methods Stone Column, Stage construction and Band drains were suggested. Ground improvement using vibro stone column technique (wet method) was proposed for the faster consolidation of sub soil and for increasing the bearing capacity of sub soil. Both the flexible and cement concrete pavements along with their design and construction methodologies were proposed for new sections as well as on the existing sections. Figs. 30, 31, 32 & 33. show typical road section, material usage, failure and remedial works at Visakhapatnam Port.

Fig. 30 Failed berth on the sea side

Fig. 31 Repair of failed section of in use two lane road by concrete blocks

Fig. 32 View of 3rd tippler approach of H2 drive House in OHC along East side of S1 conveyor

Fig. 33 Iron ore material on the surface H6 to SBC Road at OHC

Pavement Engineering and Materials

Flexible Pavements

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report 2009-10

Project Team Members of Flexible Pavements Division

Development of Polymer Modified Bitumen with Improved Compatibility using Non-biodegradable Waste

In this study, PVC pipe waste is used as a modifier for making Polymer Modified Bitumen. The main reason for using PVC is that after secondary recycling, the impermeable properties of PVC could not economically be achieved even by adding increased doses of additives, thus becoming a burden to the environment.

Shredded PVC pipe waste was activated and then blended with 80/100 bitumen to make two different blends with 3 and 5 percent PVC. Improvement in physical properties of blends was found in comparison with neat 80/100 bitumen. Better elastic, TSR, and stability properties were also found.

Development of an Advance Technology to Produce and Lay Down the Asphalt Mixes at Lower Temperatures than the Hot Mix Asphalt Process

This study has been undertaken with following objectives:

- Development of an additive to produce asphalt mix at lower temperature than hot mix asphalt (HMA).
- Study of the commercially available technology to produce warm mix asphalt (WMA).
- Performance testing of the binder and WMA mix and compare it with properties of HMA mix.
- To check the plant emissions, and comparison of fuel consumption for WMA and HMA.

Two types of commercially available materials (wax based and emulsion based) were studied for their physical and mechanical properties. A new material has been developed which can compact the mix at as low as 90°C. Marshall samples were prepared and mechanical properties like stability, TSR, retained stability were found. Performance tests are in progress.

Cold Mix Technology for Structural Layers of Flexible Pavement

Performance Monitoring of Test Sections of Structural Layers with Cold Mix Technology

The distress components viz., general appearance of binder, loss of aggregate, surface texture, cracking, surface evenness, raveling and stripping are most predominant and generally considered very important on bituminous road surface. The evaluation indicates a level of performance and reduction in performance points indicates the deterioration of service life of renewal treatment. The bituminous mixes were taken out from the test section in Rajasthan. The performance monitoring of test section on Dantaur – Khajuwala Road indicates good performance after two and half year (Figs. 34 & 35).

Fig. 34 Satisfactory performance of mix seal surfacing with emulsion on Dantaur- Khajuwala road after 2 years

Fig. 35 Satisfactory performance of SDBC with emulsion on Dantaur- Khajuwala road after 2 years

Development of Cold Mixed Patching Materials for Instant Repair of Potholes

CRRI has developed environment friendly and energy efficient emulsion based cold mix technologies for repair of patches and pot-holes even in inclement weather. The CRRI guidelines (revised) were prepared for Patch/potholes repair with cold mix technology and ready to use for construction agencies

Fig. 36 Determination of field density of soil

Consultancy Assignments

Investigation for Various Treatments to take care of Soil Settlement of Two Large Ditches and Design for 30 Meter Wide Road From NH-8 to Mehrauli - Mahipalpur Road

The consultancy was sponsored by Delhi Development Authority to improve the traffic flow between Mahipalpur to Airport / NH-8, Industrial Areas of Gurgaon and Jaipur, the tourist capital of Rajasthan. The investigation of proposed road alignment was carried out by different tests on soils (Fig. 36), it is proposed to construct a road from Mahipalpur to NH-8 with recommendations for soil filling and pavement crust thickness.

Investigations for the Design of Bituminous Overlays on NDMC Service Roads

In cities, there have been large scale damage of the existing service roads due to (a) cross cuttings at frequent intervals for service lines (b) longitudinal cuttings for repair of service lines (c) digging of the roads for various other purposes, and (d) being last priority on the maintenance programs. The consequent damage to pavements is thus enormous. Due to this, the maintenance and rehabilitation of urban roads need special attention. Apart from these problems associated with construction and maintenance of roads, the existing road network is facing an accelerated damage threat due to poor drainage including manmade drainage problems.

The New Delhi Municipal Council(NDMC) has got several service roads/lanes within its jurisdiction, mainly falling in the VIP area of Delhi. These roads had been in dire requirement of rehabilitation, since no major improvement was carried out for quite some time, as was learnt (Figs. 37 & 38). The Executive Engineer (R-IV), NDMC had requested CRRI to provide expert technical recommendations for the

rehabilitation of the twenty four number service roads/lanes from three sub-divisions. The general condition of service roads is given in Table III.

The scope of the study included:

a) Field investigations

- General condition assessment by visual survey
- Structural evaluation of pavement
- Extraction of material samples including bituminous mixes.

b) Laboratory investigations by studying engineering properties of pavement materials and mix.

c) A comprehensive analysis and recommendations for remedial actions.

Fig. 37 A close up view of distressed surface

Fig. 38 A general view of service road in JJ environment

The field investigation work was undertaken with a view to assess the quality of pavement layers and to carryout structural evaluation of the pavement, so that suitable recommendations for improvement may be suggested. The following field studies were undertaken to assess the condition in detail.

- Visual Surface Condition assessment
- Benkelman Beam deflection measurements
- Test pit observations (Fig. 39)
- Extraction of pavement material samples including bituminous layers

The comprehensive report made available to NDMC provided details of field investigations and the data on evaluation of pavement materials in the laboratory. The report also gave the recommendations for provision of needed rehabilitation treatments to improve the condition of the road.

Table III General Condition of Study Roads (Service Roads/Lanes) in NDMC Area

Sl. No.	Sub-Dvn.	Road Name	General Condition (By visual observation)			
			Pavement Surface	Longitudinal Drainage	Cross Drainage, Surface (Camber)	Terrain
1		Rizal Marg	Fair to Good	Poor	Poor	Plain
2		Artigas Marg	Good	Poor	Poor	Plain
3		Cross Road, 1 to 5(CG Marg)	Fair	Poor	Poor	Plain
4		SS Road of Primus Hospital	Fair (Partly Fresh)	Poor	Poor	Plain
5	I	Back lane of OMAN Embassy	Fair to Poor	Poor	Poor	Plain
6		SS Road of UAE Embassy	Fair	Poor	Poor	Plain
7		SS Road of Austria Embassy	Fair	Poor	Poor	Plain
8		Back SS Road of A,B,C,D,E,F,X&Y	Fair to Poor	Poor	Poor	Plain
9		Side lane of Kautilya Marg	Poor	Poor	Poor	Plain
10		Side Lane of Chattisgarh Bhavan	Poor, undulating	Poor	Poor	Plain
11		Kanventor Lane	Fair	Poor	Poor	Plain
12		Back Lane of Anchal School	Fair	Poor	Poor	Plain
13		Parallel Road of S.P.Marg	Fair to Poor	Poor	Poor	Plain
14	II	Krishna Menon Lane 1&2	Fair to Poor	Poor	Poor	Plain
15		K.Kamaraj Lane	Fair to Poor	Poor	Poor	Plain
16		Tyagaraj Lane 1&2	Fair to Poor	Poor	Poor	Plain
17		Kaushik Lane 1,2&3	Very Poor	Poor	Poor	Plain
18		Teen Murti Lane 1,2,3 &4	Poor	Poor	Poor	Plain
19	III	Service Road behind Sanjay Camp	Fair to Poor	Poor	Poor	Plain
20		Lane in front of Thai Embassy	Good (Fresh)	Poor	Poor	Plain
21		Service Road.Singapore Embassy	Fair	Poor	Poor	Plain
22		Service Road.Admiral Hellary Marg	Fair	Poor	Poor	Plain
23		Service Road around Rose Garden	Poor	Poor	Poor	Plain
24		Parking at Ashoka Hotel	Fair to Poor	Poor	Poor	Plain

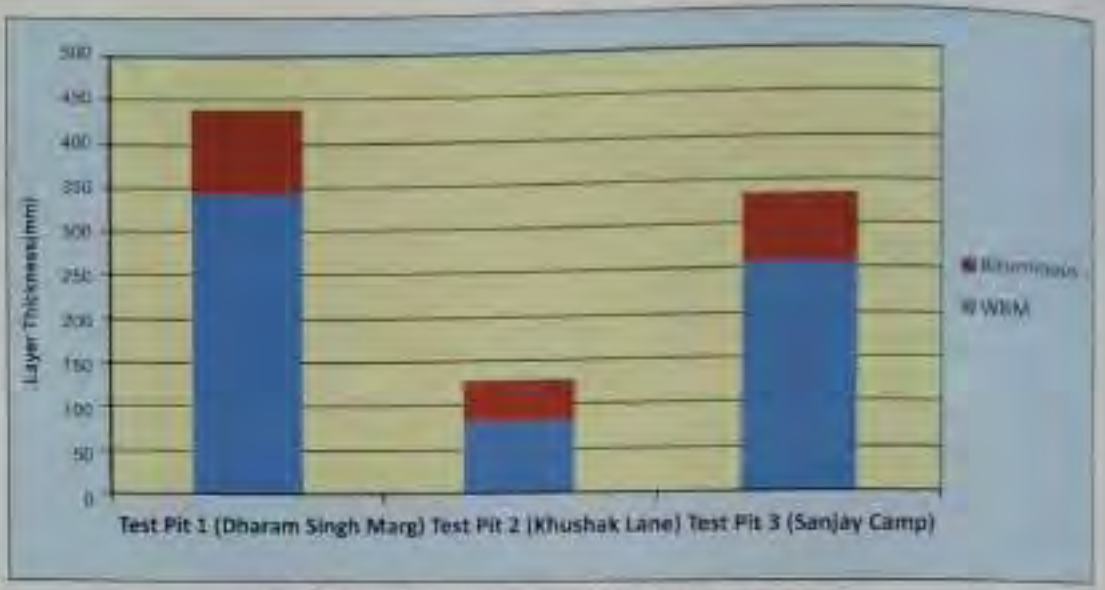


Fig. 39 Layer thicknesses measured from test pit observations

Investigations for the Causes of Pavement Failure at Truck Parking Area of IMT(Sector-3),Manesar

The Haryana State Industrial & Infrastructural Development Corporation (HSIIDC) has recently got constructed a parking bay at IMT, Sector-3, Manesar in Haryana. However, with the flexible pavement constructed as per MoRT&H's 'Specifications for Road and Bridge Works' experiencing very early failure, just within 2 month's of operational activities. At the request of the Additional General Manager (IA) of HSIIDC, IMT, Manesar investigation has been taken with the following objectives.

- To evaluate the existing pre-maturely failed flexible pavement of the parking bay for the general condition and structural condition in order to assess the deficiencies
- To ascertain the causes of pre-mature failure of the flexible pavement as contributed by constituent layers.

The existing condition of pavement at the parking bay is shown in Fig. 40.

To assess the quality of pavement layers and to carryout structural evaluation of the pavement, the following field studies were undertaken.

- Visual Surface Condition Assessment
- Benkelman Beam deflection measurements
- Test pit observations
- Extraction of pavement material samples including bituminous layers

Laboratory evaluation of the materials collected from field aimed at evaluating them for their compliance with the required properties for a good performance. Various pavement materials viz., subgrade soil, granular sub-base(GSB), wet mix macadam(WMM) base, bituminous macadam(BM) binder course and semi-dense bituminous concrete(SDBC) wearing course were subjected for detailed laboratory investigations

Fig. 40 A view of existing condition of pavement at the parking bay of IMT (Sector 3), Manesar

like strength properties and performance indicators. The salient findings emerged based on field & laboratory investigations are as under.

- The subgarde soil was found to be predominantly sandy, but had been found considerably under compacted. This was expected to result in an inadequate support at the bottom most stratum of the pavement structure.
- The gradation of GSB was on finer side than specified, thereby defeating the very purpose of providing it as a drainage layer. Also, the field compaction was considerably insufficient rendering it to be weaker than expected.
- The gradation of WMM was on finer side than specified. This makes it unsuitable for the base material. Also, the field compaction was significantly inadequate, hence making it vulnerable for a load associated failure.
- The material in BM and SDBC seemed to have got not much attention. This

was evident from the lessar thicknesses of the layers, coarser gradation of the mix, insufficient binder content and poor quality of workmanship.

- The overall quality of the materials used in the construction and the execution of work had been inferior making the pavement weak and non-functional.
- Since all the component layers have inherent weaknesses/deficiencies, the pavement structure was unable to withstand the deteriorating effects of loads and climate. Thus, it was emphasised that the present condition of pavement was due to the combined effect of many factors.

Since the parking area was severely distressed at many locations, the entire area was considered to be in very poor condition, which needs immediate attention. Keeping in view the surface condition of the existing pavement, traffic loads and damaging factors, following corrective measures were suggested:

Alternative A:

It was recommended that the existing bituminous layers shall be rolled. Fresh Dense Bituminous Macadam(DBM) layers to a total of 150 mm (two layers of 75 mm each) followed by Bituminous Concrete(BC) of 40 mm thickness shall then be laid on the entire parking area. This shall then be covered with 25mm thick Mastic Asphalt, with all the specifications for all the treatments complying with MoRT&H requirements.

Alternative B:

As an other alternative, Pavement Quality Concrete (Cement Concrete Pavement) could be constructed over the existing pavement structure with a proper base for which the required design needed to be got done.

Investigations for the Flexible Overlay Design of DSC Road from Kulesra to Surajpur, Greater Noida

The Greater Noida Industrial Development Authority (GNIDA) has been developing and maintaining road network within its jurisdiction. Dadri-Surajpur-Challera (DSC) road is one of the major and important link in the road network which caters to heavy commercial traffic by virtue of its location. Kulesra -Surajpur section of the DSC road has developed distress over time and the serviceability is affected (Fig. 41). The Officer on Special Duty (Projects) of GNIDA, Greater Noida had requested CRRI to design the structural requirement for Kulesra-Surajpur road section of the DSC road.

The Objectives and Scope of the study are:

- To evaluate the existing distressed flexible pavement of the road section both the general condition and structural condition in order to assess the deficiencies.
- To ascertain the needed strengthening and corrective measures of the existing flexible pavement.

Field investigations and laboratory evaluation were carried out. The Kulsera-Surajpur section of DSC road was examined by engineering evaluation criteria for their present condition and the maintenance needs. It was apparent from the field observations and laboratory evaluations

Fig. 41 Existing condition of pavement at the DSC road from Kulesra to Surajpur

that the road section is in immediate need of Maintenance & Rehabilitation (M&R) attention. The requirements were worked out on the basis of visual/ structural/significance basis for all the road section.

The structural evaluation was carried out by rebound deflection measurement using Benkelman Beam on possible available segments of the road section. The corrected characteristic deflection, existing pavement layer details and the field conditions were used in arriving at the needed structural improvement measures.

Also, the extracted bituminous cores were utilised for laboratory evaluation for the constituent properties and to examine any inherent distress like cracks, if any, at different locations.

Based on the field, laboratory and other data/ information like traffic intensity and loading, the required strengthening and rehabilitation measures were worked out. Following recommendations were made.

- A bituminous overlay consisting of 110 mm Dense Bituminous Macadam (DBM) in two layers of say 60mm and 50 mm thickness and 40 mm Dense Bituminous Concrete(DBC) for mid-block sections.
- 'Mastic Asphalt' for the portions at intersections, entry/exit points and surface over Pulesra bridge.
- Repairing of the existing surface before implementing the overlay, by filling cracks, potholes and undulations wherever necessary and later on by a profile corrective course with Bituminous Macadam (BM) to even out the existing surface and to bring to proper camber.

- Clearing of the vegetation and mud on earthen shoulders and improvement of drainage.
- Avoiding the 'water on pavement' at various locations, especially near Suragur.
- Stringent quality control and supervision measures for the execution of all the works.

Laboratory Evaluation and Field observations on Patch Repair Mix

Maintenance of roads form an integral part of the infrastructure requirements. The technologies currently adopted in India are in-situ patching mixes using either hot mix or cold mix technologies. The main hurdle faced by use of site patching mixes is that the mixing is generally left to unskilled labour with no control over grading or binder content. Adoption of these technologies leads to premature failure of potholes and ultimately causes failure of the road sections. The use of readymade mixes for pot hole repair materials have been in vogue, for last many years all over the world. These materials have not found much popularity from application point of view in India due to high cost. Cold mix pot holes repair materials are widely used globally since these alleviate many problems associated with the conventional methods such as requirement of high temperature for production of mix, and its laying and compaction process which are complex, time consuming and inconvenient to the road authorities. There are a variety of cold mix pot holes repair materials available in India. One of such commercially available material was studied in laboratory and for field observations with the following objectives:

i) Determination of binder content, gradation of washed aggregates and Marshall stability

ii) Repair of patches and pot holes with Cold Mix material on MCD and PWD roads, at some locations in Delhi and

iii) Periodic observations (surface distress and settlement) of repaired pot holes at different intervals for a period of about one year

Volatile content is about 0.12 percent. Bitumen content in pot hole repair mix was estimated by cold extraction process, using Trichloroethylene as a solvent. This material contains bitumen 5.56 to 5.9 percent by weight of the mix. Sieve analysis was conducted on washed aggregates as per the test procedure specified in IS: 2386 (Part - 1). The grading of washed aggregate, after binder extraction, is also indicated in Table IV.

Table IV Gradation of Washed Aggregate and Binder Content of Pot hole Repair Mix

Sieve Size (mm)	% Passing by Weight	
10.0	100	100
4.75	85	87
2.36	30	31
0.075	13	18
Binder Content by Weight of Mix, %	5.56	5.90

Application of Commercialy Available Patching Mix in the Field and its Performance Evaluation

Repair to three potholes, using cold patching mix was done at on three different roads with varying traffic and its severity, in Delhi.

The efficacy of patching mix in the field was investigated through limited field trials, particularly under heavy and medium traffic conditions. The field studies conducted were limited to three different locations in Delhi (PWD & MCD roads, and IIT campus road). Three roads identified for field observations are (i) Road from NH-2 to Escort Hospital, adjacent to Modi Mill Flyover near Mathura Road, (ii) Road from NH-2 to Sukhdev Vihar and (iii) Internal road near New Campus, IIT. Field trials were conducted by applying patching mix in potholes on above stated locations. Potholes and ravelled/ worn out surface indicated distressed condition of roads at these locations, before applying pot hole repair material (Fig. 42). The patch was leveled and brought to shape and then the mix was compacted with conventional rammer (Fig. 43). A typical view of finished pot hole after its repair at Sukhdev Vihar road is shown in Fig. 44. The repaired/affected area was then opened to traffic immediately. Periodic performance of commercially available patch repair mix filled in potholes was carried by visual observations only. Performance is indicated in Figs. 45 & 46.

Fig. 42 Preparation of pot hole area in rectangular shape at Sukhdev Vihar road

Fig. 43 A view of pot hole repair process (Compaction with Conventional Rammer) at Sukhdev Vihar road

Fig. 44 A typical view of finished pot hole after its repair at Sukhdev Vihar road

Fig. 45 Condition of repaired pot hole after two months at Sukhdev Vihar

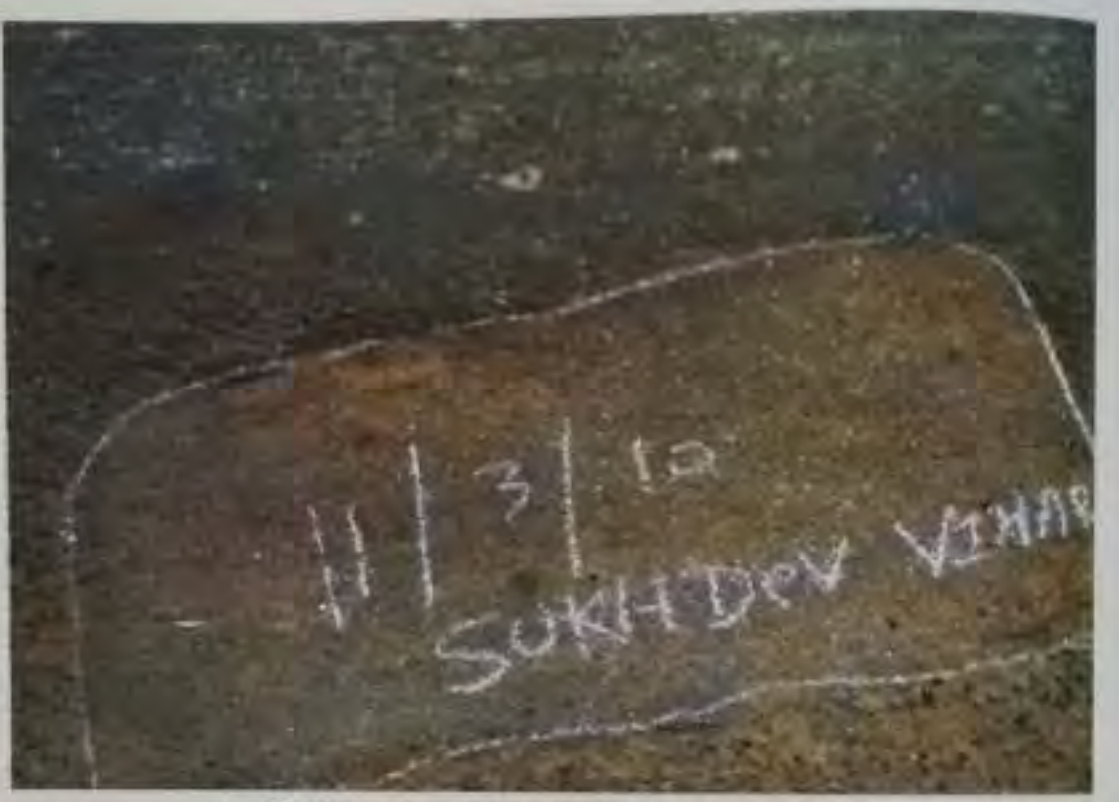


Fig. 46: Condition of repaired pot hole after six months, Sukhdev Vihar

Further field observations indicated good adhesion of patch mix and no sign of cracking, stripping and raveling due to traffic movements

Commissioning of Accelerated Pavement Testing Facility

The Institute has procured a 'Heavy Vehicle Simulator', an on-site version of 'Accelerated Pavement Testing Facility'. The South-African built facility was received and commissioned within the premises of the Institute Fig. 47.

Accelerated Pavement Testing involves the controlled application of a prototype wheel loading, at or above the appropriate legal load limit to a prototype or actual, layered, structural pavement system to determine pavement response and performance under a controlled, accelerated accumulation of damage in a compressed time period

Objectives of Creating APT Facility:

- Establishment of Centralised National Accelerated Pavement Testing Facility (APTF)
- To generate data similar to Long Term Pavement Performance (LTPP) Studies and to develop pavement deterioration models for flexible and rigid pavements (for typical pavement structures)

Advantages of APTF

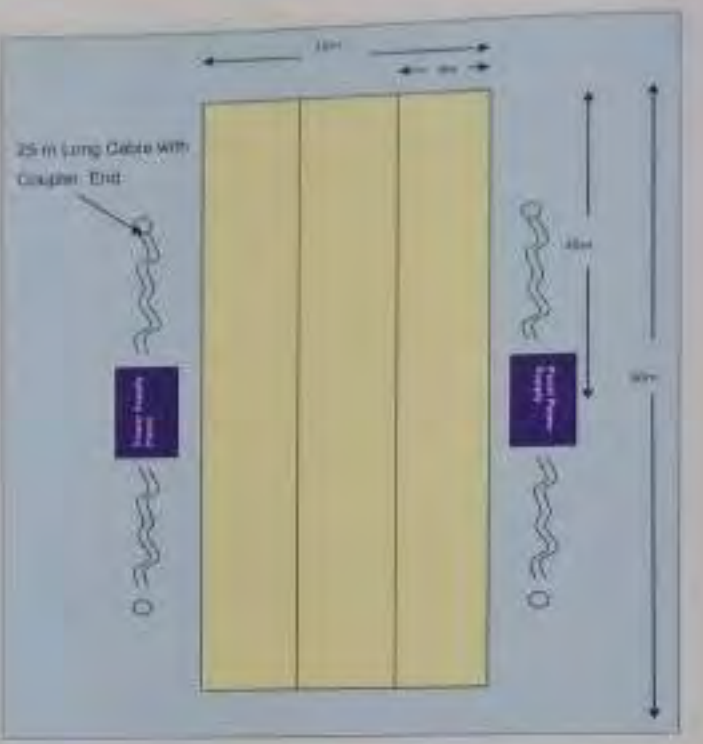
- Advance information on pavement performance
- Evaluation of New designs, specifications, mixes and materials
- Studies for anticipated traffic conditions

Fig. 47 Accelerated pavement testing facility

- Greater control over uniformity and quality of construction because of small size of test sections
- Control over environmental factors such as pavement temperature and subgrade moisture
- Simulated field conditions
- Economical and ready to use technical solutions
- Substantial savings with improvements in pavement design procedures and maintenance practices
- Well targeted pavement research programme
- Knowledge gained from APTF affects decision of road authorities
- Determination of magnitude and timing of asset establishment and preservation costs

Major Priority Areas of Research for India

Performance	Various Pavement Specifications
Impact	Heavy vehicles on pavements (axle load, tyre type and pressure)
Evaluation	Non-standard materials
Processes	In-situ stabilisation, emulsions, by-products, recycled materials, reflection crack retarders etc.
Maintenance	Efficacy of treatments, intervention strategies
Low volume roads	Surface treatments
Construction	Quality, effect of mechanization



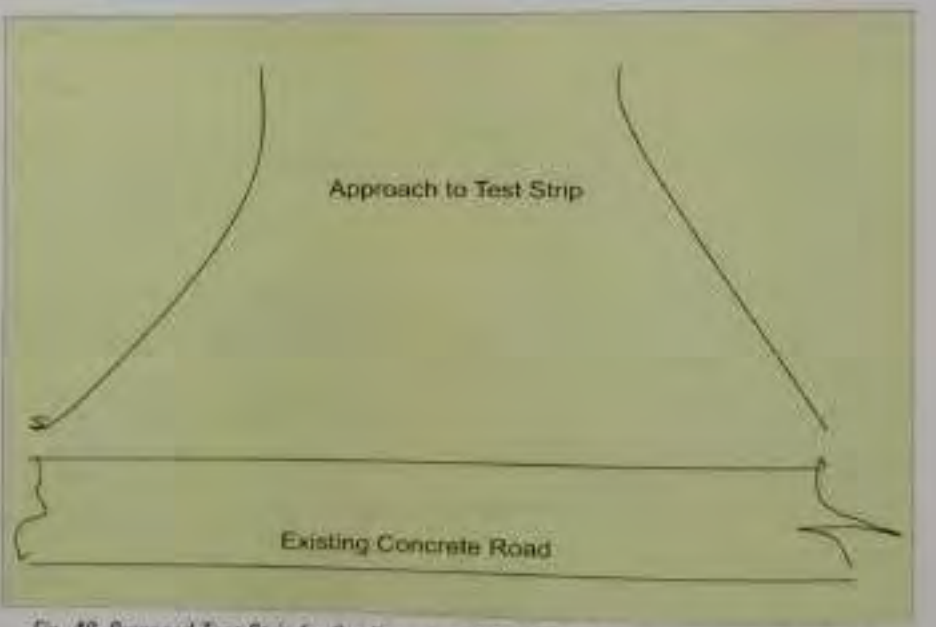


Fig. 48 Proposed Test Strip for Studies using HVS (APTF) (Schematic only, Not to Scale)

Proposed Immediate Study :

- Construction of a Test Strip within CRRI (Fig. 48)
- Specifications conforming to MoRT&H
- Verify the 'Design Life' as envisaged
- Attempt to rationalise IRC design method

Pavement Engineering and Materials

Rigid Pavements

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report
2009-10

PROJECT TEAM MEMBERS OF RIGID PAVEMENTS DIVISION

A Study on Dry Lean Concrete containing Portland Pozzolana Cement

Dry Lean Concrete (DLC) is an important part of modern rigid pavement. It is a plain concrete with a large ratio of aggregate to cement than conventional concrete and generally used as a base/sub base of rigid pavement. The compaction of DLC is done under 10 to 12T vibratory roller in field. Further DLC is mostly made with Ordinary Portland Cement. However, IRC:SP49 advocates use of Portland Pozzolana cement(PPC) in DLC but does not mentioned about the amount of PPC, its curing period etc. Therefore, the study focuses on the determination of optimum mix proportions, amount of Portland pozzolana cement, optimum moisture content for achieving maximum dry density, and optimum curing period for DLC with PPC meeting the strength requirements of IRC:SP 49. Fig. 49 shows the compaction of DLC in the laboratory.

Fig. 49 DLC being compacted with the help of Jack Hammer

Carbon Dioxide Sequestration in Cementitious Products

It is now generally accepted that the global warming is caused by an increase in the concentration of green house gases (GHGs) in the Earth's atmosphere from human activities. Carbon dioxide gas is the principal greenhouse gas. It exists in gaseous form in the Earth's atmosphere at a standard temperature and pressure. The major human activities which contribute to the emission of the CO_2 gas in the Earth's atmosphere include combustion of fossil fuels and deforestation. The increasing concentration of carbon dioxide gas in the Earth's atmosphere has raised concerns about global warming, climate change and their subsequent effects on its inhabitants.

Therefore, scientists, engineers, researchers, environmentalist, geologists and others along with carbon dioxide contributing industries are making tireless effort to develop efficient and viable technologies in their respective areas that could help in reducing carbon dioxide concentration in the atmosphere. From an environmental prospective, concrete construction industry is a very large consumer of natural resources and is also one of the biggest generator of large amount of waste. Each of the primary ingredients of concrete i.e. cement, aggregate, and water has some adverse environmental impacts. Cement industry contributes approximately 6 per cent of total anthropogenic CO_2 emission. Since global warming has emerged as the most serious issue of the recent time, therefore there is an urgent need that the carbon dioxide contributing industries must develop technologies that could help in reducing carbon dioxide concentration in the atmosphere. The major environmental issue associated with the concrete construction industry is the CO_2 emissions from the production of portland cement. The study is focused on CO_2 sequestration in cement based materials such as concrete and controlled low strength material (CLSM) (Figs. 50 & 51)

Fig. 50 Concrete test cylinder showing carbonation depth

Fig. 51 CLSM specimen showing carbonation depth

The major benefits of the study include safe and easy method for permanent carbon dioxide sequestration by mineralization; sustainable by-products management including ash utilization; increasing productivity of pre-cast industry and earning of carbon credit.

Foundry Silica Dust in Manufacture of Economical Self-Consolidating Concrete

Self-consolidating concrete (SCC) or self-compacting concrete is an advanced step towards development of a sustainable concrete. Sustainable properties of concrete are also enhanced with the adoption of SCC.

Self-consolidating concrete provides benefits beyond conventional concrete in all three aspects of sustainable development (economical, sociological and environmental). Enhanced durability of the in-situ concrete is the most important benefit of using SCC. Further, it provides opportunity to use one or more industrial by-product materials such as fly ash, foundry baghouse dust, granulated blast furnace slag, limestone quarry fines and other similar by-product materials in its manufacturing.

The use of large amount of by-product materials as powder or fines not only avoids the requirement of landfills but also reduce the environmental pollution. SCC is considered more environmental friendly than conventional concrete. The study concludes that used foundry sand can be used to replace 35 per cent of regular concrete sand for structural concrete.

R & D Studies on Performance Evaluation of Rigid Pavements on High Density Traffic Corridors using Instrumentation supported by Laboratory Tests

As reported earlier, the study has been sponsored by Ministry of Road Transport and Highways, Govt. of India with the objective to validate and verify the actual relationships between various design parameters assumed in theoretical design and those actually observed under the rigid pavements. The results of the study are to be used for the actual design consideration and incorporating modifications in the design methodology to be used in future.

Under this research scheme, response of concrete pavement slabs to environmental and traffic loadings has been captured through instrumentation at Allahabad by-pass on NH-2; Kota, Rajasthan, on NH-76 and Siliguri, West Bengal, on NH-3. The sensors, embedded into the concrete pavement slabs during construction, included Vibrating Wire (VW) type temperature sensors and strain gages, VW joint meters, and resistance type dynamic strain gages. VW temperature sensors measured temperature within the concrete slabs at various depths. VW strain gages measured the strain induced at different depths due to the temperature. Joint meters installed at transverse joints measured the amount of movement due to expansion and contraction at joints. Resistance type strain gages measured the strains induced within the concrete due to vehicle axle loads under dynamic conditions.

Tests were conducted under road traffic to measure the strains induced at non-tied and tied edges at different speed of trucks with different axle loads. The data from all the sites have being collected and is being analyzed. Fig. 52 shows the truck wheels passing over the non-tied edge of the instrumented slab. Fig. 53 shows the tyre pressure being measured during the tests.

Fig. 52 Wheels passing over non tied edge

Fig.53 Tyre pressure measurement during tests

Consultancy Assignments

Evaluation of Suitability of Oil Well Drill Cuttings for Road Making

Oil & Natural Gas Commission Ltd. (ONGC) is the premier E & P organisation of the country. For exploration of the oil reserves hundred of wells are drilled every year. The drilling operation is carried out with the help of a Drilling Rig (Fig. 54). Different sizes of drill cuttings are seperated by the shale shaker, de-sander & de-silter. The process of drilling oil and gas wells generates large volumes of drill cuttings and spent muds. The disposal of drill cuttings in environmental friendly manner is an area of concern. Oil & Natural Gas Corporation Limited approached Central Road Research Institute to evaluate the utility of drill cuttings in road making.

Fig. 54 A typical rig in operation

The scope of work includes collection of representative samples of the oil well drill cutting to evaluate their possible utilization in

different layers of the road construction. Work on the characterization of samples collected from different depths of the oil well is in progress.

Investigation of Cracked Pavement Quality Concrete Slabs in Fatehpur to Kokhraj Section of NH-2 (km 100 to 158)

The rigid pavement on Allahabad by-pass from km 100 to 158 (Fatehpur –Kokhraj section) of NH-2 was constructed in 2004. With passage of time cracks were developed on the pavement. The National Highways Authority of India requested the Institute to ascertain the causes of the distresses developed and to suggest the remedial measures for their rectification.

To investigate the severity, causes and quantum of damaged concrete panels, condition assessment and crack mapping of the entire road length i.e from the km 100 to 158 were carried out. The various distresses observed were the longitudinal & transverse cracks, corner breaks, pop-outs, joint sealant damage & loss of surface texture etc (Figs. 55 & 56). The main distresses observed are the longitudinal cracks developed in the outer lane of the road. (Fig. 57). The causes for the cracks are the late sawing of the longitudinal joint, inadequate joint width and drying shrinkage. Hardening and loss of joint sealant and intrusion of incompressible materials in the joints are adding to the problem. Further work is in progress.

Fig. 55 Longitudinal crack

Fig. 56 Corner break crack

Fig.57 Full depth longitudinal crack

Design of Rigid Pavement at Loni Road from Wazirabad to U.P. Border

The study was sponsored by Municipal Corporation of Delhi for providing design of rigid pavement over existing distressed bituminous road at Loni Road from Wazirabad to U.P. Border for the solution of water logging on this road stretch during monsoon and to meet the increased heavy traffic on the road (Fig. 58). This road has also to be widened wherever possible. The concrete pavement was designed. A shoulder of concrete paver blocks of varying width between 0.5 and 1.0 m has to be provided to take care of the utilities services provided along the road. A typical cross section of proposed road is shown in Fig. 59.

Fig. 58 A view of existing road

Review of Designs of Concrete Pavements for Vilayat Industrial Estate, Bharuch, Savli Industrial Estate, Baroda and Atali Housing Estate, Dahej, Gujarat

The assignment was referred by Gujarat Industrial Development Corporation (GIDC), Gujarat with the objective to study the field conditions for the construction of concrete road and to review the designs of concrete pavement for all three locations for the required modifications, if any.

The design consultant of GIDC had suggested 250 to 280 mm thick Pavement Quality Concrete (PQC) over 125 to 150 mm thick Dry Lean Concrete (DLC) with temperature reinforcement in the form of 8 mm dia TMT bars spaced at 300 mm centre to centre both ways (A view of the DLC laid over the road in shown in Fig. 60). During the construction of concrete roads with slip form paver, the difficulty was faced due to the presence of reinforcement, as the compaction of concrete with in-built vibrators of the paver was difficult to achieve. Therefore, GIDC requested CRRI for reviewing the design of concrete pavement for 500 commercial vehicle per day (CVPD) and maximum single axle load of 20 T with

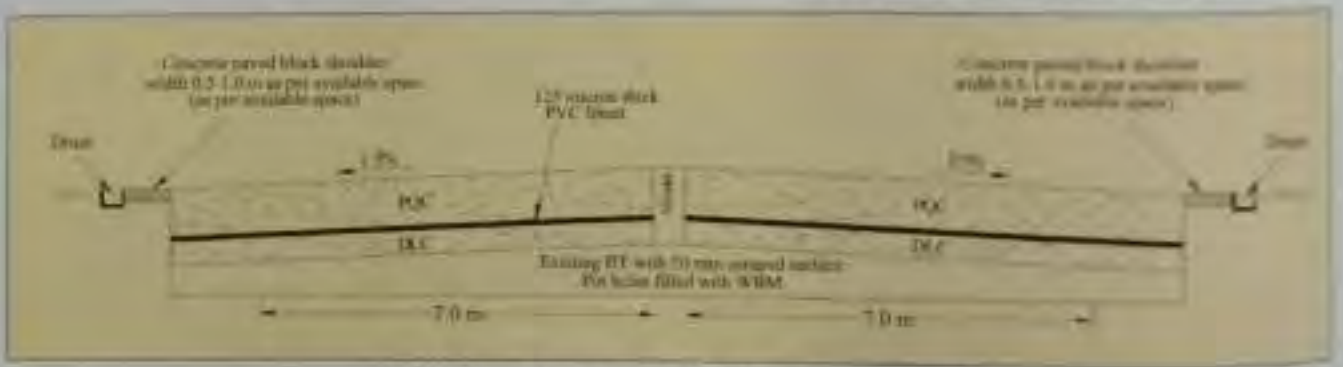


Fig. 59 A typical cross section of the designed concrete road

the possibility of omitting the temperature reinforcement.

The suggested designs for the Jointed Plain Concrete Pavements without any temperature reinforcement included 250 to 280 mm thick Pavement Quality Concrete, 125 to 150 mm thick Dry Lean Concrete Sub base, 125 micron thick Polythene Sheet as separation layer, 100 to 200 mm thick granular sub base cum drainage layer for all three locations.

Fig. 60 A view of the DLC laid over the road in Vilayat Industrial Estate

Evaluation of Fly Ash and Development of High Volume Fly Ash Concrete Mixes for the Construction of Concrete Road from Dadri to Dehra Jhal

The project was sponsored by National Thermal Power Corporation Limited, Dadri, U. P. the Scope of work involved evaluation of fly ash used in the concrete, development of suitable fly ash admixed concrete mixes, on-site demonstration and training of staff about construction methodology for fly ash based concrete road, random quality checking of materials, concrete mixes and laboratory testing of concrete samples prepared at site.

The work involved the construction of approximately 14 km long concrete pavement from Dadri to Dehra Jhal via NTPC Plant over existing bituminous pavement. The designed thickness of the roads is 28 cm to be provided over 10 cm thick dry lean concrete sub base. The designed 28 days flexural strength of the pavement quality concrete is 4.5 MPa. A concrete mix containing 371.25 kg/m^3 of Ordinary Portland Cement and 98.84 kg/m^3 of fly ash was suggested. On-site training, demonstration and instructions were given to the staff for carrying out the quality construction of concrete roads. The construction was carried out by adopting semi-mechanized methodology using needle and screed vibrators. Fig. 61 shows the laying of Pavement Quality Concrete (PQC) with screed vibrators and Fig. 62 shows a view of the constructed portion of the road.

Fig. 61 PQC laying with Screed Vibrator

Fig. 62 A view of the constructed road

Design of Cement Concrete Pavement on Dadri-Sultanpur-Chellra (DSC) Road at Bhangel Village, Noida, U.P

At the request of Noida Authority, the Institute undertook the design of cement concrete road on DSC road in the reach of Bhangel village of Noida. The existing bituminous pavement was worn out and damaged at many places due to mainly poor drainage condition. The stagnation of water on the Bhangel village road is highly deplorable. In order to avoid further damage, Noida Authority decided to make cement concrete road on this stretch for permanent solution. Based on the traffic census and axle load survey, profile correction course using BM and 60mm DBM on existing road was done (Fig. 63). The site condition, traffic data, soil properties and design parameters were also studied for the design of cement concrete pavement. The designed thickness of the cement concrete pavement was 28 cm over the existing profile correction course.

Design of Concrete Pavement for Strengthening and Restoration of MGR Road from Sirsoti to Ganyari, Sonebhadra, (U.P.)

National Thermal Power Corporation Ltd. (NTPC), requested the Institute for providing designs, drawings and technical specifications for strengthening and restoration of MGR road

Fig. 63 A view of existing flexible pavement with profile correction course

connecting village Sirsoti to Ganyari (Waidhan), Sonebhadra, U.P. The existing bituminous pavement has badly deteriorated at several places on account of poor drainage condition (Fig. 64). The traffic on the approach road is likely to increase further due to expansion of the plant, transportation of heavy power plant equipments and fly ash from the plant. To cater for badly deteriorated pavement and increased traffic density, NTPC has desired to strengthen the existing roads by providing concrete overlay. Soil samples were collected from the pit to find out the CBR and moisture content in laboratory. Concrete pavement was designed for 4.5 MPa flexural strength of concrete. The design suggested for concrete pavement included 28 cm thick Pavement Quality concrete (PQC) over 10 cm thick Dry Lean Concrete (DLC).

Design of Rigid Pavement for 2nd Entry Road to Nizamuddin Railway Station

The 2nd Entry Road to Nizamuddin Railway Station is a bituminous road and damaged severally at various places (Fig. 65). Repair and overlay work was done in the past but not found satisfactory. As a permanent solution, Public Works Department, Delhi has decided to convert it to a cement concrete road. The topological survey, soil condition, existing crust thickness and water logging situations were studied and the design of road pavement was given to the sponsorer.

Fig. 64 A view of existing worn out surface at MGR road from Sirsoti to Ganyari Village

Fig. 65 A view of the 2nd entry road to Nizamuddin railway station

Pavement Engineering and Materials

Pavement Evaluation

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report 2009-10

PROJECT TEAM MEMBERS OF PAVEMENT EVALUATION DIVISION

Development of Management System for Maintenance Planning and Budgeting of High Speed Road Corridors - Supra Institutional Project

The overall objective of the study is to develop management system towards making logical decisions about the budget requirements and allocation of funds thereof for maintenance of pavements and bridges, based on optimal life cycle costs. Flexible as well as Rigid Pavements and Bridges involving network of high speed road corridors are included within the scope of this study. The system proposed to be developed will enable engineers and decision/policy makers to pre-conceive funds requirement for maintenance of road network in order to bring them to a desired level of serviceability. The system developed will assist in minimizing wasteful losses occurring every year on account of poorly maintained roads. It will also provide powerful tool to the road authorities in allocating maintenance funds judiciously and in prioritizing the maintenance treatments in view of limited resources. During the year following work has been completed under different aspects.

Pavement Related Aspects

- State of the Art Report on pavement maintenance management system prepared
- Identification of test sections completed.
- Formulation of methodology for field studies completed.
- Data management and information system architecture completed.
- Performance observations on test sections to be commenced shortly.

Landslide Related Aspects

- A total of 16 landslide prone locations identified on Mumbai-Pune Expressway
- Fieldwork completed at four locations
- Remedial measures suggested for three locations and analysis for 4th location is currently in progress
- Fieldwork for remaining twelve locations is currently in progress

Road User Cost Related Aspects

- Fieldwork for Chennai & Kolkata cities completed
- Fieldwork for Hyderabad, Vijayawada & Delhi is currently in progress.
- Preliminary analysis completed.

Bridge Related Aspects

- Design and development of culvert inventory module completed.
- Design and development of minor bridge & major bridge inventory completed.
- Design and coding pertaining to deck slab inspection completed.
- Design of proformae pertaining to inspection of various components of Bridge Superstructure, Bearings & Foundation completed.

- The subroutine pertaining to "Cracking of Concrete", including rating of distress, repair & rehabilitation strategies (on the basis of crack width) completed.
- Study on performance of well foundation of bridge under seismic force completed.

Consultancy Assignments

Design of Flexible Pavement for Master Plan (M.P) Road between Sector 31 to 32 and Sector 36 to 37 (proposed Heliport) at Rohini

At the request of Delhi Development Authority (DDA), this study has been undertaken with the objective to design a flexible pavement for master plan (M.P) road between Sector 31 to 32 and Sector 36 to 37, Phase IV & V at Rohini, linking the proposed heliport. The proposed road is 2940 metre long having 60 m Right of Way (ROW) and would cover an area of about 1,76,400 square metre. This road is to be developed as a six lane divided carriageway. The scope of work included the following:

- Traffic assessment / surveys on road(s) around the proposed new alignment for assessing the expected commercial traffic.
- Field investigation and collection of sub-grade samples from the existing built road.
- Laboratory testing of soil samples proposed to be used as subgrade for the new road.
- Analysis of data / results for design of flexible pavement.

Out of the total length, about 440 metre of road length has already been constructed as stage construction in June 2004. In order to find out the structural composition of existing built / constructed road (which is currently non-trafficable), a total of two test pits were dug open in both carriageways. Test pits, measuring 1.0 m x 1.0 m, were dug open upto the subgrade level to measure the thickness of each pavement layer and to collect the samples of subgrade soil for laboratory evaluation. Field density of subgrade in both pits was also determined by sand replacement method. Three samples of soil, proposed to be used as subgrade for designing the flexible pavement, were collected subsequently at different locations from the cut area along both sides of the proposed alignment and evaluated in the laboratory. Classified traffic volume surveys were conducted for 24 hours round the clock for up and down directions, at two different locations viz. (i) Rithala Metro Station road (having divided carriageway), and (ii) Bawana Road near Maharishi Valmiki Hospital (having undivided carriageway). Table V presents number of commercial vehicles plying in both directions at the two survey locations.

Category wise, traffic volume surveys (commercial vehicles) were conducted on the two identified road corridors, which are Rithala and Bawana road corridors. CBR of subgrade soil, as determined in the laboratory, is considered as 6 percent. These road corridors are adjacent to the new road alignment and it is learnt that these roads will be connected to the new road alignment in

Table V Daily Commercial Traffic Volume

Location Nos.	Road Corridor / Directions	Bus	LPV	LCV	Heavy Commercial Vehicles		Total (as on April 2009)	*Total (as on Sept. 2010)
					2 Axle	Multi Axles		
1	Kanjawala to Rithala	223	167	406	322	261	1379	1537
	Rithala to Kanjawala	254	194	375	275	132	1230	1370
2	Shahabad to Bawana	338	226	640	418	214	1836	2046
	Bawana to Shahabad	401	270	473	407	279	1830	2040

Note: LPV – Light Passenger Vehicles; LCV – Light Commercial Vehicles
* Assuming construction period of about 18 months.

future after its completion, under road expansion/ connectivity plans. Assumptions made to calculate the expected traffic loading after the construction of proposed road are as under:

- Commercial vehicles plying on Bawana road will be fully diverted (100 percent) onto the proposed / new road when the project road will be connected in the near future to Western Yamuna Canal Road.
- In the above scenario, half of the traffic will be diverted to "Kanjawala to Rithala direction" and the remaining half traffic will be diverted to "Rithala to Kanjawala direction".
- The above traffic will be added, as per their respective directions, to the commercial vehicles plying on Rithala corridor.
- The construction period will be about 18 months.

Based on the assumptions made, as mentioned above, the design parameters were finalized.

The projected traffic computed for Kanjawala to Rithala and Rithala to Kanjawala carriageways during the design life of 15 years are 92 msa and 88 msa respectively. As can be seen, Kanjawala to Rithala carriageway has slightly higher design traffic loading (92 msa) than Rithala to Kanjawala carriageway (88 msa). It was ultimately decided to design each carriageway of new flexible pavement for 100 msa. The total pavement thickness thus comes out to be 700 mm for traffic loading of 100 msa. Design options arrived from the analyses of data are as given under:

Option–I: Structural Composition of Flexible Pavement for Full Design Life

Total Pavement thickness for subgrade CBR of 6 percent and design traffic loading of 100 msa comes out to be 696 mm, which can be very well

assumed as 700 mm. The structural composition of flexible pavement, as worked out from IRC 37-2001 for a total pavement thickness of 700 mm, is as follows:

- Wearing Course – 40 mm Bituminous Concrete (BC)
- Binder Course – 150 mm Dense Bituminous Macadam (DBM)
- Base Course – 250 mm Wet Mix Macadam (WMM)
- Subbase Course – 260 mm Granular Sub base (GSB)

  (CBR of not less than 30 percent)

Fig. 66 shows the cross section of main carriageway.

Fig. 66 A cross section of main carriageway

Option-II: Alternate Pavement Design for Stage Construction

Keeping in view the gross uncertainties with regard to extent of traffic and axle loading likely to use the new road (as is usually the case) which will be diverted / generated and also the proposed future plans for development of new roads and upgradation / connectivity / expansion plans for existing roads in the project area, it will be better to go for stage construction. Towards this end, the following design of flexible pavement is recommended:

- Wearing Course – 40 mm BC
- Binder Course – 100 mm DBM (2 layers of 50 mm)
- Base Course – 250 mm WMM (2 layers of 125 mm)
- Sub base Course – 260 mm GSB (2 layers of 130 mm)

The above design is applicable for about 5 years design life, at which time the projected traffic loading is about 30 msa. The pavement, as constructed above, can be evaluated after 5 years of its operation since by this time the traffic would have stabilized on the newly constructed road. At this point of time, detailed structural evaluation by measuring Benkelman beam deflections and the magnitude of traffic loads can be undertaken for arriving at the structural overlay requirements, if any, for the next 10 years design life. The pavement design, as recommended, shall be adopted for the entire

length of project road. It is recommended that Option-II may be preferred.

As far as the service road is concerned, it is expected that the type of traffic likely to use service road(s) will be light and local in nature and will be very less. Therefore, the structural composition of flexible pavement for service road (on either sides of the main carriageway) has been designed for 2 msa and should serve the purpose. The pavement design recommended for service road is given below:

- Wearing Course – 25 mm Semi Dense Bituminous Concrete (SDBC)
- Binder Course – 50 mm Bituminous Macadam (BM)
- Base Course – 225 mm Water Bound Macadam (WBM) / Wet Mix Macadam (WMM)
- Sub base Course – 175 mm Granular Sub base (GSB)

Pavement Designs and Circulation Plan for Parking Facility at Safdarjung Airport Area

A variety of sports / events are planned to be organized at Jawahar Lal Nehru Stadium, near Safdarjung Airport, Lodhi Road during October 2010 for the Common Wealth Games – 2010. In order to provide comfort and convenience to the spectators likely to visit this stadium, it is essential that an adequate parking plan be developed along with a proper transportation/ circulation plan for movement of vehicles in and around the parking area and stadium area. Towards this end, New Delhi Municipal Council (NDMC) has decided to develop the green field area within Safadarjang Airport campus, as a park and ride facility for the spectators / visitors of Jawahar Lal Nehru Stadium. The total parking area, to be developed inside Safadarjung Airport, will be a large parking facility and is of the order of 1,75,000 Sq. m. The parking facility being created will be able to accommodate 6000 two-wheelers, 3000 cars and 400 buses at any given time. In addition, circulation plan for movement of different types of vehicles viz., Two wheeler's (Scooters / M. Cycles), Cars and Buses, which will only be allowed to use this parking facility, also needs to be developed. Pavement designs and construction specifications for the new roads (to be developed as internal roads inside Airport area), widening of existing roads, and strengthening / rehabilitation requirements of existing roads also need to be developed / formulated.

The assignment was taken up at the request of New Delhi Municipal Council (NDMC) with the objectives to (i) formulate pavement designs and materials / construction specifications for the development of parking facilities to be used by different types of vehicles inside Safadarjung airport area (ii) construction of new roads (inside airport area), widening and strengthening requirements of existing roads in and around the airport area, and (iii) Development of circulation plan for movement of buses, cars, two-wheelers etc. which will be using the parking facility so created / developed.

Field investigations in and around the airport area was undertaken to appraise the site

conditions and to fully understand the NDMC requirements. Based on the field and laboratory investigations, recommendations on pavement designs separately for parking facility of two wheelers, cars and buses were given as under:

i. Pavement Design for Parking Facility of Two Wheelers and Cars

- Strength of Concrete Paver Blocks — M-40
  (Specified Compressive Strength of Paver Blocks at 28 Days) — (40 MPa)
- Thickness of Concrete Paver Blocks — 80 mm
- Bedding Sand — 30 mm
- Wet Mix Macadam (WMM) Base layer — 150 mm
- Granular Sub-base (GSB) layer — 150 mm

ii. Pavement Design for Parking Facility of Buses

- Strength of Concrete Paver Blocks — M-50
  (Specified Compressive Strength of Paver Blocks at 28 Days) — (50 MPa)
- Thickness of Concrete Paver Blocks — 100 mm
- Bedding Sand — 40 mm
- Wet Mix Macadam (WMM) Base layer — 150 mm
- Granular Sub-base (GSB) layer — 150 mm

The pavement designs, as recommended above, have been suggested keeping in view the special requirements of parking facilities on the eve of forthcoming Common Wealth Games, by assuming that the facilities being created are to be used only for a shorter duration and may not be used extensively in a regular way after the games are over.

In general terms, the concrete paving blocks are required to have adequate strength to withstand their handling, construction stresses and affect of traffic, though the strength as such is not considered a vital factor in the satisfactory performance of block pavements. However, it is recommended that the minimum compressive strength of a single block should be above 35 MPa for parking facility of two wheelers / cars and 45 MPa for parking facility of buses.

iii. Pavement Design for Internal Roads in Airport Area

- Wearing Course — 40 mm Bituminous Concrete (BC)
- Binder Course — 50 mm Dense Bituminous Macadam (DBM)
- Base Course — 150 mm Wet Mix Macadam (WMM)
- Granular Sub-base — 150 mm Granular Sub Base (GSB)

iv. Pavement Design for External Roads

a. For Widened Portion

- Wearing Course 40 mm BC
- Binder Course 50 mm DBM
- Base Course 150 mm WMM
- Granular Sub-base 150 mm GSB

b. For the Existing Roads

Resurface with 40 mm Bituminous Concrete (BC)

Design of Flexible Pavement for 100 M RoW Urban Extension Road No.II (UER-II) from Western Yamuna Canal to Kanjhawala Road Near Village Karala Majari

The consultancy assignment was entrusted to Central Road Research Institute (CRRI), New Delhi by Delhi Development Authority (DDA) with the aim to design flexible pavement (as a four lane divided carriageway) for 100 m RoW Urban Extension Road No. II (UER-II) from Western Yamuna Canal to Kanjhawala Road near village Karala Majari passing through Rohini Zone. Assignment also included design of 100 m RoW flexible pavement for eight lane divided carriageway.

In order to assess the properties of soil available along / or nearby the proposed road alignment, eight samples of soil were collected from various locations. Eight samples of soil, proposed to be used as subgrade, were collected from different locations from the cut area along both sides of the proposed road alignment and laboratory evaluation of materials was done in laboratory. CBR of subgrade soil, as determined for pavement design purpose, is considered as minimum 6 per cent.

Origin – Destination surveys (OD surveys) at NH-10 (near Tikri border) and at NH-1 (near Singhu border) were conducted to find out the percentage shift of commercial vehicles which are likely to use the newly proposed road after its construction since the new road would get connected with NH-1 and NH-10. Classified traffic volume surveys were also conducted for 24 hours round the clock, in both up and down directions, at Tikri (NH-10) and Singhu (NH-1) borders and also at Bawana Road (having undivided carriageway) near Maharishi Valmiki Hospital. Table VI gives number of commercial vehicles found to be plying in both directions and at the three count stations.

For calculation of the projected traffic loading after the construction of newly proposed road, the following assumptions have been made:

- Newly proposed road would start from Western Yamuna Canal road which will finally be extended and connected to NH-1, in future road development plan.
- The other end of the newly proposed road will finally be extended and connected to NH-10, near Mundaka railway station, in future road development plan.
- Out of total number of commercial vehicles using Bawana road presently (both directions combined), 50 percent of these commercial vehicles will be using the newly proposed road. Out of

Table VI Daily Traffic Volume (Commercial Vehicles)

Location No.	Road Corridor / Directions	Bus	LCV	HCV	Total (as on April 2009)	Expected Percent Shift of Vehicles on the New * Road	No. of Commercial Vehicles (CV) Expected on the New Road	*Total no. of CV Expected on the New Road (as on March 2011)
1.	Tikri border to Delhi (NH-10)	1185	1172	2690	5047	14	707	788
	Delhi to Tikri border (NH-10)	1431	2942	2368	6741	9	607	677
2.	Singhu border to Delhi (NH-1)	1205	2019	2435	5659	19	1075	1198
	Delhi to Singhu border (NH-1)	1254	3766	4170	9190	21	1930	2151
3.	Shahabad to Bawana	338	866	632	1836	50	918	1023
	Bawana to Shahabad	401	743	686	1830	50	915	1020
	Expected No. of Commercial Vehicles Per Day on New Road (After Construction)					=		6857

Note: 1. LCV – Light Commercial Vehicles; HCV – Heavy Commercial Vehicles
2. * Assuming construction period of about 18 months.
3. Expected percentage shift computed based on results of O-D survey.

this generated traffic (i.e. 50 percent of commercial vehicles), half of it will further get distributed evenly in up and down directions of the new road facility, when the project road will be connected to Western Yamuna Canal Road and at Mundaka on NH-10, in future.

- The construction period will be about 18 months.

Based on the assumptions made, as mentioned above, the input parameters for design of four lane divided carriageway and eight lane divided carriageway were finalized.

As computed, Mundaka to Western Yamuna Canal carriageway (i.e. from NH-10 to NH-1) has slightly higher design traffic loadings of 128 msa and 77 msa for four lane and eight lane divided carriageway respectively, while it is 94 msa and 56 msa for Western Yamuna Canal to Mundaka (i.e. from NH-1 to NH-10) carriageway respectively. It was ultimately decided to design flexible pavement based on the higher loading

amongst the two carriageways i.e. for four lane divided carriageway to be designed for a traffic loading of 128 msa while eight lane divided carriageway designed traffic loading would be 77 msa.

Total Pavement thickness for subgrade CBR of 6 percent at design traffic loading of 128 msa comes out to be 710 mm. The structural composition of flexible pavement for four lanes divided flexible pavement for full design life (Option-IA), as worked out from IRC 37-2001, for a total pavement thickness of 710 mm is as follows:

- Wearing Course – 50 mm Bituminous Concrete (BC)
- Binder Course – 150 mm Dense Bituminous Macadam (DBM)
- Base Course – 250 mm Wet Mix Macadam (WMM)
- Subbase Course – 260 mm Granular Sub base (GSB) (CBR not less than 30 percent)

Total Pavement thickness for subgrade CBR of 6 percent at design traffic loading of 77 msa comes out to be 687 mm. The structural composition of flexible pavement for eight lanes divided flexible pavement for full design life (Option-IB), as worked out from IRC 37-2001, for a total pavement thickness of 687 mm is as follows:

- Wearing Course – 40 mm BC
- Binder Course – 140 mm DBM
- Base Course – 250 mm Wet Mix Macadam (WMM)
- Subbase Course – 260 mm Granular Sub base (GSB) (CBR not less than 30 percent)

Fig. 67 & 68 show the cross section of main carriageway for four lane and eight lane divided carriageway. Keeping in view the gross uncertainties with regard to the extent of traffic and axle loading likely to use the new road which will be diverted / generated and also the proposed future plans for development of new roads and upgradation / connectivity / expansion plans for existing roads in the project area, the alternate pavement design for flexible pavement under stage construction for four lane divided carriageway (Option – IIA) is also recommended as given below:

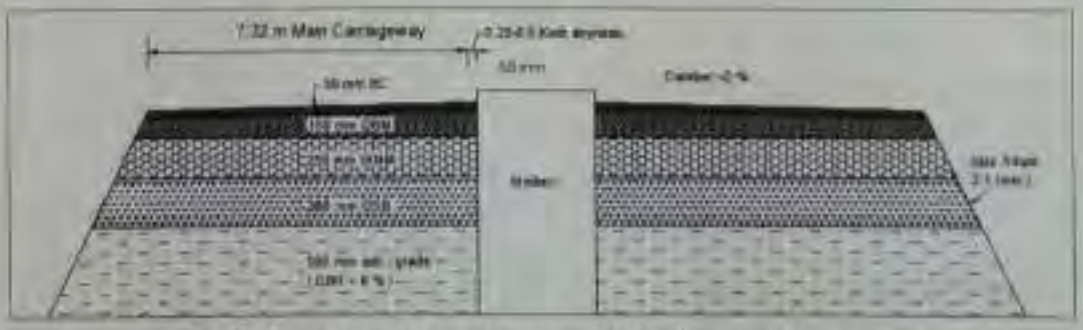


Fig. 67 A cross section of main carriageway for four lanes divided carriageway

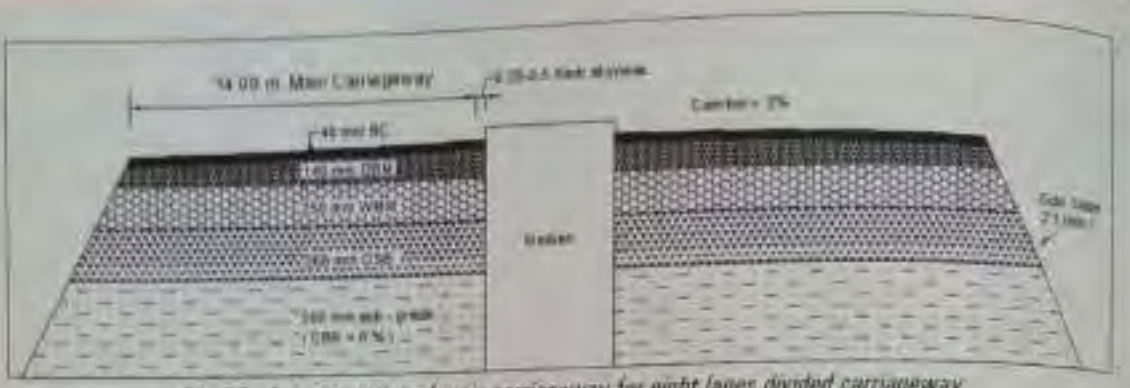


Fig. 68 A cross section of main carriageway for eight lanes divided carriageway

- Wearing Course – 40 mm BC
- Binder Course – 100 mm DBM (2 layers of 50 mm thick each)
- Base Course – 250 mm WMM (2 layers of 125 mm thick each)
- Sub base Course – 260 mm GSB (2 layers of 130 mm thick each)

The above pavement design is applicable for 5 years design life, at which time the projected traffic loading is expected to be about 28.44 msa (about 30 msa for the maximum number of commercial vehicles of 3961). The pavement, as constructed above, can be evaluated after 5 years of its operation (when the resurfacing also becomes due) since by this time the traffic would have stabilized on the newly constructed road. It is recommended that Option-II may be preferred.

Similarly, as above, the alternate pavement design for flexible pavement under stage construction for eight lane divided carriageway (Option – IIB) is recommended as given under:

- Wearing Course – 40 mm BC
- Binder Course – 75 mm DBM
- Base Course – 250 mm WMM (2 layers of 125 mm thick each)
- Sub base Course – 260 mm GSB (2 layers of 130 mm thick each)

The above pavement design is applicable for 5 years design life, at which time the projected traffic loading is expected to be about 17.00 msa. The pavement, as constructed above, can be evaluated after 5 years of its operation (when the resurfacing also becomes due) since by this time the traffic would have stabilized on the newly constructed road. It is recommended that Option II may be preferred. The structural composition of flexible pavement for service roads (on either sides of the main carriageway) has been designed for a projected traffic loading of 2 msa during the design life and should serve the purpose. The pavement design recommended for service roads is as given below:

- Wearing Course – 25 mm Semi Dense Bituminous Concrete (SDBC)
- Binder Course – 50 mm Bituminous Macadam (BM)
- Base Course – 225 mm Wet Mix Macadam (WMM)
- Sub base Course – 175 mm Granular Sub base (GSB)

Traffic Counts and Axle Loads Survey on Azamgarh-Mau-Phephna Road for Determination of Vehicle Damage Factor

At the instance of Chief Engineer, World Bank Projects (Roads), Uttar Pradesh Public Works Department, Lucknow, this study was carried out primarily to determine (i) Average Daily Traffic (ADT) based on 7 days traffic survey, (ii) Vehicle Damage Factors (VDFs) for different types of commercial vehicles, and (iii) Cumulative Numbers of Standard Axles (CSALs) passing over the road section of Azamgarh-Mau-Phephna. Duration of axle loads and traffic counts survey at one location was kept as 4 days and 7 days (24X7) respectively, round the clock, covering both directions of travel. Portable and non-embedded type wheel weighing pads were used for recording of axle loads. Fig. 69 shows the arrangement for weighing commercial vehicles.

Fig. 69 Front wheel of a 2 - axle truck being weighed using non embedded type wheel weighing pads

Based on the data collected and results obtained through traffic volume surveys and axle loads spectrum study, conducted at one location, on Azamgarh-Mau-Phephna road continuously for 7 days and 4 days respectively, the following major conclusions were drawn:

- A total of 13898 commercial vehicles (both heavy and light) were counted during the period of traffic survey (i.e. 168 hours round the clock for 7 days) in up and down directions. The average daily traffic (ADT) in terms of commercial vehicles per day calculated based on 7 days traffic counts data, is found to be 1985.
- A total of 6542 commercial vehicles (both heavy and light) were counted during the period of traffic survey (i.e. 168 hours round the clock for 7 days) in up direction (towards Dhorighat). A total of 3585 commercial vehicles (both heavy and light) were counted during the period of axle loads survey (i.e. Day 1, Day 3, Day 5 and Day 7 round the clock) out of which

2445 commercial vehicles were weighed which is 68.20 per cent. The overall VDF for the road in up direction is found to be 35.93

- A total of 7356 commercial vehicles (both heavy and light) were counted during the period of traffic survey (i.e. 168 hours round the clock for 7 days) in down direction (towards Azamgarh). A total of 4092 commercial vehicles (both heavy and light) were counted during the period of axle loads survey (i.e. Day1, Day 3, Day 5 and Day 7 round the clock) out of which 2222 commercial vehicles were weighed which is 54.30 per cent. The overall VDF for the road in down direction is found to be 1.69.
- The cumulative numbers of standard axles are 203 and 224 million standard axles (msa) during a design life of 8 years at growth rates of 7.5 percent and 10 percent per annum respectively.
- It was noticed during the period of surveys that large scale road construction activities are currently in progress towards Gorakhpur. Substantial numbers of overloaded trucks, transporting the construction materials, were found to be using the project road which may be temporary or seasonal. The extent of overloading by trucks, in up direction, carrying construction materials are abnormal and beyond imagination. However, these overloaded trucks/dumpers have significantly influenced the loading scenario and have contributed heavily to the increase in value of VDF and deterioration of road. Most of these trucks, on the other hand, were found either emptied or lightly loaded while returning to Azamgarh, leading to a wide difference in the values of VDF between the two directions of travel.
- Overloading affects significantly the pavement's service life and leads to pre-mature failure/distress of the road. It is, therefore, suggested that stringent measures may be taken by enforcement authority to control and/or minimize the excessive overloading by trucks, particularly vehicles carrying construction materials towards Gorakhpur in order to (i) ensure desired level of pavement performance / serviceability within the design period, (ii) avoid the risk of pre-mature distress / failure, and (iii) minimize maintenance and rehabilitation costs and road user costs.

Evaluation of Serviceability of Pavement Surface of Eastern and Western Express Highways in Mumbai Region

This assignment was referred by Mumbai Construction Circle, P.W.D. Mumbai to evaluate the serviceability or functional quality in terms of riding quality (roughness) and surface friction characteristics of the Eastern and Western Express Highways from traffic safety point of view in Mumbai region.

Necessary field works for assessing / measuring roughness Index and skid resistance of Eastern and Western Express Highways were carried out in the month of May 2009. The investigations undertaken included the following:

a. Assessment of pavement surface condition (on visual basis)

b. Measurement of pavement surface roughness for full length on all the ten lanes of Eastern and Western Express Highways using Fifth Wheel Bump Integrator (FWBI)

c. Measurement of skid resistance values at representative locations, by using British Portable Skid Resistance Tester on Mastic Asphalt surface only covering various lanes over the entire length of two Expressways.

Fig. 70 shows a typical view of Eastern Express Highway. Skid resistance measurements were carried out on the representative locations, by using British Portable Skid Resistance Tester (Fig. 71) on Mastic Asphalt surface only covering various lanes over the entire length of two Expressways.

Methodology adopted for measurements of roughness and surface friction (skid resistance) of the pavement surface for Eastern and Western Express Highways alongwih the data / results obtained during the field investigations, major conclusions drawn and recommendations made were reported to the PWD, Mumbai.

Fig. 70 A typical view of Eastern Express Highway

Fig. 71 British Pendulum Tester used for measurement of surface friction

Performance Study on Use of Fly ash in Construction of Bituminous Road Surfacing

The study has been taken up at the instance of National Thermal Power Corporation Limited, Noida (U.P.) with the aim to conduct performance study and to explore the use of fly ash in construction of various types of Bituminous Surfacing for internal roads within the premises

of NTPC plants located in Dadri and Badarpur including rehabilitation / strengthening.

Field visits and inspection of various roads in the plant areas (NTPC-Dadri and Badarpur Campus) were made in order to have physical assessment of the roads which have to be rehabilitated / strengthened / resurfaced within NTPC Dadri plant campus and to appraise the current condition of project roads. Subsequently, detailed investigations / surveys related to the pavement evaluation on the identified project roads which needed maintenance / rehabilitation were also undertaken.

The primary objective of the R&D study is to evaluate performance of road sections constructed with different types of bituminous surfacings constructed by using fly ash as mineral filler vis-a-vis constructed in a conventional way (by using lime as mineral filler).

The scope of work of the study included

1. Pavement condition survey before construction, materials and construction specifications, preparation of BOQs, job mix designs, and limited construction quality checking / supervision of road sections. .
2. Association during laying of demonstration stretches for use of fly ash in Bituminous Concrete (BC), Stone Matrix Asphalt (SMA) and Slurry Seal / Micro-Surfacing.
3. To develop periodic pavement performance data (such as deflection, roughness, surface distress, traffic volume etc.) at six months interval for a period of 3 years.

The road length considered under this study in Dadri is about 5414 meter having variations in pavement width from 3 to 7 meter. The details of road length of project roads are presented in Table VII.

Detailed investigations (structural and functional evaluation) were undertaken on the project roads with a view to assess the condition of existing pavements. Tasks / activities included

Table VII Details of Length and Width of Project Roads in the Study Area

S. No.	Link / Road Name	Length (m)	Width (m)	Total Road Length (m)	Traffic Category (in terms of CVs*)
1	Gate No. 3 to T- Junction	964	7	964	High
2	T-Junction to Paschi Vihar	186	3	4450	Nil / Insignificant
	Paschi Vihar to Culvert (near Paschi Vihar)	3116	7		Nil / Insignificant
	Culvert to Entry Gate of Ash mound Control Room to T-Junction	1168	7		Medium
TOTAL ROAD LENGTH				5414	

* CVs – Commercial Vehicles in terms of 2-axle and multi-axle trucks

assessment of pavement surface condition (visual basis), roughness measurements, Benkelman Beam deflection measurements, traffic volume surveys (only commercial vehicles) and test pit observations

The major types of surface distress recorded in terms of percentage of the total pavement's surface area are cracking, ravelling, pot holes, shoving, bleeding, corrugation and rutting etc. The structural inadequacy of pavement is worked out by using characteristic deflection values and cumulative number of standard axles. Using average characteristic deflection data (average of all the roads / links) and projected traffic loading (msa), the overlay thicknesses have been worked out for different project roads in terms of Bituminous Macadam (BM) for 10 years design life as per IRC: 81- 1997. The overlays required for different project roads are given in Table VIII.

Table shows that the existing roads / links are structurally adequate for a design period of 10 years. On the other hand, pavement surface roughness for these roads indicates that these roads are in poor condition. Hence, in order to improve the current condition of project roads / links from their functional point of view and to provide comfortable ride to the users, renewal / resurfacing treatments in terms of 40 mm thick Bituminous Overlay is recommended. Table IX shows the proposed specifications on various sections of different project roads, which are to be constructed using lime and fly ash as the mineral filler.

Design of Pavement around Rotary Junction 26 between Sectors 16 to 17 and 22 to 23 at Chandigarh

The rotary (Junction No. 26) i.e. between Sectors 16 to 17 and 22 to 23 is a very busy roundabout, which is located very close to Interstate Bus Terminus (ISBT). This rotary caters to a very large number of mixed types of vehicles consisting of two-wheelers, cars, three wheelers, buses and commercial

Table VIII Overlay Thickness Required for Different Project Roads (Design Life = 10 Years)

Direction	Traffic (CVPD)	VDF	Average Characteristic Deflection (mm)	Design Traffic (msa)	Overlay Requirements (BM), in mm
Gate No. 3 to T-Junction	495	4.5	0.82	10	Nil
T-Junction to Ash mound	248	4.5		5	Nil
Ash mound to Paschi Vihar	Nil	4.5		2	Nil

Notes: CVPD – Commercial Vehicles per Day; VDF – Vehicle Damage Factor; MSA – Million Standard Axles ; BM – Bituminous Macadam

Table IX Recommended Specifications to be laid on Project Roads / Links

S. No.	Road Section	Proposed Specifications	Road Length (m)
1.	Gate No. 3 to T Junction	40 mm thick SMA (with Lime as Filler)	241
		40 mm thick SMA (with Fly Ash as Filler)	241
		40 mm thick BC (with Lime as Filler)	241
		40 mm thick BC (with Fly Ash as Filler)	241
2.	T Junction to Paschi Vihar (Total Length of 4450 m) excluding the proposed 1300 m length of Concrete Pavement which is from Control Room to Entry Gate of Ash mound		
S. No.	**Road Section**	**Proposed Specifications**	**Road Length (m)**
a)	T-Junction to Control Room (– 1168 m in length)	40 mm thick BC (with Lime as Filler)	292
		40 mm thick BC (with Fly Ash as Filler)	292
		40 mm thick SMA (with Lime as Filler)	292
		40 mm thick SMA (with Fly Ash as Filler)	292
b)	Entry Gate of Ash mound to Culvert near Paschi Vihar (– 4416 m in length)	40 mm thick BC (with Lime as Filler)	620
		40 mm thick BC (with both Lime and Fly Ash as Fillers in 50:50 Proportion)	620
		40 mm thick BC (with Fly Ash as Filler)	620
		40 mm thick SMA (with Lime as Filler)	628
		40 mm thick SMA (with Fly Ash as Filler)	628
c)	Culvert to Paschi Vihar	40 mm thick BC (with Fly Ash as Filler)	168

Notes : BC – Bituminous Concrete ; SMA – Stone Matrix Asphalt

Fig. 72 A typical view of vehicular movements around Rotary Jn. 26

vehicles (Fig. 72) entering into / leaving Chandigarh from / to different places / states. Due to the frequent movement of large number of heavy vehicles (particularly buses) using this roundabout, extensive severe cracks and large settlements have occurred on the existing pavement surface (Mastic Asphalt) particularly in the innermost lane which was laid about 6 to 7 years back.

Keeping in view the frequent problems being faced by the Administration with regard to the upkeep and maintenance of Mastic Asphalt surface

the Chief Engineer, Union Territory-Chandigarh Administration, requested the Institute to take up an assignment with the objectives to suggest pavement design and materials / construction specifications bituminous layers and using concrete paver blocks alternatively.

Field visits / inspection of Rotary Junction 26 were made to appraise the site conditions. Based on the inspection of rotary, following recommendations on pavement designs were given.

Recommended Rehabilitation Design with Bituminous Layers (Option-I)

The recommended rehabilitation treatments which will be laid over the existing bituminous pavement after milling / scarifying the existing mastic asphalt surface included.

a.	Mastic Asphalt	40 mm
b.	Dense Bituminous Macadam (DBM)	50 mm

Recommended Rehabilitation Design with Concrete Paver Blocks (Option-II)

a.	Thickness of Concrete Paver Blocks	100 mm
b.	Strength of Concrete Paver Blocks (Specified Compressive Strength of Paver Blocks at 28 Days)	M-55 (55 MPa)
c.	Bedding Sand	30 - 40 mm
d.	Dry Lean Concrete (DLC) (Specified Compressive Strength at 28 days)	150 mm M-10 (10 MPa)

The typical laying pattern of concrete paver blocks at Rotary Jn. 26, is shown in Fig. 73.

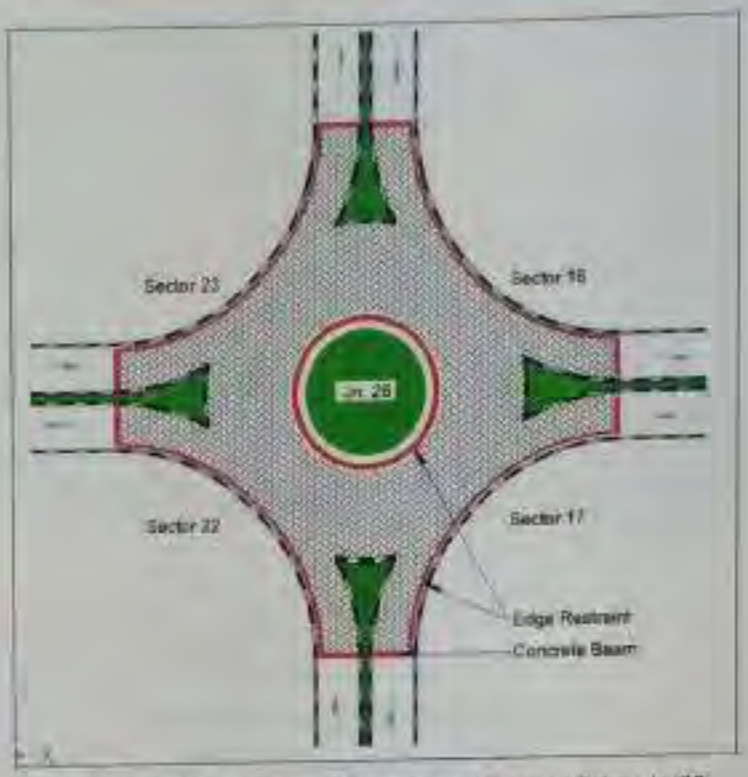


Fig. 73 Typical laying pattern of concrete paver blocks at Rotary Jn. 26.

Determination of Pavement Classification Number (PCN) and Suitability of Existing Runway for use at Surat Airport

This assignment was sponsored by Surat Airport Project, Airports Authority of India (AAI), Surat with the aim to determine the load carrying capacity in terms of Pavement Classification Number (PCN) for different portions / sections of the existing runway pavement at Surat Airport and to evaluate the quality of different sections of the runway pavement with regard to their use by different aircrafts currently operating and for the projected aircraft operations.

The scope of work includes the following major activities / tasks:

- Measurement of pavement deflections on different sections of the runway, at pre-determined loads, by using Falling Weight Deflectometer (FWD)

- Assessment of pavement surface condition through visual inspections
- Extraction of 4" diameter cylindrical cores
- Measurement of layer thicknesses in the pavement structure
- Test pits observations and collection of subgrade soils and other road building materials used for construction of runway pavement
- Laboratory evaluation of in-situ materials and mixes retrieved from the existing pavement structures for ascertaining the construction quality of pavement component layers
- Analysis of data / results to estimate PCN of different sections of the runway pavement
- Recommend remedial measures to improve the current condition of different sections of runway pavement so as to make the whole runway pavement suitable for the anticipated proposed aircraft operations.

Surat airfield is presently being used by various types of aircrafts such as A319, A320 and CRJ700 on "one flight a day" basis. The airfield pavement is to be evaluated for determination of PCN towards finding out its suitability for unrestricted operations / use by different types of aircrafts (A 319, A320 and A321) on ultra low subgrade strength (in terms of CBR). Based on the general appraisal of the pavement surface condition, representative locations for taking 4" (10 cm) diameter cylindrical cores were marked / identified. Cores were taken for determining the layer thicknesses and for evaluating the construction quality of asphalt mixes. Concrete cores were also recovered from the runway end / turning pad. As reported by AAI, runway was classified into five distinct sections, as given below:

i. **Central 30 m wide portion of old runway from 0 to 1400 m**

This section of runway is not showing any signs of rutting, depression, deformation or any other distress types except for segregation of bituminous mix on top layer at few isolated locations.

ii. **Widened portion on both sides of the old runway from 0 to 1400 m(15 m to 22.5 m)**

Widened portion of the old runway from 0 to 1400 m (15 to 22.5 m on East and West sides from the central line of runway) had developed / witnessed (in the past) some depressions / settlements at scattered locations of varying length and width in April 2007 which were subsequently repaired in July 2007 itself by removing bituminous layers in some portions and relaying and by providing additional bituminous layer (DAC) in some portion. The present surface condition of this section of runway is satisfactory with no visible distress found on the pavement surface.

iii. **Extension portion from 1400 to 1585 m for full width of 45 m**

This section also includes RESA portion of 60 m from chainage 1525 to 1585 m. Some

settlements / depressions on this portion of runway, specifically on the wheel tracks (4 to 4.5 m wide strips on both sides from the central line), were observed sometimes after the runway was put to operation. Overlays of bituminous layers (30 to 50 mm DAC) were then provided twice on this section, first time during July, 2007 and during January, 2008 due to development of deformation / rutting, especially along the wheel paths (about 4 to 5 m from the central line on both sides).

iv. Extension portion from 1585 to 2094 m for full width of 45 m

This section of runway presently neither has any signs of depression or any other distress nor is reported to have developed any distress in the past.

v. Rigid turning pad and Dumbbell from chainage 2094 to 2250 m at End 22

The most common type of distress found on this portion was surface cracking in the centre of slabs. Such cracks were however epoxy repaired by AAI. Two to three slabs were found to be having wide cracking.

Pavement deflection measurements, by using FWD, were undertaken on runway pavement and rigid ends at Surat Airport. The FWD system was applied on several sections of the airfield pavement with known cross sectional details obtained from the records / test pits. Pavement deflection measurements by FWD were undertaken on the main runway at an interval of about 50 meter in staggered position and largely on the most used portion of runway on both sides of the centre line. Similarly, FWD deflection measurements were taken on runway ends / turning pads also at representative locations well spread over the paved area.

Fig. 74 Deflection measurements using FWD on runway at Surat Airport

Fig. 74 shows FWD being used for taking deflection measurements on the runway.

Based on the field and laboratory investigations, carried out on different sections of the runway pavement, the following major findings emanated:

1. CBR of subgrade soil is found to be less than 2; and therefore it is categorized in 'ultra low' category as per ICAO guidelines for PCN evaluation.

2. Typical distress types found on the rigid runway End 22 include edge cracking, corner cracking and full width cracking, all in the longitudinal and transverse directions, on a considerable number of slabs.

3. The values of PCN determined for different sections of the runway pavement, viz. (i) original portion of the old runway at 04 End from 0 to 1400 m (30m wide), (ii) widened portion of the old runway from 30 to 45 m, (iii) Extended portion of runway from 1400 to 1585 m (45 m wide), (iv) Extended portion of runway from 1585 m to 2094 m (45 m wide),

and (v) Rigid turning pad at 22 End from 2094 to 2250 m including dumbbell, are 80/F/D/W/T, 36/F/D/W/T, 27/F/D/W/T, 22/F/D/W/T and 70/R/D/W/T respectively.

4. Problematic areas / locations assessed during the evaluation of runway pavement include extended portion of the runway pavement from 1400 to 1585 m (45 m wide). This section of runway is recommended to be reconstructed for a design PCN value of 63 on the existing 'Ultra Low' subgrade strength, as per AAI / ICAO design guidelines.

5. Widened portion of original runway from 0 to 1400 m (30 to 45 m) and the extended section of runway pavement from 1595 to 2094 m, are recommended to be strengthened / overlaid with the following specifications:

a) Widened portion of old runway on both sides (30 to 45 m)
Provide bituminous overlay of 125 mm thick (75 mm DBM + 50 mm BC)

b) Extended portion of runway pavement (1585 to 2094 m)
Provide bituminous overlay of 200 mm thick (2x75 mm DBM +50 mm BC)

Evaluation of Master Plan Road No.1 and Udyog Marg in Noida

The assignment was taken up at the request of New Okhla Industrial Development Authority (NOIDA) to carry out detailed investigations of the two roads i.e. Master Plan Road No. 1 (MP-1 Road) and Udyog Marg in Noida towards determining the likely causes of distress/ defects developed on these roads and to suggest remedial measures needed to overcome the problem (s).

The scope of work included the following major activities:

a. Field investigations

- Functional evaluation of pavement surface through roughness measurements, using duly calibrated fifth wheel bump integrator, on each lanes of both carriageways for the entire length of project roads
- Assessment of pavement surface distress (types and extent) by visual observations.
- Structural evaluation of pavement by Benkelman Beam deflection measurements (11 points per Km in each carriageway), covering the entire length of project roads
- Test pits evaluation (about 2 to 3 on each of the two roads, representing variations in surface condition)
- Classified traffic volume surveys at one location for 24 hours round the clock on each road

b. Laboratory evaluation by determining the engineering properties of materials retrieved from different layers of the existing pavement structures of two roads.

The type of surface distress is mainly cracking, patching / potholes and slippage occurring mostly on Mastic Asphalt surface at the intersections. Also, undulations/ settlements were observed on the road in few places which are also affecting the riding quality. The extent of distress found on Udyog Marg in both directions of road was more than MP-1 Road (Figs. 75,76,77 & 78).

The major findings, based on the data/results, are summarized as under:

i. The total surface distress on Udyog Marg is maximum 45 to 50 percent while it is maximum 25 to 30 percent on MP-1 Road. The major types of surface distress/defects developed on the project roads are cracking, potholes, patching and raveling.

ii. Deflection values clearly indicate that the existing pavements are deficient with regard to their structural adequacy for the prevailing and projected traffic volume and loads.

iii. Based on the characteristic deflections data and cumulative number of standard axles worked out for the project roads, it becomes very clear that the existing roads are structurally inadequate and would not be able to cope up with the expected traffic loads. Consequently, the roads are in dire need of immediate rehabilitation/ strengthening to augment their structural capacity so as to improve their load carrying/ bearing capacity.

Following are the major likely causes which may be responsible for development of distress/

Fig.75 Extensive alligator cracking on MP-1 road

Fig. 76 Slippage at the intersection on MP-1 road

Fig. 77 A typical view of distress on Udyog marg

Fig. 78 Patching, potholes and loss of materials on Udyog marg

defects on the pavement surfaces of two roads:

- Inadequate structural capacity of the existing pavements in regard to the current and projected traffic loading, the project roads are subjected to.
- Higher volume of commercial vehicles using the roads and the overloading being caused by them.
- Application of BM + BC combination is not at all a good practice, particularly for heavily trafficked roads like the two project roads. This combination should not be used due to a number of factors which have been very emphatically brought out earlier by CRRI. The preferred combination is DBM + BC.
- Use of soling (large sized stones/ boulders) and/or WBM Gr. I material in the subbase layer may be one of the contributing factors responsible for deterioration of project roads. This specification has completely been discarded/ omitted for a long time by many road departments. This layer does not offer much strength to the pavement structure and also does not provide enough support to the overlying pavement layers because of weak interlocking and large voids therein.
- No Granular Subbase (GSB) layer/ material have been used in the pavement structures. This layer works as a drainage layer and facilitates movement/flow of water entrapped within the pavement structure. Absence of GSB layer might also have contributed for the deterioration of project roads.
- Since the type of subgrade soil used on project roads has significant proportion of clay, the provision of GSB becomes absolutely essential under such situations. Due to the absence of GSB layer, the water entering into the subgrade weakens its strength due to the volume change and plastic deformation. As can be seen, the field moisture contents in two out of the four test pits (pit number 1 and 3 which have clayey soils) are more than the optimum moisture content which substantiates the point highlighted above.
- In summary, reduced compaction levels of the subgrade layer, use of stone soling in the subbase and absence of GSB layer in the pavement structure, have probably been responsible for deterioration of project roads.
- Slippage of mastic asphalt observed at some sections on the intersections might have occurred

due to improper workmanship, inferior quality of constituent materials, inadequate job mix design and incorrect laying process etc. Mastic asphalt may be relaid as per specifications laid down in Section 500 (Item No. 515) of MORTH specifications.

- The life of Bituminous Concrete (BC) surfacing on heavily trafficked roads is generally about 4 to 5 years which has outlived its life since the resurfacing was done on project roads about 4 to 5 years back (in 2004). The life of surfacing gets further reduced if it is laid on a weak pavement structure which is the present case.

The project roads are distressed due to inadequate structural strength of the existing pavements for the present day and projected traffic loads. Thus, the existing pavement structures need strengthening / rehabilitation. The rehabilitation of roads may be undertaken by applying appropriate treatments in terms of overlay with bituminous layers, as recommended. As regards rectification of distress developed on the intersections, it is recommended that 40mm thick mastic asphalt layer may be provided at these locations. Dense Bituminous Macadam shall be prepared by using 60/70 penetration grade paving bitumen, while Bituminous Concrete shall preferably be prepared by using modified bitumen, conforming to IRC: SP: 53-2002. In Bituminous Concrete and Dense Bituminous Macadam, lime stone dust or lime having 85 per cent material passing through 75 micron sieve shall be used as the filler material.

Investigation to Determine and Ascertain Causes of Distress and Suggest Remedial Measures for the Runway Pavement at Jaipur Airport

This assignment was taken up at the request of Airports Authority of India, New Delhi with the prime objective to investigate and ascertain causes of distress and suggest remedial measures for the runway pavement at Jaipur Airport.

The main runway pavement at Jaipur Airport consists of flexible and rigid portions. The flexible portion of the runway pavement is 1823 m long and 45 m wide with 7.5 m paved shoulders on both sides of the pavement. Rigid portion of the runway is 914 m long and 60 m wide. The taxi track and apron areas are partly flexible and partly rigid pavements construction. The flexible portion of the main runway has a declared PCN value of 58/F/B/W/T while rigid portion of the main runway has declared PCN value of 57/R/B/W/T. Surface texture of the pavements can be rated as coarse / rough.

Jaipur airfield is presently being used by several types of aircrafts and deemed suitable for B767 class of aircraft operations under IMC. The airfield pavement is required to be evaluated towards determining and ascertaining the likely causes of distress and subsequently suggest remedial measures for improvement of the runway. The airfield pavements are also planned to be upgraded in future in order to

receive heavier types of aircrafts for its future operation.

Necessary field works / investigations undertaken for the evaluation of existing runway pavement included assessment of surface condition of the runway pavement by visual inspection. It was observed that there was no visible distress in the first 600 metres length of the runway except that the pavement surface was hungry. Pavement was found to be distressed mainly from 600 to 1020 m along and across the centre line on most used lanes. Distresses observed from 600 to 1020 m on the main runway are in the form of oozing of water, in the form of patches on the surface, cracking, raveling, deformation, patch work, and pot holes.

Majority of the locations were highly distressed / badly cracked. This has primarily occurred probably due to entrapment of water in the lower bituminous layers. Similar kind of distresses were observed on stretch from 1020 to 1200 m. Stretch from 1200 to 1800 m was found to be hungry surface with some patches due to oozing of water on the surface. Vegetation growth was also seen at very few locations on the shoulders. Drainage and shoulder conditions of the runway were found to be in fair to poor condition.

Based on the general appraisal of pavement surface condition, representative locations for taking 4" (10 cm) and 6" (15 cm) diameter cylindrical cores were taken over the entire length of runway for determining the layer thicknesses and for evaluating the construction quality etc. A total of 28 bituminous cores were recovered from the runway pavement, which was then tested in the laboratory for their properties.

Four test pits, one on sound condition of the pavement and three on problematic areas of the runway, of size 1.25 x 1.25m, on / near the edge of the pavement were cut open for determination of thickness of component layers and field density etc. Road construction materials from different component layers in the pavement structure were also collected for laboratory evaluation.

Further analysis of data and report preparation is in progress.

State-of-Art Equipments/ Facilities Created

Network Survey Vehicle System

The Network Survey Vehicle (NSV) system is based on the latest survey techniques utilizing Laser, Global Positioning System and Video image processing tools etc (Fig. 79). The Survey Vehicle is being used for automatic collection of road condition related data for National Highways. The inventory data collected include measurement of gradient (rise and fall), horizontal curvature, pavement surface condition (distress), roughness, and GPS coordinates (X, Y, Z) viz. longitude, latitude & altitude etc. Based on the information collected through NSV and using the map data, a user friendly GIS based interactive system is currently under development.

Key Features of the Network Survey Vehicle System are:

a High survey speed up to 100 km/hr

Fig. 79 Network Survey Vehicle (NSV)

b. Longitudinal (International Roughness Index) and transverse profiling (Rut Depth) conforms to ASTM standards

c. Pavement Texture in terms of Mean Profile Depth

d. Slope, Cross-fall, Radius of curvature

e. GPS coordinates (X, Y, Z) viz. longitude, latitude & altitude using DGPS

f. Video imaging for
   - Roadside furniture / Road asset

g. Advanced data processing and reporting software
   - Real time in-vehicle data acquisition software for display and collection of data from all parameters simultaneously
   - Post processing software for data analysis and report preparation

h. It is Windows XP based

Roughometer-II

Roughometer-II is a high speed device used for measuring pavement surface roughness. It is portable type equipment and consists of a small accelerometer (sensor) device installed at the rear axle of survey vehicle, a distance measuring instrument, interface module and a controller (Fig. 80). The pavement roughness measurements using this equipment are required to be done preferably at a speed in between 40 to 60 km/hr, in order to obtain most reliable and accurate data. The output is in the units of International Roughness Index (IRI).

Fig. 80 Roughometer -II

Walking Profiler

The Walking Profiler is a precision instrument designed to collect surface profile data (Fig. 81). The data can be used to accurately assess the characteristics and quality of any continuous paved surface. Typically the surface profile is used to generate a number of internationally recognized roughnesses, ride quality and pavement maintenance indices etc.

It is designed to operate at a moderate and steady walking pace in a straight line. The equipment has an integral Control Unit which provides all the functions of instrument calibration, survey setup and operator feedback. Like Dipstick, it also directly gives International Roughness Index in m/km.

Fig. 81 Walking Profiler

Bridges & Structures

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report
2009-10

PROJECT TEAM MEMBERS OF BRIDGES AND STRUCTURE DIVISION

Use of Recycled Coarse Aggregate in New Construction

Concrete, constitutes cement, aggregate and water, is everywhere. It is the second most consumed material after water and it shapes our built environment such as homes, schools, hospitals, offices, roads, bridges and runways etc. Concrete is extremely durable and can last for hundreds of years in many applications and is the basis for the urban environment. It can be roughly estimated that in 2006 between 21 and 31billion tonnes of concrete (containing 2.54 billion tonnes of cement) were consumed globally compared to less than 2 to 2.5 billion tonnes of concrete in 1950 (200 million tonnes of cement).

Concrete waste is generated when structures made of concrete are demolished or renovated due to change in human needs. Concrete recycling is an increasingly common method of utilizing the rubble concrete, was once routinely trucked to landfills for disposal or is used in the sub-base of road construction. Although the extensive use of recycled coarse aggregate (RCA) in the construction industry has environmental benefits, even then only a very small portion of the concrete waste is being reused as aggregate in the new concrete construction. This is mainly due to the lack of technical data, clear specifications, and quality control guidelines in the processing of RCA and in the production of concrete mixes made with RCA.

CRRI has taken up a research programme in this direction to study the properties and behaviour of the concrete made with RCA in comparison to the concrete made from virgin aggregates. Apart from the determination of basic properties of RCA, the residual mortar content in the recycled coarse aggregates have been determined by immersing the RCA in **sodium sulphate solution (similar concentration to that used in the IS2386:1963 (Part V)) and daily** freezing and thawing cycles. Fig. 82 (a & b) shows the specimens before and after freezing thawing cycles (16 hours of freeze (-18°c) and 8 hours of thaw (80°c)).

(a) With mortar content

(b) After freezing and thawing cycles

Fig. 82 (a&b) Recycled coarse aggregate

Concrete mixes made of RCA are under trial using different proportions of fine aggregate, different ratio of RCA to virgin aggregate, and replacement of cement with fly ash. Few properties (compressive strength, splitting strength, elastic modulus) of hardened concrete made using RCA have been determined and the results are quite encouraging. The study on flexural behaviour of prototype rectangular RC beams using RCA in concrete is also in progress and casting of specimens is shown in Fig. 83.

Fig. 83 Fabrication of specimen in progress

Simplification of Design Live Loads for Highway Bridges

The current design practice of highway bridges in the country is based on the prevalent live loads (governed by IRC) and its combination with the different forces. The analytical work in the design of bridges involves placement of Wheel loads (IRC A, AA and 70R) under various combinations which involves cumbersome calculations.

The objective of the study is to evolve loading in a form that will be simple to use and at the same time ensure that the loading reflects, without wasteful exercise, the effect of actual traffic as per IRC code. The basis of the proposed loading is governed by following factors:

- Maximum Bending Moment (BM) and Shear Force (SF), caused by plying of design vehicles on simply supported spans of 5 to 50m and width 2.6 to 9.6m, have been computed under IRC Class-A, Class-AA Wheeled and Class 70R loading. (Figs. 84, 85, 86, 87, 88 & 89).
- The impact factor on these loadings has not been considered due to the fact that same can be applied in the final calculations depending upon user requirement for a particular span length as per IRC.
- Maximum BM and SF have also been computed for various simply supported spans of bridges by applying unit distributed load of the same length and width as of IRC loading.
- From these maximum BM and SF under unit distributed load, equivalent distributed load has been worked out for each case in such a way that maximum values of BM and SF are same under IRC loading.
- Finally, the equations have been derived from this study for uniformly distributed load which will be used to compute the value of maximum BM and SF for a given span length for various load cases enumerated as per IRC.

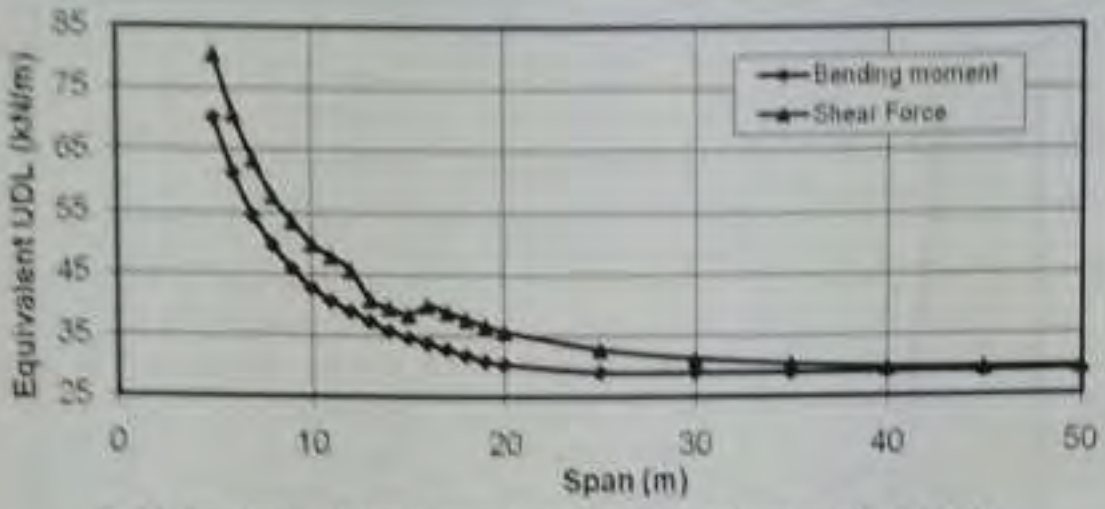


Fig. 84 Equivalent UDL for simply supported one dimensional beam element under Class A loading

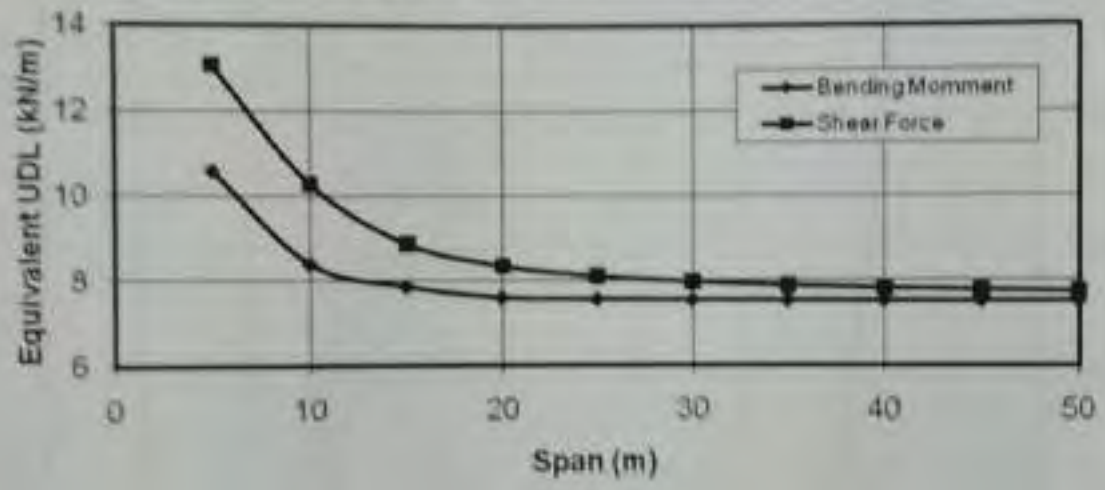


Fig. 85 Equivalent UDL for simply supported one dimensional beam element under Class AA wheeled loading

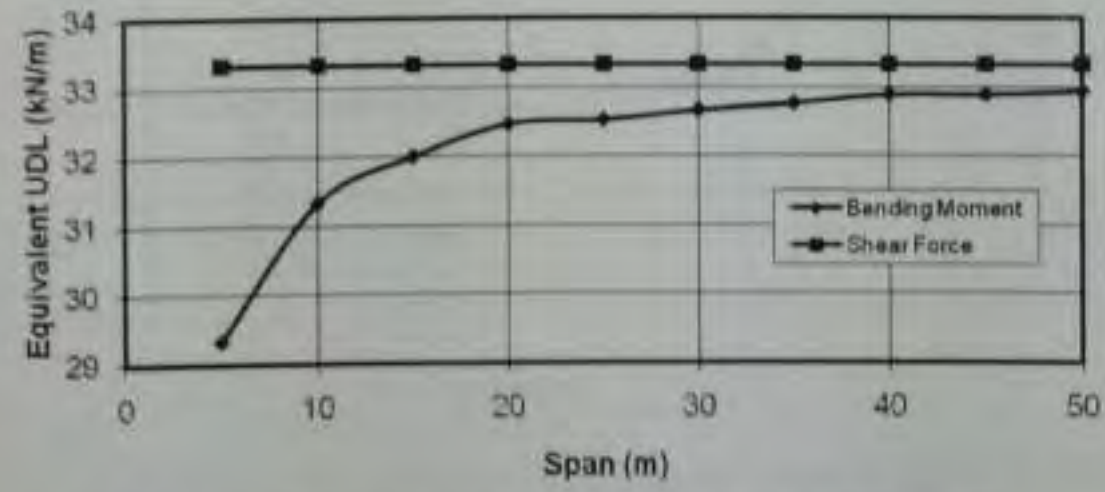


Fig. 86 Equivalent UDL for simply supported one dimensional beam element under Class 70R loading

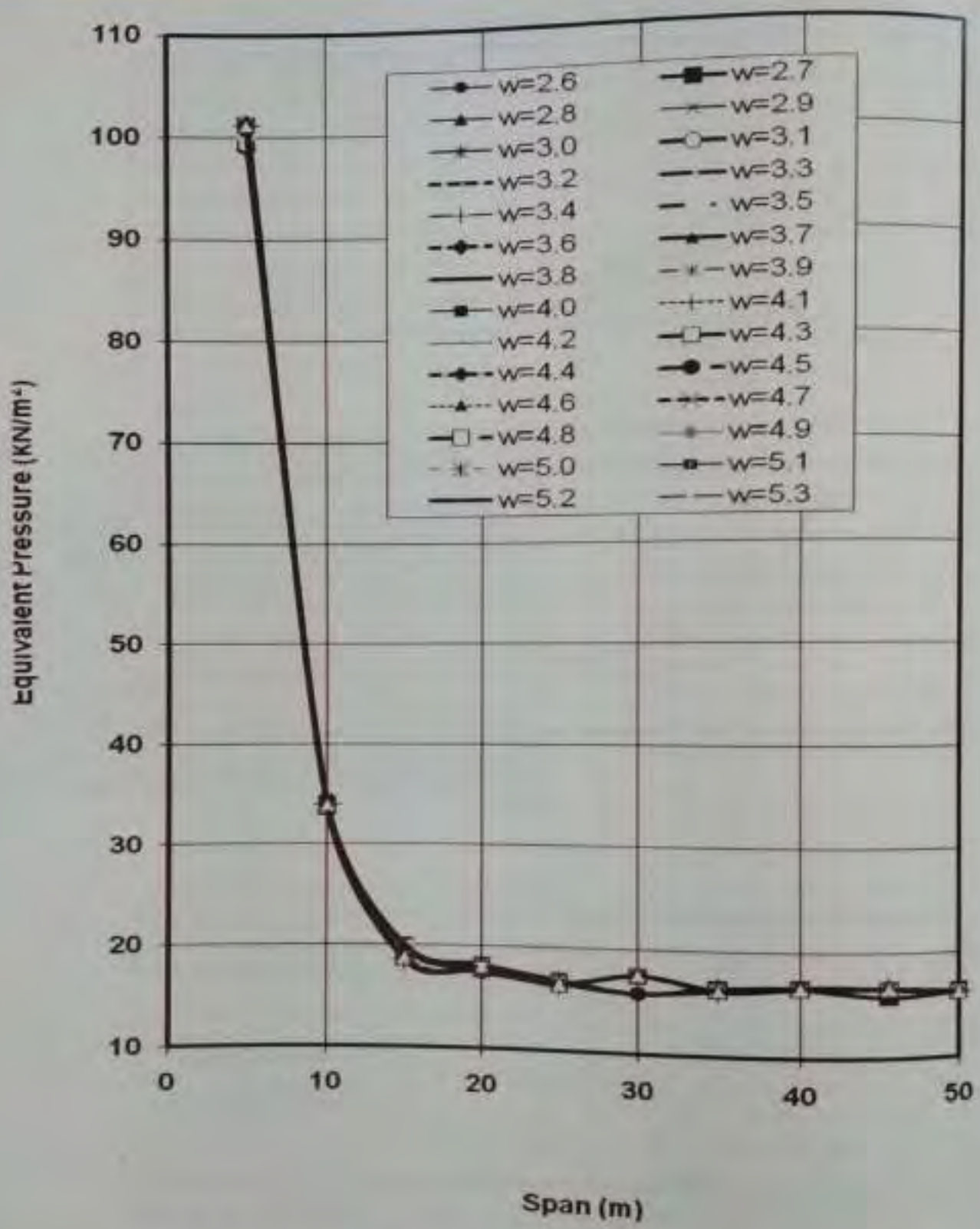


Fig. 87 Equivalent pressure for simply supported two dimensional slab element under IRC Class-A loading

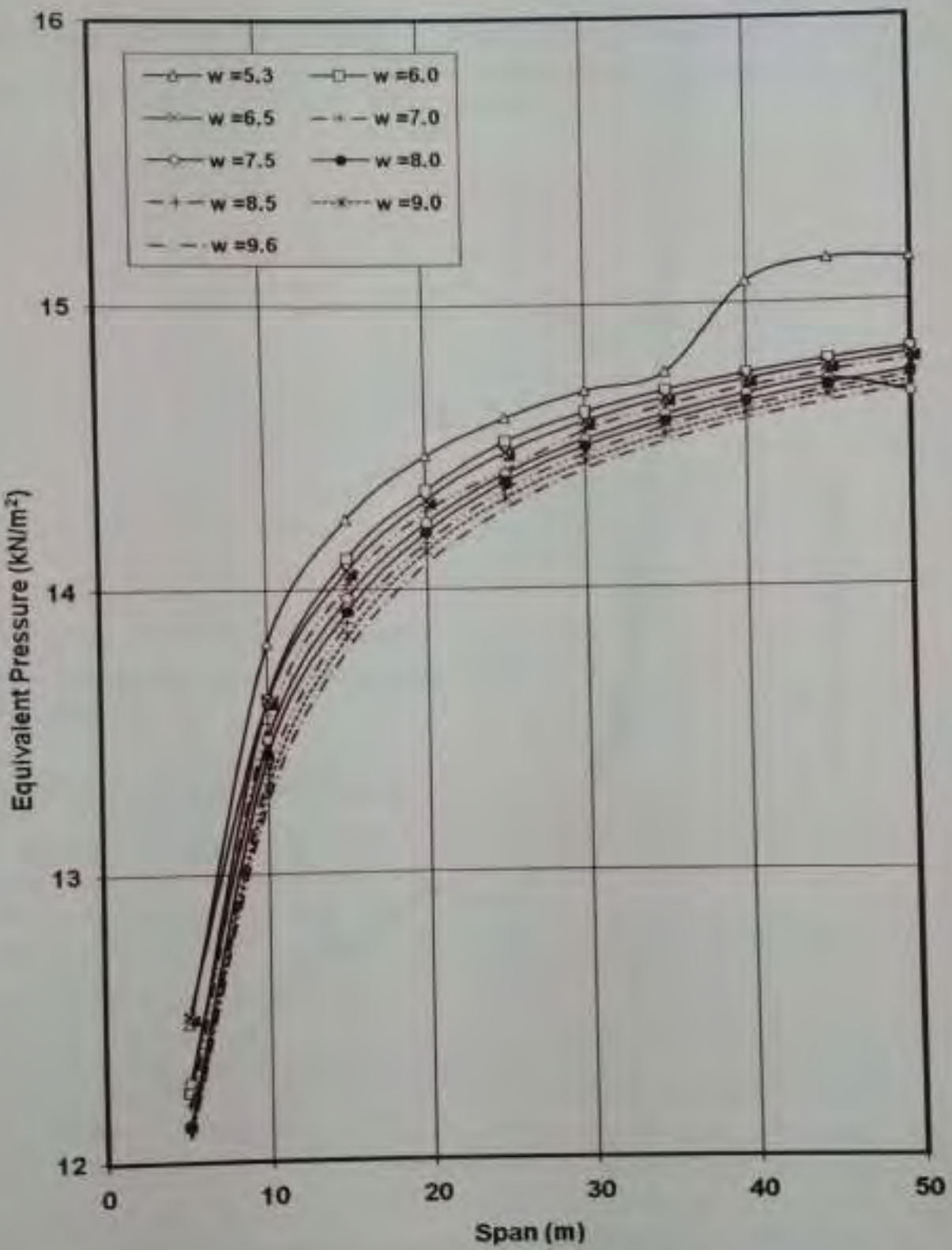


Fig. 88 Equivalent pressure for simply supported two-dimensional slab element under IRC Class AA wheeled loading

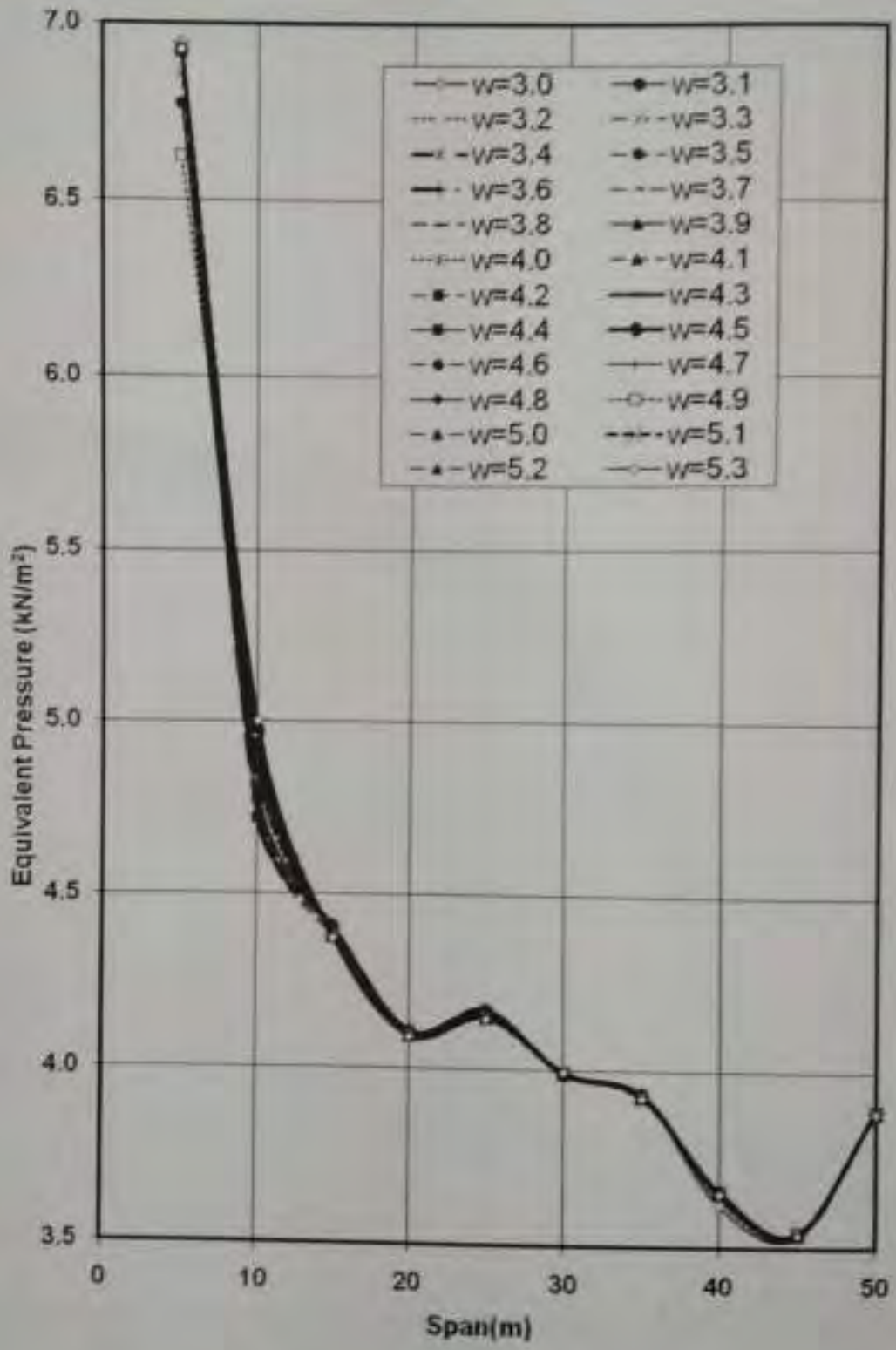


Fig. 89 Equivalent pressure for simply supported two dimensional slab element under IRC Class 70R loading

Validation of Simplified Loading

Validation of the simplified loading has been done by comparing the results obtained for IRC loading as well as simplified loading. Results are as follows:

Sl. No.	IRC Vehicle	Range of Percentage Error (%)	
		Bending Moment	Shear Force
	A. Simply Supported One-dimensional Beam Element		
1.	Class-A vehicle	1.37 to -1.51	1.57 to -6.13
2.	Class-AA Wheeled vehicle	0.79 to -0.31	0
3.	Class-70R vehicle	0.96 to -4.39	1.38 to -0.52
	B. Simply Supported Two-dimensional Slab Element		
4.	Class-A vehicle	4.15 to -6.00	
5.	Class-AA Wheeled vehicle	1.10 to -2.41	
6.	Class-70R vehicle	0.93 to -1.62	

Note: Negative values of percentage error shows that the values computed using Simplified loading are on higher side

Applicability of Simplified Loading

This simplified loading has been computed considering the following conditions and hence can be applied only under these conditions:

i) Support system : Simply supported

ii) Span length of the bridge : 5m to 50m

iii) Width of the bridge : 2.6m to 5.3m for Class-A vehicle

3.0m to 5.3m for Class-70R vehicle

5.3m to 9.6m for Class-AA Wheeled vehicle

Seismic Resistant Design of Bridges: Performance of Concrete Bridges

In a structure, within linear elastic range, stress does not exceed beyond a certain percentage of yield strength. The structure beyond the elastic range, that is in post-elastic range, may still carry some load thus possess post yield strength. A careful design consideration utilizing this post yield strength has been a subject of interest, especially for resisting severe magnitude of seismic forces which are less frequently occurring loads. By utilizing post yield strength (introducing ductility), bridge can be designed for lesser forces than obtained based on elastic range; thus the load carrying capacity can be

enhanced. This requires ideally employing non linear analysis tools (for simulating post-elastic range). Pushover analysis is an effective tool to evaluate the expected non linear behavior and consequent failure patterns occurring in different components of the bridge.

In the present study, typical short and medium span bridges such as a mono-pier (typically resembling the pier used in Delhi Metro construction), bent beam-pier frame (typically found in flyover) with and without elastic-foundation in the urban area are considered. Nonlinear push over analysis procedure as recommended by ATC-40 was adopted under various conditions of seismic demands. The hinge formation in pier for expected performance level is obtained, and compared for different boundary conditions in terms of different types of soil using soil-structure interaction. Parametric study considering various values of ground acceleration input and ductility factors has also been carried out. The response parameters such as base shear and tip (top) displacement of the piers for each case are assessed. This study would help in assessing load carrying capacity in post-elastic range of an existing bridge pier for appropriately retrofitting and also for the performance based design of new bridges.

Seismic Response Study of Earth Embankment

This study has been carried out with the following objective:

i) Analysed the layered ground including earth embankment of the Bhuj site and study the seismic response of horizontally layered soil deposit.

ii) Carried out parametric study using Artificial Neural Network to investigate the effect of various parameters of earthquake and soil strata on liquefaction of underground soil.

The followings conclusions are derived from the study:

i) In spite the good quality construction of embankments in the Bhuj area, wide and deep cracks are observed due to lateral spreading because of extensive liquefaction of the foundation soil caused by the Bhuj earthquake.

This soil amplification has caused large acceleration to the surface soil in the area. Close matching of the resulting wave frequencies with resonant frequencies of the high-rise building is one of the factors responsible for their collapse. Hence codal provisions in this area should emphasize strongly on geotechnical investigation and understanding the seismic behaviors of sub soil.

Evaluation of Corrosion of Steel in Concrete through Galva-pulse and Gravimetric Method

The scope and objective of this study is to develop a correlation between the corrosion loss of steel rebar, embedded in test specimen made of concrete grades M 20 and M 30, determined gravimetrically and estimated from the corrosion current measured using Galvapulse.

To achieve the above objective, rebar embedded slab specimens of size 50 x 100 x 230 mm, and 50 x 100 x 330 mm were prepared using

concrete of strength grades M 20 and M 30 (Fig. 90). The specimens were subjected to the accelerated corrosion conditions by in NaCl solution and then drying. The embedded rebars were pre-weighed before inserting in to the concrete specimen. The corrosion current of the rebar specimen was measured using Galvapulse quarterly (Fig. 91).

Some of the test specimens were broken and the steel bars were extracted. After cleaning the steel bars, the bars were weighed and the loss of steel due to corrosion by gravimetric method was determined. The corrosion current of the corresponding steel bars was converted into the weight loss using the Faraday's law. The weight loss obtained from both the methods were then plotted and an correlation graph was developed.

The equation of the correlation graph was: $y = 265.4x - 0.861$ where x = weight loss from the corrosion current (calculated using Faraday's law) and y = actual weight loss determined from the gravimetric method.

Fig. 90 Rebar embedded specimen prepared for testing with Galvapulse

Fig. 91 Testing of corrosion of rebar embedded in concrete slab specimen with Galvapulse

Consultancy Assignments

Creep Testing of M 60 Grade Concrete

The objective of the project is to determine the creep of concrete specimens of Grade M 60 supplied by M/S Gammon India Ltd from their bridge construction site. To achieve the above objective, fabrication of creep testing assembly (3 Nos.) conforming to the guidelines provided in ASTM C512 was completed. Guided the client in preparation of the test specimen, (prisms) embedded with vibrating wire strain gauge. After obtaining the requisite prism and cube specimen of M60 grade concrete from the client, tested the cubes for compressive strength of concrete at the time of commencement of creep testing, and the same was found to be 85.5 MPa. Loaded one prism specimen in the creep test assembly (for creep + drying shrinkage measurement at ambient temperature – A)) and the other prism specimen was left open in the ambient temperature (for

Fig. 92 Creep testing of M 60 Grade Concrete

drying shrinkage - B). The shrinkage strains from both A and B were measured at hourly interval for the first 24 hours, then once daily for the first one week and then weekly once for the first one month and then monthly once. An interim report was prepared and submitted to the client.

After the acceptance of interim report, a total of six prism specimen (each embedded with a vibrating wire strain gauge) were supplied by client. Three specimen were loaded in the creep testing assembly (for determination of creep + drying shrinkage (A)) and the other three specimen were used to measure the drying shrinkage (B). All the specimen were exposed to the ambient temperature.

The measurements of shrinkage strains at A and B were measured at an hourly interval for the first 24 hours, daily for the first week, and weekly once for the first one month and then monthly once. The measurements shall be concluded in June 2010. The analysis of test results is in progress.

The basic creep strain was measured as A-B at a given age (Fig. 92). In this testing, the basic creep at an age of 8 days was determined as 707.83 micro-strains. This value conforms to the range for the strength of concrete specimen under observation.

Assessment of Structural Integrity of Piles and Quality Control of Construction of a 4 Lane Pre-stressed Concrete Girder Bridge at RD-50 across Gurgaon Canal Feeder

This study was entrusted by Water Supply Division, Faridabad, to assess the integrity of piles by conducting one initial test and routine load tests at site and random quality control of the construction of the bridge 4- lane prestressed concrete bridge of 30m span, designed earlier by CRRI.

The structural integrity of piles was carried out by the Geotechnical Division. The quality control of construction of superstructure and substructure was taken-care. The team frequently visited the site and inspected the concrete quality being delivered from the RMC truck (irrespective of the time of concreting).

Fig. 93 Load testing of formwork of concrete girder at a bridge construction site on Gurgaon Feeder Canal

the reinforcement detailing, etc. during the construction of the girders, deck slab etc. Also, carried out the load testing of the girders before construction of the deck slab (Fig. 93).

Non-destructive Testing of Water Tank in MBSO, Maharani Bagh, New Delhi

The scope of this work was to assess the strength of concrete and the condition of reinforcement with respect to corrosion and the contamination of concrete of the water tank located in the CRRI staff quarter premises.

The water tank in CRRI Colony at Maharani Bagh was non-destructively tested using rebound hammer (for compressive strength), ultrasonic pulse velocity (for concrete integrity) (Fig. 94), test for corrosion potential (for detection of corrosion), chloride and sulphate contents (for extent of contamination) of concrete of staging wall, tank wall, deck slab, and columns in the tank. Galva-pulse was used to measure the corrosion potential. Concrete cores were also extracted from the staging wall and the tank wall, and the same were tested for compressive strength.

The compressive strength of staging wall as determined from rebound hammer varied from 19 to 42 MPa with an average of 29 MPa, while that of the tank wall varied from 39.6 to 52.2 with an average of 46 MPa. The compressive strength of columns in the tank varied from 22.8 to 35.8 MPa with an average of 28 MPa. The ultrasonic pulse velocity of concrete of staging wall varied from 2.07 to 3.04 km/sec while that of the tank wall varied from 2.92 to 3.90 km/sec. The testing of concrete cores also resulted in lower compressive strength values for concrete of staging wall while that of the tank wall yielded higher strength. The chloride and sulphate contents of concrete measured 0.2 percent and 3.4 percent, which are well within the permissible limits. However the carbonation of concrete was found to be extended up to the depth of the reinforcement.

Fig. 94 Testing of [illegible] of staging wall of the water tank at MBSO

Assessing Condition of Distressed Bridge at Kangsaati Bridge on NH-6

At the instance of ICT Pvt. Ltd., this assignment has been up with the objective to assess the strength and integrity of concrete of box girder of Kangsaati bridge located on NH-6.

To achieve the above objective, carried out non-destructive testing at site involving rebound hammer and ultrasonic pulse velocity of the concrete of, and extracted concrete cores from, the distressed deck slab of one span (LHS spanning P1-P2), and tested the concrete cores in the laboratory for compressive strength. Based on the analysis

of test results following conclusions were drawn:

a) The ultrasonic pulse velocity of the deck slab beyond 5L/8 (reckoned from Kolkatta end) and upto the Kharagpur end of the span, decreased drastically (values below 3.0 km/sec) indicating that the quality of concrete beyond the said location is not good.

b) The compressive strength of concrete as determined through the rebound hammer varied from 46 to 65 MPa. However, the influence of the rebound hammer extends up to 20 to 30 mm from the surface end, the condition of the concrete beyond this depth is not indicated by the rebound hammer testing.

c) The compressive strength of concrete cores varied from 32.5 to 50 MPa.

d) It was concluded that the distress found near the hole on the deck slab did not extend beyond a small distance / vicinity from the hole and the same is evident from the test results of the rebound hammer, ultrasonic pulse velocity and the core testing.

Evaluation of Ganjal Bridge for Increase in Axle Load of Freight Wagons on Routes of Western Central Railway

This assignment was referred by Western Central Railway. Fig. 95. shows the position of centrally loaded Engine on the Instrumented span of fish belly type Steel Bridge of WC Railway site at Ganjal (M.P). The different sensors and gauges installed at predetermined locations measured the various parameters such as strain, displacement etc. which are recorded using a data acquisition system under various test load cases. The recorded data have been analysed and compared with the results of theoretical analysis for the health assessment of this Railway Bridge.

Fig. 95 A view of Ganjal bridge of WC railway during field monitoring

Instrumentation

CENTRAL ROAD RESEARCH INSTITUTE

Multifunction Sidewalk Survey Vehicle System

Annual Report 2009-10

PROJECT TEAM MEMBERS OF INSTRUMENTATION DIVISION

Development of GIS based National Highway Management System

As reported earlier (Annual Report 2008-09), Ministry of Road Transport & Highways, has sponsored a study on "Development of GIS Based National Highway Management System" for effective and efficient management of primary road network of the country. Under this project an advanced Network Survey Vehicle (NSV) from ARRB, Australia, has been procured for generation of data base on road conditions and inventory of road for National Highway network in the country (about 50,000 km) (Fig. 96).

Fig. 96 Multifunction network survey vehicle system

During the year, the collection of primary road condition and road inventorisation data through NSV on National Highways was continued in North Eastern States.

Upgradation of Road Geometrics and Road Condition Evaluation System

Upgradation of Road Geometrics System

CRRI has developed an instrumented van for Road Geometric and Pavement Condition Evaluation. Road geometric measurement involves measurement of road roughness, vertical gradient and horizontal curvature. Axle mounted roughness measuring device, vertical profile meter (VPM) and Gyroscope are used for measurement of road roughness, vertical gradient and horizontal curvature respectively.

In the existing Road Geometrics Measuring System, measurement of road geometrics (Roughness, gradient, curvature) is done using electro-magnetic counters. These parameters are recorded manually from these electro-magnetic counters in data recording sheets. In the upgraded system, data will be downloaded directly to computer.

Upgradation of Road Condition Evaluation System

In the existing road condition evaluation system, video image of the road are recorded by an analog video camera covering a max. of 2m. road width (approx. half lane width). In the upgraded system, this analog camera will be replaced by high resolution firewire camera having capability of covering entire length. In the present system Pentium-I laptop and PC are used which will be replaced by a Pentium-IV laptop and PC in the upgraded system.

Two additional cameras will be used for recording the right of way and front view. Firewire cameras will be used and these cameras will be triggered by distance pulses. Two pavement cameras will be triggered, when length of one frame has been covered by the van. If the length covered by one frame of the camera is two meter, the cameras will be triggered at every 2m distance traveled. With this technique recorded frames will cover the entire length without overlapping. The total cost of the project is Rs. 50 lakhs. During the year the second part of

the project i.e. "Upgradation of Road Condition Evaluation System" has been taken up. After extensive literature survey the specifications of the equipment were finalized and equipment were indented. Procurement of the equipment is under process.

Fuel Consumption Studies

Under the study on development of Management System for maintenance planning and budgeting of high speed road corridors, fuel consumption studies are conducted for building up relationships between fuel consumption and important roadway characteristics and some other factors such as speed.

These relationships will be of immense value in planning road improvement and working out strategies for efficient fuel management in the country.

For measurement of Road Geometrics, following equipments have been installed in the Maruti Van. The equipment have been calibrated.

Axle Mounted Roughness Measuring System

In this equipment the differential movement between the rear axle of the vehicle and the body, floor of the vehicle, due to road unevenness is measured by the upward vertical motion of a wire which is transmitted into uni-directional rotatory movement of pulley of the integrator unit fitted in the rear of the vehicle. In the integrator unit rotatory movement of the pulley is converted into electric pulses which are recorded in electronic counters. One count in electronic counter corresponds to 1 cm relative movement between axle and floor of the vehicle.

Vertical Profile Meter (VPM) for Gradient Measurement

The instrument consists of a heavy aluminium alloy pendulum suspended at a fulcrum. A horizontal shaft passing through the fulcrum has a gear wheel at its end which activates another gear wheel provided at the centre of a graduated semi circular disc. This disc is provided with a pointer needle at its centre. By this arrangement small angular deviations of the pendulum are magnified by its pointer. The disc is rigidly attached to a frame, which is in turn attached to the vehicle body. The platform for mounting the frame containing the Vertical Profile Meter is first of all lavelled very carefully to horizontal position by means of spirit level. The system enables the pendulum to retain the vertical position even when the vehicle is traveling on a plus or minus gradient. The graduated disc attached to the vehicle body shifts the position, resulting in the pointer recording the angle of inclination of the plane on which the vehicle is traveling.

Calibration of Automatic Road Unevenness Recorder (ARUR)

About thirty five (35) numbers of Automatic Road Unevenness Recorder (ARUR) units, comprising both Car Axle Mounted Bump Integrator and Fifth Wheel Bump Integrators, received from different manufacturers and user agencies, were calibrated using Dipstick, Class I equipment. Roughness measurements, using Dipstick and the response type roughness measuring device were undertaken on a number of selected test sections having varying roughness levels (excellent to very poor). Calibration equation between the observed roughness and the standard roughness is developed to determine the Corrected / calibrated roughness. Calibration certificate is issued to these agencies.

Traffic & Transportation Planning

Traffic Engineering and Road Safety

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report 2009-10

PROJECT TEAM MEMBERS OF TRAFFIC ENGINEERING AND ROAD SAFETY DIVISION

Understanding Road Rage: Implementation Plan for Promising Mitigation Measures

Road rage is a phenomenon which indicates that society is on edge. Increasingly, aggression and violence has appeared to drift further into mainstream of Indian society. Stories of school shootings, workplace violence, violence on the airlines, and "road rage" abound. Road rage has recently been cited as equalling alcohol-impaired driving in the number of resultant motor vehicle accident related injuries and fatalities [Martinez, 1997 and Snyder, 1997]. The probability of becoming a victim on the roadways is significantly increased by the average exposure of the individual on the road. Presently Indian roads and driving conditions are a point of discussion moreover no comprehensive data is available to how many persons die or are injured due to road rage cases. In the last three years in the capital of India sudden provocation prompted people to kill or physically assault each other .In 2005-2006 it topped the list of murder motives. In 2007 it was the second highest cause in murder list (Fig. 97).

This report discusses results of opinion survey of experts as well as of the drivers/ commuters, detailed analyses of the causes and time-wise, vehicle-wise, location-wise aggressive behaviour among drivers. Report further highlights action plan for mitigating measures for reducing aggressive behaviour among Indian drivers.

This study was conducted on drivers randomly across age group, qualification, profession and driving exposures with the help of experienced traffic police personnel. Various aggressive driving behaviour parameters were measured by the administration of propensity of aggressive driving scale (PADS). Following steps were adopted in the present study:

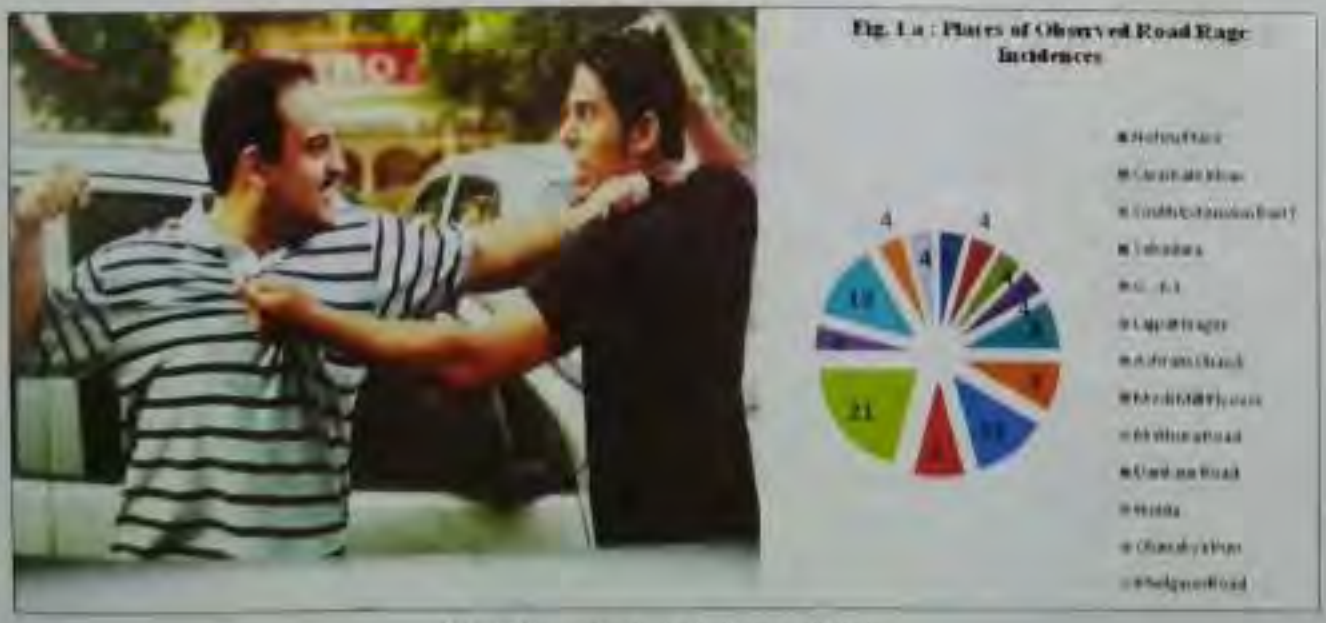


Fig. 97 Places of observed road rage incidences

- Interview with the Additional CP Licensing, Delhi regarding opinion about road rage
- Data collection by administering PAD Scale on drivers
- Data compilation and analysis
- Report writing
- Planning and implementation of mitigation measures

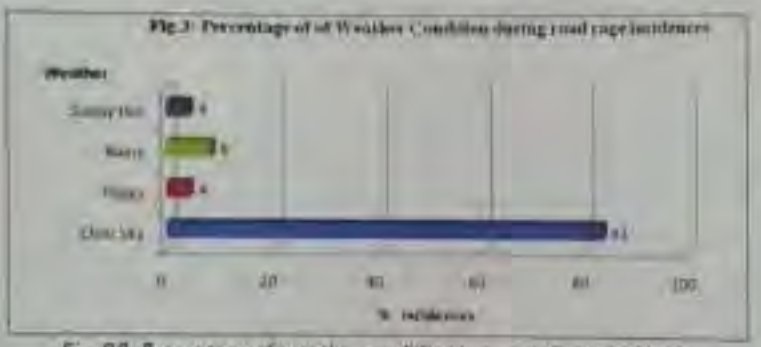


Fig. 98 Percentage of weather condition during road rage incidences

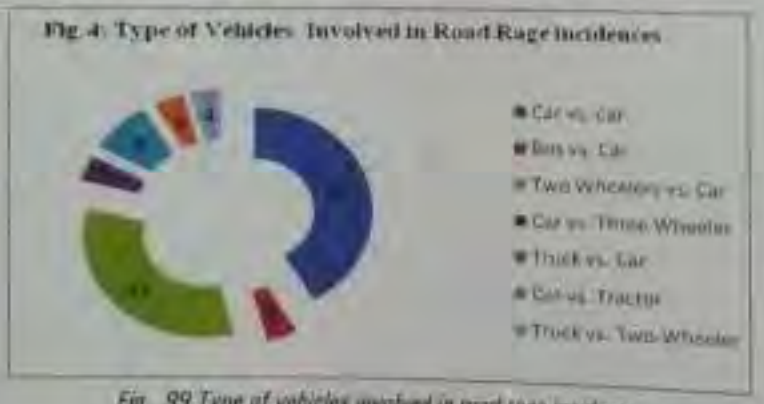


Fig. 99 Type of vehicles involved in road rage incidences

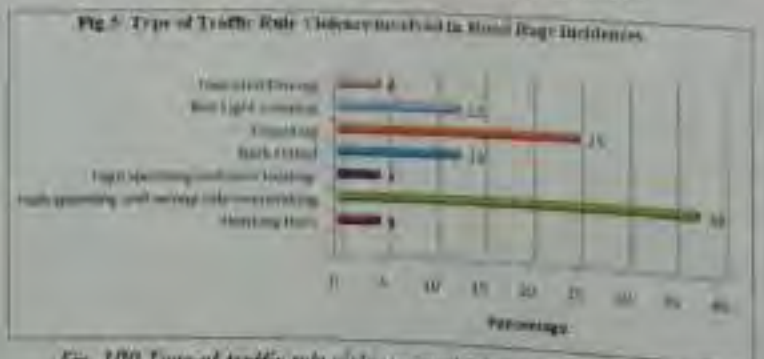


Fig. 100 Type of traffic rule violence involved in road rage incidences

This research report discusses results of opinion survey of experts as well as of the drivers/ commuters, detailed analyses of the causes and time wise, vehicle-wise, location-wise aggressive behaviour among drivers. This research work further highlights action plan for mitigating measures for reducing aggressive driving behaviour among Indian drivers. Overall 503 (whole vehicle population) number of red light jumping cases were observed out of which drivers of two wheelers & light motor vehicles were observed maximum violating traffic signals by jumping red lights. Maximum numbers of red light jumping cases were observed during the evening peak hours. On the basis of this survey it was observed that road rage incidences were not always related to adverse weather conditions except some exceptional cases (Fig. 98). Road rage cases were maximum observed with car vs. car followed by car vs. two wheelers (Fig. 99).

From the survey, it was observed that 38 percent road rage incidences were triggered due to high speeding accompanied with wrong inside overtaking and 25 percent due to tailgating by any of the parties (victim or aggressor). Other types of violence involved during road rage incidences were red light jumping 13 percent, hitting from the back 13 percent, high speeding with overloaded vehicle 4 percent, aggressive honking horn 4 percent and driving under influence of alcohol 4 percent (Fig. 100). Almost similar results have been observed in the data analysis according to driving experiences. Respondents of category one i.e. the drivers having driving experiences up to 5 years have shown maximum aggression

level while the other groups has almost same level of aggressiveness. This observation of research data proves that the novice drivers have maximum chances for involving in road rage incidences. Respondents of category one i.e. students have shown maximum aggression level while the other groups has almost same level of aggressiveness. This observation of research data shows that the drivers of having new driving experiences have maximum chances for involving in road rage incidences as compared to the other professional categories.

Additional Commissioner of Police Licensing branch, Defence Colony, New Delhi expressed her opinion in an interview which was conducted by the research team that road rage is a phenomenon which shows that the society is on an edge; moreover it is a symptom of social fragmentation where one person is not able to appreciate and adjust with the problems of another.

Due to time and manpower constraint the observation area surrounding Delhi and NCR was kept limited. Various levels of aggressiveness were analysed on the basis of six major independent variables i.e. age, gender, profession, driving experiences and qualification taken up in the study.

Overall responses of the respondents in all situations of PADS scale were compiled and analysed to observe the age-wise effect of aggression over different situations. On the basis of the data overall maximum aggressive responses were shown by the respondents of 19 to 25 years age group who has shown 12.9 percent extreme aggressive responses, 23.7 percent aggressive responses followed by the below 18 years age groups whose parents had provided them their vehicles to drive and some respondents were having motorbikes. These age groups were observed as most vulnerable groups for involving in road rage cases resulting to fatalities and accidents.

Female drivers showed more aggression as compared to the male drivers as female drivers have shown 10.2 percent extreme aggression level as opposed to 6.4 percent of male drivers.

As with most human behaviour, there is a stated and unstated, a conscious and unconscious motivation for most traffic disputes. Today aggressor could be male or female, young (usually), or old, educated or uneducated, rich or poor. Violent traffic disputes are rarely the result of a single incident but the cumulative result of a series of stressors.

Overall, there was no significant difference up to .05 level in ANOVA has been found as drivers qualified up to post graduate levels were found showing maximum aggressive responses followed by drivers qualified up to primary and secondary levels.

Interventions of Road Rage:

Lack of tolerance with growing indiscipline accompanied with reducing fear of imprisonment or penalties among road users curbing the Indian cities more insecure for vulnerable group which include psychically weak, poor or powerless

person. The mitigations measures can broadly be divided into following main areas.

- Education and Enforcement
- Behaviour Scanning and Modification

CRRI has initiated significant mitigation measures for controlling road rages:

a) By creating awareness among school children

b) By helping students for road rage related research and mitigation measures through www.navchetna.com

Adequacy of Traffic Signal Timing for Pedestrians

Pedestrian facilities are awfully lacking. The roads are widening but the traffic signal timing at most of the places is unchanged. There are virtually no pedestrian signals. As the time allotted to cross the road is inadequate, it is giving rise to many road traffic fatalities involving pedestrians. The traffic signal timing is to be according to the requirements of pedestrians. A study on Adequacy of Traffic Signal Timing for Pedestrian has been taken up with the following objectives.

- To find out the adequacy of signal timing for pedestrian safety.
- To study the effect of inadequate traffic signal time for pedestrian safety in particular and road safety in general.
- To provide recommendations

Surveys at five most accident prone intersections for pedestrians have been undertaken. Opinion surveys are also being conducted. Work is in progress.

Road Audit Safety Manual

As reported earlier, under the study sponsored by MORTH, a manual has been produced in April 2003. This manual is based on research work. However, it is now substantially revised. The Manual is aimed at decision-makers, engineers and technicians throughout the Indian road sector, irrespective of whether they work at National, State, District or Local level. It is intended for all those who can and should contribute to improving safety on Indian roads. It provides procedures for applying quality assurance to road projects, from the standpoint of road safety. The methodology is known as 'road safety audit'. When its application becomes widespread, it is expected to make a significant contribution to the prevention of accidents on roads.

The application of cost-effective measures on existing roads as a basis for accident reduction is established through accident investigation procedures, whereas the application of safety principles in the provision, improvement and maintenance of roads as a means of accident prevention can be established through road safety audit. Thus, the purpose of this audit is to ensure that all road schemes should function as safely as possible, which means that the road users will be exposed to a minimal risk of accident, both on new roads as well as on existing roads. The purpose of the Manual is to introduce the subject of road safety audit and to make it possible for everyone to apply it. It is also an important tool for the technicians who will work with road safety

audit. In public private partnership projects and model concession agreements, provision is made for road safety audits to be ensured by the concessionaire during development construction and operation & maintenance phases.

This Manual is arranged in nine chapters as under:

- ***CHAPTER 1*** describes the accident scenario in India, prevention of accidents, and significance of road safety audit.
- ***CHAPTER 2*** describes in detail the concepts of road safety audit, when to conduct, quality assurance, procedure to conduct audit and value of safety audits. Also describes cost and benefit scenario with respect to road safety audit.
- ***CHAPTER 3*** describes the stages of road safety audit i.e., during feasibility study, during completion of preliminary design, during completion of detailed design, during construction stages, during pre-opening and on existing roads.
- ***CHAPTER 4*** describes the road safety audit process for new and existing roadway sections and surveys to be carried out on existing roadway sections for achieving good quality of safety audit.
- ***CHAPTER 5*** describes the salient features and principles for safer road designs with safe environment to warn, guide, inform and control the driver on the road.
- ***CHAPTER 6*** describes the specific parameters to be considered in the present day traffic scenario in India.
- ***CHAPTER 7*** describes the purpose of checklists, when and how to use the checklists and the checklists that are to be applied in different stages of safety audit.
- ***CHAPTER 8*** gives suggestions on the measures of the success of safety audit.
- ***CHAPTER 9*** outlines how to get road safety audit started in an organization concerned with roads.
- ***Annex A*** provides the checklists related to different stages of road safety audit.

Manual on Economic Evaluation of Highway Projects in India

The Special Publication Number 30 on "Manual on Economic Evaluation of Highway Projects in India" was first published by the Indian Roads Congress in the year 1984 and subsequently revised version of this manual was published in 1993. Since 1984, this manual has been recognized as an invaluable tool for the highway engineers, who are not professional transport economists by education or training, to understand and evaluate the economic implications of a highway project. It was very well received by highway professionals all over the country.

However, during the last decade, the equations for Vehicle Operating Cost *(VOC)* and other parameters provided in the manual

have become obsolete considering two important reasons. Firstly, the economic liberalization process initiated in India more than fifteen years ago has resulted in the entry of vehicles having better fuel-efficiency and also possessing excellent pick-up in the Indian market. Due to this, it has become imperative that the research on road user cost has to be reviewed and updated periodically so as to adequately represent the changed conditions. Secondly, the cost parameters considered in the first revision of this manual have also undergone radical changes during the intervening period due to cost escalations.

In view of the above, the research scheme sponsored by the Ministry of Road Transport and Highways (MORT&H) titled, "Updation of Road User Cost Data" to the Institute, in 2001 has served as the backbone for bringing out this updated version *i.e. second revision* of this manual. Further, the research findings obtained from other studies have also been incorporated in this updated version. The updated VOC equations incorporated in this manual account for changes in the new generation vehicles in terms of their operating characteristics coupled with design characteristics of the roads. Therefore, this manual is expected to be a valuable tool for working out economic justification of medium and large sized highway projects. It is hoped that the highway engineers as well as consultants will be able to use this revised manual for making comparative evaluation of choices with respect to the road development programmes.

Consultancy Assignments

Traffic Studies for Preparation of Transport System Management Plan for Major Corridors of Lucknow

Lucknow Development Authority (LDA) has requested Central Road Research Institute (CRRI) to prepare Comprehensive Traffic and Transportation Plan for Lucknow. It was decided to take up this study in two phases viz. Phase I : short term immediate traffic studies to prepare Traffic System Management Plan to address the problems of Traffic in shortest possible time and Phase II : Comprehensive Traffic and Transportation Study for preparation of long term Transport System Plan. The technical proposal was submitted for Phase I of the study to prepare Traffic System Management Plan for selected major corridors of Lucknow to address the immediate problems of traffic. The objectives and scope of the study are :

(i) To conduct appropriate field studies to appreciate and quantify the traffic problems, traffic characteristics and site conditions of these corridors.

(ii) To prepare traffic system management plan by employing various Traffic Management Techniques and to prepare the required transport infrastructure improvement proposals for the selected corridors for efficient movement of traffic.

(iii) To evolve and recommend various measures and policy guidelines for efficient management of traffic on these

corridors.

The scope of the study is limited to field studies, preparation of infrastructure improvement plans and traffic parking management plans for the selected major ten corridors, six major intersections and eight parking areas. The work pertaining to field survey is in progress. The selected corridors are shown in Fig. 101.

Traffic and Air Pollution Surveys on Road Network Connecting Darlaghat – Ropar and Darlaghat – Nalagarh

M/S Ambuja Cements limited has initiated expansion of one of its Cement plant at village Rauri, Darlaghat (HP), Clinker 1.8 MTPA to 2.6 MTPS. It is proposed to establish a new grinding unit at village Panjehra in Nalagarh

Fig. 101 Selected corridors for study

(H.P.), which is situated at a distance of about 20 km from its existing grinding plant at Ropar (Pb). The expansion of the capacity of the plant would impact the transport infrastructure and environment in the influence area to a large extent. In order to study the impact of the expansion of the capacity of the cement plant on local and surrounding transport infrastructure and the environment, a study has been sponsored by M/S Ambuja Cements Limited to the Institute with the following objectives.

- To study the impact on local transport infrastructure (including those outside the project area) due to the proposed expansion project.
- To study the impact on environment (air pollution) due to the proposed expansion project in the influence area.
- To suggest the measures and arrangement for improving the transport infrastructure and environment and actions to be taken by various agencies including state government.

The Darlaghat Cement Plant is situated at Suli 2 km. from NH-88 which is connecting Shimla and Hamirpur. It is about 18 km. from Arki (Tehshil of Solan District) and is about 40 km. from Shimla. The Ropar grinding unit is situated at about 2.5 km from NH-21 (Chandigarh-Manali Highway), 50 km from Chandigarh and 6 km. from District headquarter Roopnagar in the north. The nearest Railway Station is Ghanoli on Ambala-Nangal Dam-Una broad gauge line of Northern Railway which is about 2 km from the Ropar Unit. While the Nalagarh grinding unit is being developed about 3 km from Sawarghat-Nalagarh Highway (NH-21A) and is about 20 km from Ropar plant at about 2.5 km on opposite side of NH 21 i.e. between NH-21 and NH-21A. The road connecting Ropar unit and Darlaghat pass through Kiratpur, Sawarghat, Nauni on NH-21 (having four lane divided carriageway up to Kiratpur, two lanes with paved shoulders from Kiratpur to Swarghat and two lanes carriageway from swarghat to Nauni). The road network of the surrounding area is shown in Fig. 102.

The roads are used by Ambuja Cements trucks to carry the clinker from Darlaghat unit to Ropar unit (and will be used for same to Nalagarh unit) and majority of same trucks while returning back carry fly-ash from Guru Govind Singh Super Thermal Plant at Ropar to Darlaghat (and would carry the same to Nalagarh plant also) (Fig. 103).

Based on survey and detailed study of the influence area and the road network, fifteen traffic survey locations were selected in consultation with GACL officials. The important criteria considered for selection of the survey points was similarity of traffic on the selected influence sections and extent of usage by GACL vehicles and other traffic. Following conclusions and recommendation were made.

Conclusions

- From analyses of traffic data it is found that total daily (24 hour) traffic volume at Darlaghat Intersection is of the order of 9100 vehicles (14800 PCUs); of the order of 10500 vehicles (18500 PCUs) at Nauni intersection; of the order of

21000 vehicles (33000 PCUs) at Kiratpur intersection and of the order of 13600 vehicles (16600 PCUs) at Panjehra intersection.

- Both direction traffic volume at various sections of the influence road network varied from 2466 Vehicles (4005 PCUs) at Nauni- Bhrampukhar section to as high as 15955 Vehicles (24501 PCUs) at Kiratpur-Ropar section.
- It is found that heavy commercial vehicles (trucks) have dominant share varying from 26 to 37 percent followed by cars 26 to 27 percent and motorised two wheelers 32 to 14 percent in total daily vehicular flow at Kiratpur intersection and Nauni intersections respectively.
- It is found that the total numbers of yearly accidents are high (104 to 140) though they are not rising. Similarly the numbers of persons killed yearly (20 to 38) and seriously injured yearly (15 to 30) are also high though they are not increasing for the past five years.
- Capacity assessment has been done for the existing traffic loads including that due to existing Ambuja Cement

Fig. 1B2 Transport network of surrounding area

Fig. 103 A view of Barlaghat intersection

plant and other cement plants in the area and is found that most of the sections are over utilized with volume to capacity (V/C) ratio varying from 0.6 at Nauni-Bhrahmpukhar section to 2.7 at Kiratpur-Swarghat section.

- Future traffic has been projected by applying a uniform annual growth rate of 5 percent at all the sections of road network in the initial stage without taking into consideration the proposed expansion of GACL Plant or other Cement Plants in the area and volume to capacity ratio has been assessed for two scenarios.
- It is found that under do-nothing scenario volume to capacity (V/C) ratio for future traffic (year 2020) will vary from 0.9 at Nauni-Bhrahmpukhar section to 4.4 at Kiratpur-Swarghat section while it will vary from 0.8 at Nauni-Bhrahmpukhar section to 4.4 at Kiratpur-Swarghat section under second scenario of ongoing capacity augmentation under National Highway Development Programme (NHDP) particularly on NH-88 and NH 21A which indicate adverse congestion on almost all the sections.
- Even after this the Nauni- Swarghat section require immediate special capacity augmentation program in the form of widening or at least paving of shoulders as this section caters to

traffic from all the cement plants in the area and traffic from Shimla-Hamirpur (NH-88) and Manali-Kullu (NH-21) and there is no alternate road to it.

- All the sections require major augmentation in their capacity by way of widening and development of alternative routes for handling the future projected traffic.

Recommendations

Keeping in view the capacity and characteristics of the existing transport infrastructure of the influence area, existing traffic volume and other traffic characteristics, it is recommended to go for immediate capacity augmentation of the transport infrastructure based on requirements of various sections.

Taking into consideration future traffic projection due to natural growth and growth in traffic due to industrial and other developments induced due to the existing cement plants operated by various companies in the area and their normal growth it is recommended to plan transport infrastructure development based on comprehensive study. Development plans must be backed by transportation demand and feasibility of various alternatives from physical/implementation and economic point of view.

Any expansion in the existing capacity of the cement plants operated by various companies or upcoming plants in the area is going to load the transport infrastructure adversely. It is recommended to study the cumulative effect of proposal of expansion of various plants and evolve strategic and feasible plan for development.

In the mean time it is recommended to complete the ongoing capacity augmentation under the NHDP (National Highway Development Programme) on existing highway sections i.e. NH-88 (Bilaspur Nauni-Bhrampukhar Darlaghat Shimla) and NH 21A (Swarghat- Panjehra-Nalagarh) which are being widened from existing intermediate lane to two lanes with paved shoulders at the earliest. This will enhance the capacity of the sections of transport infrastructure to cater to the existing demand of traffic to a great extent. Augmentation of capacity of NH 21A (Swarghat- Panjehra-Nalagarh) will relieve Swarghat-Kiratpur section of the worst congested sections viz. (Kiratpur-Swarghat-Nauni) of NH-21. Even after this the Nauni- Swarghat section requires immediate special capacity augmentation program in the form of widening or at least paving of shoulders as this section caters to traffic from all the cement plants in the area and traffic to/from Shimla-Hamirpur (NH-88) and Manali-Kullu (NH-21) and there is no alternate road to it.

Though it is the responsibility of the State Government to provide and maintain the required infrastructure including road infrastructure to attract and sustain the industrialization and development investments, still various models of funding these projects can be evolved by partnering with the stakeholders.

Assessment of Drivers Driving Characteristics Using Advanced Driving Simulator

Main objective of this project is to modernize the existing Driving Testing System with virtual reality testing system with real time information system with randomized testing facilities for more efficient automated data capturing system to discourage subjectivity, cheating and duplication.

This project will be helpful to test the driver's capacity to tolerate the stress situations under laboratory generated controlled conditions. The testing process features a number of measures during different driving skills under different weather conditions and traffic densities. The administrator can evaluate online drivers' skill by tracking his positions and maneuvering capacities during the testing process. The Institute has installed the Car Driving Simulator. The executives of the company have trained our scientists and twenty-five drivers from cabinet secretariat (Ministry of Surface Transport) were tested and evaluated.

Traffic & Transportation Planning

Transport Planning and Environment

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report 2009-10

PROJECT TEAM MEMBERS OF TRANSPORT PLANNING AND ENVIRONMENT DIVISION

Environmental & Road Safety Considerations during Transportation of Hazardous Materials by Road

In recent years, keeping pace with other industrialized countries, India has also witnessed rapid growth in transportation of hazardous goods by road. Experiences from all over the world have shown that the movement of such substances is more prone to accidents than the movement of the other goods. It has been observed that the carriers of such hazardous materials, when involved in a road accident may lead to disastrous consequences like fire, explosion, spillage and leakage, resulting in a number of fatalities and injuries besides property loss and environmental pollution.

At present in India there are several agencies of the Government, both Central and State, which prescribe various rules and regulations regarding the safe handling (e.g., manufacture, storage, transportation, treatment and disposal) of hazardous materials. The Ministry of Environment and Forests (MoEF), Govt. of India has prescribed various rules and regulations under various Environmental Legislations/Acts for safe handling of these hazardous materials (excluding related to their transportation by road), which has been covered under the different provisions of the Motor Vehicles Act (MVA) (1988) including the Central Motor Vehicle Rules (CMVR) (1989). In spite of these rules and regulations, accidents do take place due to the lack of their strict implementation and awareness amongst different stakeholder. In India, Rule 129 to 137 of the CMVR (1989) contains several provisions for safe transportation of hazardous materials in India. These rules, which are applicable to whole country, stipulates various provisions related to educational qualifications for drivers, manner of display of Class Labels and Emergency Information Panel (EIP), responsibility of the consignor, transporter or owner & driver, instructions to the driver and requirement of driver to report to police station about the accident.

Present study has been undertaken to know the present status of compliance of various CMVR provisions related to safe transportation of hazardous materials by road. Study findings have indicated that the compliance and awareness of these rules and regulations have improved quite significantly since last 10 years. A higher percentage of the hazardous material carriers now display correct EIP, although significant percentage of drivers are still not fully aware about the contents and purpose of the display. It was also found that the most of the drivers were carrying Transport Emergency Card (TREMCARD), but they were found to be carrying them like any other important document without understanding their importance. In many cases, the drivers were carrying different TREMCARDs, which were not relevant to the hazardous materials being transported by them and probably was pertaining to earlier assignment.

It was found that the drivers employed by reputed Public Sector Undertakings (PSUs)/big industrial houses for transporting hazardous materials, were much more aware than the drivers employed by others and had attended at least one training programme regarding various safety aspects during transportation of hazardous materials by road. As a part of the study, a compilation of the road accidents involving hazardous material carriers in India was also done for the period between 1996 to 2009 and various major national laws were also

enlisted which are applicable while transporting such hazardous materials by road in India. The present study has clearly revealed that, while there are ample legal provision and guidelines for transportation of hazardous materials their implementation is grossly lacking in India due to lack of awareness among transporters, drivers as well as among enforcement agencies.

Various enforcement agencies and other stakeholders including transporter, drivers, and general public are also not fully aware about the various provisions/guidelines stipulated in MVA (1988) & CMVR (1989) and about disastrous consequences in case of their accidents. There is an urgent need that the Central, State Governments and local authorities remain to fully prepare to meet any eventualities involving such carriers.

Awareness amongst the general public, proper and systematic training to traffic police, fire brigade personnel and most important to the drivers can drastically reduce the frequency and magnitude of such accidents Fig. 104.

Fig. 104 Incorrect display of Emergency Information Panel (EIP) on a hazardous material carrier (Rule 134 of CMVR (1989))

Feasibility Study to Examine the Possibility for Installation of Weigh-in-Motion (WIM) System at Various Entry Points of Delhi

A Writ Petition (W.P.) Civil No. 14423/06 in Hon'ble High Court of Delhi was filed against Department of Transport, Govt. of NCT & Others in August, 2006 by an NGO. Four Government Departments viz. Department of Transport, Govt. of NCT Delhi; Addl. Commissioner of Police (Traffic), Police Headquarters, Delhi; Municipal Corporation of Delhi (MCD), Town Hall, Delhi; and Central Road Research Institute, (CRRI) New Delhi were made as the Respondents. Petitioner had expressed serious concerns about the rampant excess loaded trucks which are not only commuting within the State of Delhi but are also not being prosecuted. The CRRI was asked by the Hon'ble High Court of Delhi to assist it by producing reports and documents related to the case. Further, Hon'ble High Court of Delhi in its order directed CRRI (Respondent No.4) to carry out a feasibility study to examine the possibility for installation of weigh brides (in particular the Weight-In-Motion System) at 13 entry points for the purpose of checking overloaded trucks entering in Delhi.

A total of fifteen entry points/ borders were studied in detail to determine the possibilities of installing WIM system to check overloading by commercial vehicles at these locations (Figs. 105, 106, 107, & 108). Further, since the Weigh-in-Motion is a very advanced computerised based technique for weighing commercial vehicles (primarily trucks) has

not been extensively used so far in India. To collect the relevant information concerning the installation of Weigh-In-Motion, a CRRI team had also visited the Jaipur-Kishangarh Expressway (BOT Road) near Jaipur where NHAI has recently installed High Speed Weigh-in-Motion System at two locations.

The methodology adopted for conducting the feasibility study at 15 entry locations involved the following major activities / tasks, (i) Identification of site at each of the 15 entry points of Delhi, (ii) Classified traffic volume counts, (iii) Appraisal/ Assessment of Right-of-Way (ROW) situation on carriageway towards Delhi, (iv) Photographic views of site locations as well as traffic conditions, (v) Videographic coverage of site as well as traffic conditions, (vi) Live coverage of WIM system functioning on NH-08 (Jaipur-Kishangarh Expressway) to get firsthand knowledge, (vii) Live coverage of Toll Plaza on NH-08 near Gurgaon, (viii) Literature search on aspects of WIM system and formulate suitable Specifications for Indian conditions, (ix) To identify ideal locations for installation of Weigh-In-Motion system for Pilot Study.

Based on the data/information available through (i) site assessment and its appraisal, (ii) traffic surveys, and (iii) situational studies carried out at fifteen (15) identified entry points/borders of Delhi, the following major recommendations/ suggestions can be made:

Out of 15 entry points, only 9 entry points, as indicated in Table X, are found to be feasible for installation of WIM system. Therefore, these 9 locations only may be considered further by the concerned agencies.

Fig. 105 Oversized multi-axle vehicle plying on border

Fig. 106 Typical view of Badarpur border

Fig. 107 Typical view of Kalindikunj border

Fig. 10B Typical view of traffic movement at toll plaza

Table X : Recommended Locations for Installation of WIM System

Entry Point No.	Description	Border	Installation of WIM Required (Yes/No)	Feasibility of WIM (Yes/No)	Reasons for Recommendation
1.	Badarpur Border	Delhi/ Haryana	Yes	Yes	Substantial commercial traffic and availability of space
2.	Kalindikunj Border	Delhi/UP	Yes	No	Large number of commercial traffic but constraint of land
3.	Chilla Border	Delhi/UP	No	No	Low commercial traffic. Constraint of space / land
4.	Mandigaon Border	Delhi/Haryana	No	No	Very low commercial traffic. However, land is available
5.	Ayanagar Border	Delhi/Haryana	Yes	Yes	Moderate to high commercial traffic. land is available
6.	Toll Plaza on NH-8	Delhi/Haryana	Yes	Yes	Substantial commercial traffic. Space is available
7.	Singhu /Kundli Border	Delhi/Haryana	Yes	Yes	High commercial traffic. Space is available
8.	Bhopura Border	Delhi/UP	Yes	Yes	Moderate to high commercial traffic. Land is available
9.	Loni Border	Delhi/UP	No	No	Less commercial traffic. Constraint of space/ land
10.	Ghazipur Border	Delhi/UP	Yes	Yes	Substantial commercial traffic. Land is available
11.	ISBT Anand Vihar Border	Delhi/UP	No	No	High volume mixed traffic but low number of commercial vehicles. Constraint of Land
12.	Apsara Border	Delhi/UP	Yes	Yes	High commercial traffic. Space is available
13.	Tikri Border	Delhi/Haryana	Yes	Yes	High commercial traffic. Space is available
14.	Dhansa Border	Delhi/Haryana	No	No	Very low commercial traffic Land is available
15.	Kapashera Border	Delhi/Haryana	Yes	Yes	High commercial traffic. Space is available

Modelling Time Mean Speed and Space Mean Speed for Heterogeneous Traffic Conditions

Speed, a primary element in the area of traffic engineering has a wide range of applications. For instance, it has a vital role in determining capacity of roads through speed-flow relationships, geometric design of roads, implementation of traffic control measures to improve safety, fuel consumption and associated vehicle operating cost components for economic evaluation of road projects, evaluation of performance through journey speed etc. The mean vehicular speed on roads is generally represented in two forms namely Time Mean Speed (TMS) and Space Mean Speed (SMS). TMS is defined as the arithmetic average of speeds of vehicles observed passing a point on a highway and is also referred to as the average spot speed. Individual speeds of vehicles passing a point are recorded and are arithmetically averaged (HCM, 2000) as shown below:

UT = i = 1nuin ——— (1)

where UT is time mean speed in Km/h

u_i is spot speed of i^{th} vehicle in Km/h

n is total number of vehicles traversing in the defined period of time

SMS is a statistical term frequently used to denote an average speed based on the average travel time of vehicles to traverse a segment of roadway. Because of this it is called SMS and average travel time essentially weighs according to the length of time each vehicle spends in the defined roadway segment or space (HCM, 2000) as shown below:

US = d1n i = 0nti ——— (2)

where US is space mean speed in Km/h

d is the length of the selected stretch in Km

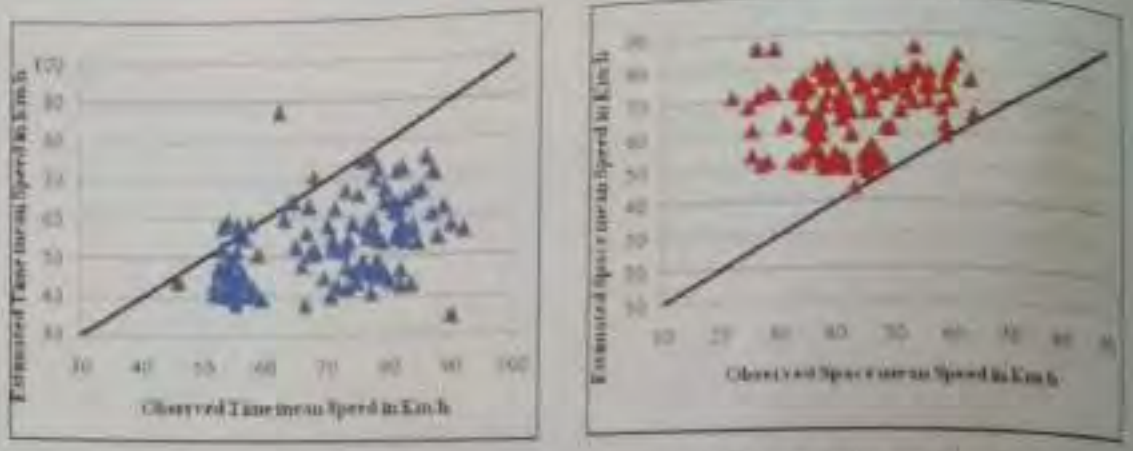
t_i is time spent by i^{th} vehicle in defined stretch of roadway in hours

n is total number of vehicles traversing in the defined period of time

In developed countries where homogeneous traffic conditions and traffic lane discipline prevails, SMS data is usually collected by automatic methods using induction loops, infrared scanners etc. (Han, *et. al.*, 2010). But in these situations, the length of stretch is very small. TMS is collected usually employing laser and radar based techniques. However, in India, the presence of induction loops etc. to measure the spot speeds/time mean speeds which can be used as the primary input to the calculation of travel times, are close to negligible. Hence the travel time/space mean speed calculations are carried out based on manual methods such as registration plate method, moving car method etc. The processes involved in these methods are very tedious and require a huge manpower.

The heterogeneous traffic data collected from the following four road sections around the city of Delhi, India was analyzed and the estimation of TMS and SMS values from Wardrop and Rakha's model were carried out.

1. Greater Noida Expressway near Lotus Valley School
2. Greater Noida Expressway near Panchsheel Bal Inter College



(a) TMS from Wardrop Model *(b) SMS from Rakha and Zhang Model*

Fig. 109 Correlation between the observed and estimated speeds

3. Delhi - Gurgaon Expressway near Mahipalpur
4. National Highway 1 near Sonepat

Correlation plots between the measured and estimated values of TMS and SMS were made as shown in Fig. 109, using the above mentioned models. The figure highlights the poor estimates of TMS and SMS obtained using these conventional models. In the case of TMS estimation from Wardrop equation, all the points lies below the 45 degree line indicating under prediction of TMS whereas in case of SMS estimation from Rakha and Zhang equation all the points lies above 45 degree showing over prediction of SMS. The poor performance by these conventional models can be attributed to high variance of speeds due to the heterogeneous traffic conditions that exist on Indian roads. From these results, it becomes imperative to modify these models to represent the heterogeneous traffic conditions with sufficient accuracy. The development of proposed speed model is described in subsequent sections.

The proposed models for estimation of TMS are as follows:

TMS 1: $UT = aUS + b\sigma S2US$

TMS 2: $UT = USa + \sigma S2USb$

where *a* and *b* are model parameters to be estimated.

The above TMS 1 and TMS 2 models were calibrated and model parameters were estimated using SPSS software. The calibration process was carried out using the data collected at three test section viz. Greater Noida Expressway and Delhi - Gurgaon Expressway whereas National Highway 1 data was used for validation purposes. The estimated statistical results along with Root Mean Square Error (RMSE) values from TMS modeling are shown in Table XI.

These models were further compared with Wardrop model (1952) to demonstrate the accuracy in considering heterogeneous traffic conditions and the same is presented in Table XII. From Table, it can be clearly inferred that TMS 1 and TMS 2 models are far better than Wardrop model and TMS 1 model has high accuracy in terms of less RMSE and percentage error values

Table XI . Parameter Estimates of Different TMS Models

Model	Model Parameter		RMSE Value	Sample Size
	a	b		
TMS 1 Model	1.368 (0.050*, 27.401†)	1.091 (0.169*, 6.454†)	13.62	78
TMS 2 Model	1.080 (0.006*, -†)	1.040 (0.044*, -†)	14.12	78

* Standard error, † t value

Table XII Validation Results of Different TMS Models

Model	Percentage of Error	RMSE Value	Sample Size
Wardrop Model	23.76	17.14	33
TMS 1 Model	6.47	14.35	33
TMS 2 Model	6.20	15.23	33

compared to TMS 2 model. Further to show the prediction capability of these models, the goodness of fit between the observed and estimated values of TMS was plotted as shown in Fig. 110. From the Figure it can be observed that predicted values from TMS 1 model are very close to 45 degree line compared to other models. From all these results, it can be said that TMS 1 model would predict more realistic values of TMS under heterogeneous traffic conditions.

In the same way, various trials were carried out to formulate different SMS models in linear and non-linear forms. The proposed models for estimation of SMS are as follows:

SMS 1: US = cUT-d σT2UT

where *c* and *d* are model parameters to be estimated.

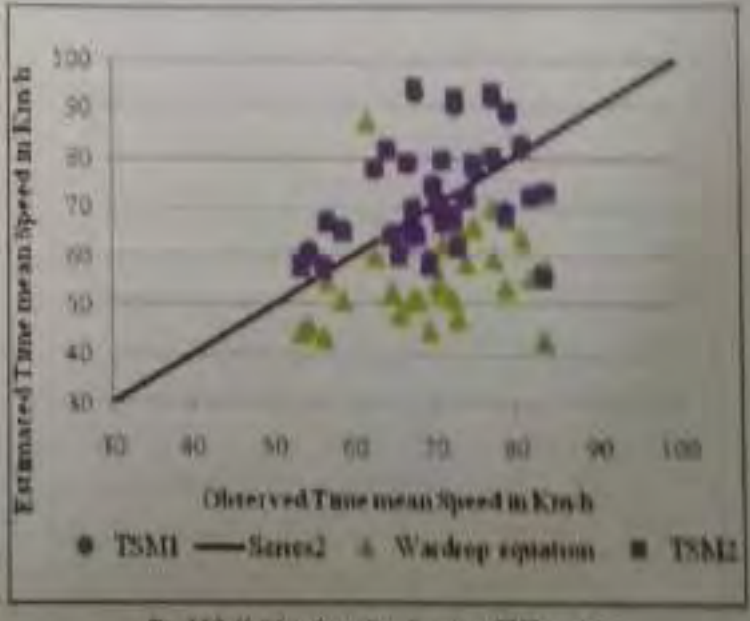


Fig. 110 Validated results of various TMS models

The estimated statistical results along with Root Mean Square Error (RMSE) values from SMS modeling are shown in Table XIII. From Table, it can be observed that SMS 1 model has

Table XIII Parameter Estimates of Different SMS Models

Model	Model Parameter		R^2	RMSE Value	Sample Size
	c	d			
SMS 1 Model	0.694 (0.050*, 13.783†)	1.343 (0.634*, 2.120†)	0.9	10.04	78

* Standard error, † t value

Table XIV Validation Results of Different SMS Models

Model	Percentage of Error	RMSE Value	Sample Size
Rakha and Zhang Model	53.29	22.81	33
SMS 1 Model	12.87	11.06	33

got good statistical validity in terms of high R^2 and low RMSE values. The very less standard error of parameters has further reinforced the good accuracy of developed SMS model. The model was then validated using the data of National Highway 1 and the percentage of error and RMSE values are calculated from observed and estimated values. The model was further compared with Rakha and Zhang model (2005) to demonstrate the accuracy in prediction considering heterogeneous traffic conditions as given in Table XIV. From the Table it can be clearly inferred that SMS 1 is far better than Rakha and Zhang model. Further to show the prediction capability of the model, the goodness of fit between the observed and estimated values of SMS was plotted as shown in Fig. 111. From the Figure it can be observed that predicted values from SMS 1 model are very close to 45 degree line compared to other model. From all these results, it can be said that SMS 1 model would predict more realistic values of SMS under heterogeneous traffic conditions of India.

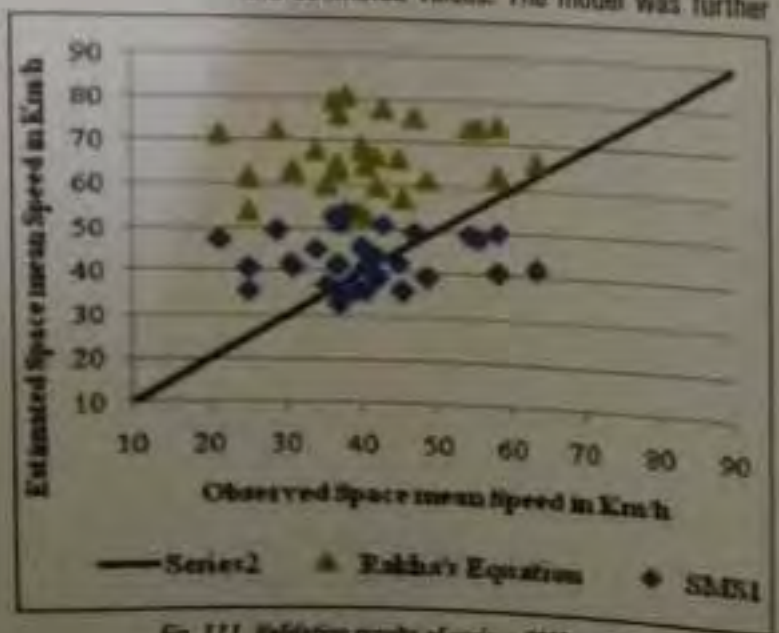


Fig. 111 Validation results of various SMS models

From the present study, it was found that the conventional and popular Wardrop (1952) and Rakha and Zhang (2005) models developed basically under homogeneous traffic conditions did not yield appropriate results for heterogeneous mix of traffic. Accordingly, TMS and SMS models were developed by collecting actual speed

data of heterogeneous traffic conditions. After making a critical comparison with conventional models, the superiority of the proposed models was demonstrated. It can be concluded based on this study that the conventional models as such cannot be used for Indian traffic conditions and therefore the proposed TMS 1 and SMS 1 models are found to be better estimators and consistent in predicting speeds with high accuracy especially for heterogeneous traffic conditions.

Modification of Bitumen and Its Emission Characteristics

There is always a need to develop new bituminous material for roads in order to face increased traffic, heavier loads etc as well as for longer repairing periods and reduce the total cost in roads maintenance / construction. Neat bitumen at higher temperatures is very soft material while at lower temperatures it is brittle material. Therefore this neat bitumen is modified / blended with different types of polymers to get desired properties. For a polymer to be effective, it must blend with the bitumen and improve resistance at high temperatures without making the bitumen too viscous at mixing temperatures or too brittle at low temperatures. So, the blending / modification of bitumen will be done at always high temperature which is much higher than its softening point.

Bitumen is very complex material and is widely known for its carcinogenic nature. It is main material used for road pavement, roofing etc. Therefore it is always associated with the health hazards for the workers associated with this industry. A study has been undertaken characterize bitumen emission while modification in the laboratory as well as at hot mix plant.

Speed-Flow Characteristics and Capacity of Four-Lane and Six-Lane Divided Carriageway

Roadway capacity is a very important parameter that is needed in almost every phase of roadway planning. It is usually estimated from speed-flow relationships and these are applied in many areas of transportation and traffic engineering. It has been used as a tool to determine design capacities for roads, to determine level of service for traffic flow and to calculate travel costs on a specific road section. In India, practically very little research was done on this important field till 1980. Traffic studies on India roads were conducted extensively for the first time under the project titled Road User Cost Study (CRRI, 1982) and were subsequently updated through different studies over the years (URUCS, 1992 and 2001). As the quantum of high speed corridors have started increasing quite drastically, these equations have to be necessarily extended for the high speed corridors as well. Also, vast changes have taken place in the country in the recent past in the transportation sector. The technology of vehicles itself has undergone major changes. New technology cars and light commercial vehicles have come on Indian roads in a big way. Also, the country is embarking upon major programmes of improvements and widening of highways under NHDP. All these developments have a definite bearing on traffic flow, and in order to make its evaluation further research work in this direction is required to establish speed-flow relationships and determine capacity of roads for the changing scenario.

In developing countries like India, where the traffic is heterogeneous, the research findings of developed countries cannot be applied directly.

In this study, realistic profile of free speeds are established and evolved speed-flow relationships for High Speed Corridors for different vehicle types and thus estimated the capacity of High Speed Corridors (namely Four-Lane and Six-Lane carriageways) for the first time in the country. It is expected that the proposed equations and capacities would improve the reliability of results in carrying out realistic economic evaluation of roads and thus help in the effective evaluation and implementation of polices.

Development of Vehicle Operating Cost Equations for High Speed Corridors

Transport sector plays a very significant role in improving the economic development of any country. Fast depleting financial, land and other resources and ever increasing travel demand calls for careful planning for optimum utilization of resources in the road transportation sector. It is most essential to utilise the available resources in an optimal way to provide an efficient road infrastructure and enable the economy to grow with minimum hindrance. In the process of economic analysis of highways projects, assessment of Vehicle Operating Cost (VOC) plays a predominant role. The major factors affecting the VOC are the speed coupled with traffic flow characteristics at which vehicles operate on roads which in turn determines fuel consumption and other cost components per unit distance traveled. In the last decade, Government of India has been involved in road capacity augmentation by building high speed corridors to link major cities through the implementation of various projects like Golden Quadrilateral, North-South, East-West and some Expressway Corridors. These radical changes in road network and vehicle technology have resulted in variations in speed - flow characteristics and subsequently road user costs. Considering the above mandate of the Government, it is felt essential to quantify the investment made on the multilane highways by developing VOC models exclusive to the high speed corridors. The term 'High Speed Corridors' implies for the two-lane to multi-lane divided carriageways.

In the present study, an attempt was made first time in the country to develop VOC equations for different vehicle types which are basically explaining the relationship between VOC components and influencing factors primarily vehicle and road characteristics. Further, it is observed that significant increase in levels of congestion on Indian roads is affecting the road user costs.

Study of Benzene and Volatile Organic Compounds (VOCs) in Delhi

This study mainly focuses on the estimation of benzene and VOCs (Volatile Organic Compounds) due to vehicular traffic and road traffic. The objectives and scope of this study included.

- To assess the concentration of benzene in different locations such as petrol pump, residential areas and other road side corridors.
- To monitor the air concentration of benzene and other aromatic Volatile

Organic Compounds in corridors with dense traffic and to determine the emissions from the car fleet.

Volatile Organic Compounds (VOCs) play a significant role in the generation of urban photochemical smog. In addition some VOCs like benzene, toluene and xylene are harmful to human health. In India, motor vehicles are the dominants source of VOCs therefore it is important to determine the emission of VOCs from vehicles in order to estimate human risk and the production mechanisms of photochemical smog. Benzene is a ubiquitous chemical and it is found in refined petroleum products like gasoline. It is volatile and it has been estimated that 10kg of benzene is lost per ton of benzene produced, during transfer and storage, with approximately 94 percent lost as air emissions and 6 percent as water effluents.

It is therefore found in air, water and soil. Benzene is present in both exhaust and evaporative emissions. Motor vehicles accounts for approximately 85 percent of the total benzene emissions. As per EPA's estimate active smoking accounts for roughly half of the total population exposure to benzene and therefore it is very important to monitor benzene near petrol pumps and traffic congested area where benzene concentration is more. It has been observed the concentration of benzene was highest near petrol pumps. The road side corridors of a busy highway (CRRI GATE) were the second highest affected areas (Fig. 112).

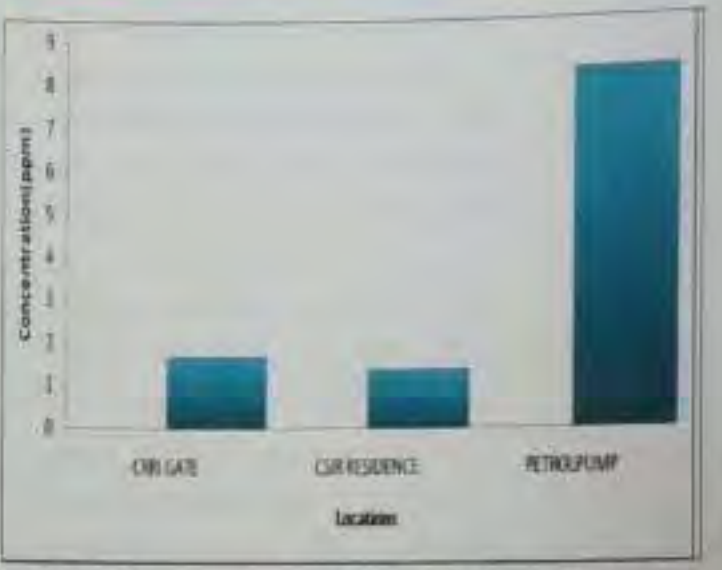


Fig. 112 Concentration of benzene in three different corridors of Delhi

Carbon Footprint of Passenger Transport in Delhi

Life Cycle Assessment (LCA) is a well known tool for analyzing the environmental impacts on a wide perspective with reference to a product system and related environmental and economic impacts. LCA is also called the "cradle to grave" approach. It is composed of a conceptual framework and a set of tools that have been studied and developed over the last 30 years. The principles and framework for LCA include definitions of goals and scope, Life cycle inventory analysis (LCI), Life cycle impact assessment (LCIA) and Life cycle interpretation phase. The core of the concept is to estimate some sustainability indicators, based on LCA, such as carbon footprint, energy footprint or emissions footprint.

The transportation sector consumes large amount of energy and draws upon the natural resources. In such a scenario, the carbon footprint can act as a means to measure

the amount of ecological pressure of a road, highway or a rail exerts on the earth. This research study aims to estimate the carbon footprint of the two main transport infrastructure, i.e. road and rail. Large amount of research has been done on the mobility and commuting indicators like travel distance, modal choice, travel time, vehicle speed etc. But while evaluating the impact of mobility on environment or on global warming, Co_2 emissions or carbon footprint appears to be a preferable method. This method accounts for direct and indirect Co_2 emissions.

Measurement of Fuel Consumption in Vehicles under Test Conditions

The objective of the study is (i) To measure fuel consumption for various speed, surface roughness, gradient and vehicle types and to develop relationship among the variables (ii) To facilitate calibration of user cost survey data.

The study will highlight the optimum fuel required for various road conditions thereby enabling efficient usage of fuels. The analysis conducted will serve a larger purpose as it will be used as an input to the road user cost study.

Fuel consumption study has been completed on one test section at Noida-Greater Noida Expressway covering various steady speed from 20 to 90 km/hr on Tata Sumo, 20 to 80 km/hr on Maruti Van, 20 to 70 km/hr on Tata Truck for all three load condition. Also completed study on test section including concrete and bituminous section at Hodal on NH-2 covering various steady speed from 20 to 80 km/hr on Tata Sumo, Maruti Van and on Tata Truck for all three load conditions (empty, half, full).

The driver evaluation was done in two aspects (i) Fuel consumption tests (involving five drivers) consisting of steady speed test and driving style test and (ii) Laboratory tests (involving six drivers) consisting of visual ability and sensory motor tests. In all four drivers were common for both type of tests and the comparison between fuel studies (steady speed and driving style) and laboratory studies (visual ability and sensory motor test) has been made with respect to these drivers.

In steady speed test, it has been observed from the test results for both the vehicles (i.e. Tata Sumo and Maruti Van) the drivers used different gear position for all steady speed tests except for steady speed of 70 km/hr for Maruti Van (all the drivers used 4th gear since option of overdrive (5th gear) was not available in the vehicle). The maximum influence on variation in fuel consumption among drivers was observed due to choice of different gear position for the same steady speed test. The variation in fuel consumption among drivers varied up to 160 percent in steady speed test for Tata Sumo and up to 96 percent in steady speed test for Maruti Van.

In driving style tests, drivers used different gear combination for Tata Sumo but for Maruti Van all the drivers used the same gear combination. In driving style tests the variation in fuel consumption among drivers was up to 42 percent for Tata Sumo and up to 34 percent for Maruti Van.

The study results reveal that for Maruti Van, there do not seem to be much variation in use

of gear especially in driving style due to the lower power of the vehicle. For Tata Sumo there seems to be large variation in use of the gears due to the reserve power available with the vehicle. It could be stated that gear change habbit has significant influence on the overall fuel consumption particularly for vehicles with higher reserve power.

While comparing the results of fuel tests (steady speed and driving style tests) to that of laboratory tests (visual ability and sensory motor tests) it is to be borne in mind that the steady speed tests has no relation to the safety aspects of driving as the driver was instructed to maintain the steady speed in a situation where there was no conflict with the traffic. However, the aspects of fuel economy and safety are reflected in the choice of gear position in the case of driving style tests.

In case of laboratory tests (visual ability and sensory motor tests) the aspects of safety of the driver is highlighted. The comparison of fuel tests to that of laboratory test was intended to understand whether safe driver are the most economical drivers. From the field results the ranking of drivers as per fuel economy (out of the drivers who took both the tests fuel and laboratory) is as follows (i) Rank I-Driver 3 (ii) Rank II-Driver 5 (iii) Rank III-Driver 2 (iv) Rank IV-Driver 6, whereas from the laboratory studies the ranking of drivers as per safety is as follows (i) Rank I-Driver 6 (ii) Rank II-Driver 5 (iii) Rank III-Driver 3 (iv) Rank IV-Driver 2.

By inter comparison of the performance of drivers in fuel tests to that of laboratory test, it has been observed that the drivers who were ranked higher based on performance related to fuel economy were found to be ranked lower in the laboratory test. The results therefore highlight the point that safe drivers might not be the economical (fuel) drivers and similarly most economical driver might not be the safe driver

Studies of Non - Methane Hydrocarbons in the Atmospheric Environment of Delhi Region

Non – methane hydrocarbon and oxides of nitrogen emitted from various anthropogenic sources in urban areas may cause an increase in the concentration of ozone in the troposphere. Ozone (tropospheric ozone) can have a negative impact on the environment and public health when present in the lower atmosphere in sufficient quantities. Ozone, however, is unique among pollutants because it is not emitted directly in to the air. It is a secondary pollutant, which is generated when nitrogen oxides (NOx) and non – methane hydrocarbon (NMHC) interact under the action of sunlight. Therefore, the primary pollutants NOx and NMHC are referred to as ozone precursors. Non- methane hydrocarbons with upto 10 carbon atoms form the main part of volatile organic compounds in urban areas. The increasing concerns of the scientific community and local authorities in non – methane hydrocarbon detection is due to the potential carcinogenity of some of these compounds like benzene. Non – methane hydrocarbons emitted in the atmosphere are pollutants of special concern due to their adverse health impact and their implication in ozone and other toxic secondary pollutants formation. Major anthropogenic non – methane hydrocarbon sources in urban areas include vehicle exhaust

gas, vehicle fuel evaporation and distribution, solvent use, natural gas emission and industrial processes. Therefore it is important to study non – methane hydrocarbons in the atmospheric environment of Delhi region-a mega city.

As we know Delhi has extra burden of non – methane hydrocarbons emitted from various industries as well as vehicular exhaust in its atmospheric air. This may affect its surroundings by prevailing winds i.e. it affects regionally and ultimately globally.

Therefore, the study of non – methane hydrocarbon in the atmospheric environment of Delhi region, could be a significant step to elucidate the relationship between ozone and its precursors like non – methane hydrocarbons. It may help in formulating policy measures to control ozone and its precursors.

Development of Road User Cost Models for High Speed Corridors

Realizing the present shortcomings in the transport sector, the Government of India during the last decade has been involved in road capacity augmentation by building high speed corridors to link major cities through the implementation of various National Highway Development Program (NHDP) projects like Golden Quadrilateral, North-South, East-West and some Expressway Corridors. This has led to gradual growth in the quantum of NH network which was around 22,255 km in 1951 has risen to 70,548 km as of March 2009. These radical changes in road network and vehicle technology have resulted in variations in speed – flow characteristics and subsequently road user costs. The High Speed Corridors referred implies the four-lane to six-Lane carriageways. The scope of the study is to mainly consider Four-Lane and Six-Lane carriageways and develop the road user cost models for the same. These high speed corridors are shown in Fig. 113.

The objectives of the study are:

- To establish realistic profile of free speeds on high speed corridors for different vehicle types
- To evolve speed-flow relationships for high speed corridors for different vehicle types and thus estimate the capacity of high speed corridors.
- To build database for quantifying Road User Costs considering the spectrum of vehicles playing on high speed corridors.
- To build Road User Cost relationships between vehicle speeds and road design parameters with emphasis on high speed corridors.
- To develop VOC equations aim at determination of the effect of road geometry (like gradients, curvature, width of carriageway), surface characteristics (type roughness), traffic characteristics (volume composition, load carried by goods vehicles) and environmental conditions (altitude, rainfall) on the VOC components (like fuel, lubricants, tyres, spare parts, maintenance labour) and thereby developing the statistical relationships covering the above variables.

Fig.113 High speed corridors in India

In the present study, an attempt has been made to identify the need to develop the equations of VOC components for specific vehicle types operating on high speed corridors in varied conditions. The vehicle types considered in the present study include small car, big car, bus, LCV, HCV and MAV. The data used are based on fuel consumption experiments conducted on selected road sections along with VOC data obtained during the road user cost study data collection from vehicle owners / operators. Using the above data, VOC model for different vehicle have been developed. Following conclusions are drawn from the study.

- The mean free speed of cars is more or less same in four lane and six lane divided carriageways, however it is slightly more in the case of heavy vehicles on six-lane as compared to four-lane divided carriageways.
- Separate speed-flow equations for uncongested and congested parts are developed for four lane and six lane divided carriageways. From the statistical results, it can be said that these equations can predict realistic capacity values as their R^2 values are very good coupled with low value of the standard error of the coefficient and the constant.
- The comparison of free speed and intercepts of speed-flow equations shows

that developed speed-flow equations are consistent.

- Considering this, the speed - flow equation developed using for cars (having the PCU value of 1) can be used with assurance for fixing capacity norms of multi-lane highways on Indian roads. Hence, the estimated capacity for the four-lane divided carriageways is 5123 PCU/hr/direction (Fig. 114).
- The speed of the vehicle mainly depends upon roadway factors like roughness, rise and fall, road width and curvature. Considering this, the free speeds of small and big cars have increased compared to 2001 study by 24 percent and 27 percent respectively which can be attributed to rapid improvement in highway standards coupled with advancements in vehicle technologies.

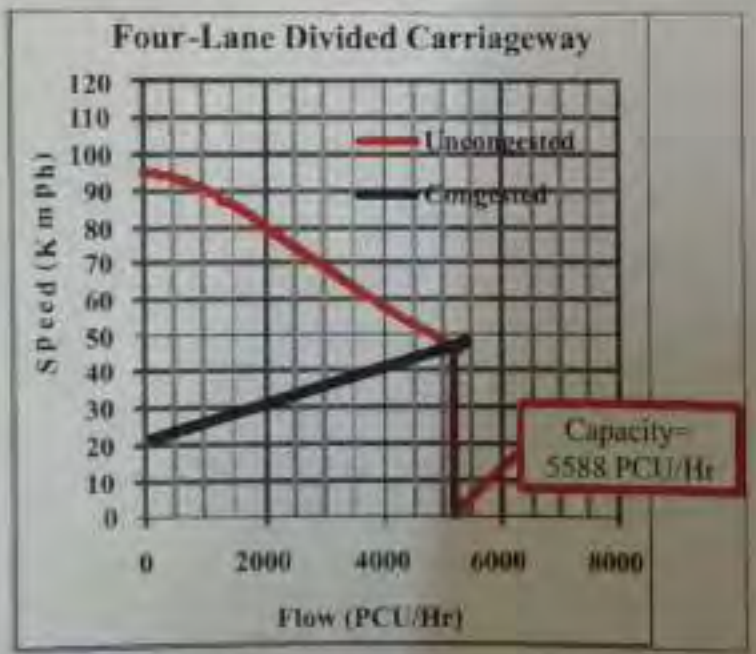


Fig. 114 Speed-flow relationship for four lane divided carriageway

- Similarly, the free speeds of buses, HCVs and MAVs have also increased substantially by about 12, 10 and 23 percent respectively whereas the free speed of LCVs has registered a marginal increase of about 2 percent as compared to 2001 study.
- Interestingly, the fuel consumption studies illustrate that the fuel consumption rate has increased as compared to 2001 study which implies the rapid advancements in vehicle technologies coupled with enhancements engine characteristics such as horsepower, engine capacity etc. (Figs. 115 & 116). On the contrary, the speed at optimum fuel consumption has gone up by about 4 to 10 km/h which can be termed as the ideal speed of the vehicle for achieving better fuel efficiency
- In case of Engine oil consumption, it was observed that 63 and 36 percent reduction for bus and HCV, however 31 percent increase was observed for LCV.
- Tyre life has increased drastically about 55 percent in case of buses, which can be attributed to advancements in tyre manufacturing and also improvements in road characteristics.
- The repairs and maintenance cost has drastically increased by 5 times compared with 2001 in case of cars. The increment is more than 100 percent in case of buses and LCVs which can be attributed to hike occurred in labour charges, cost of the spare parts due to

inflation of the economy.

- The annual utilisation has increased by 15 percent for cars, whereas reduction of 11 and 4 percent was observed in case of buses and HCVs compared to 2001 study.

Accident Studies for High Speed Corridors

Over 1.2 million people died in road accidents each year around the world and more than 90 percent of them are in low and middle-income countries, which have only 48 percent of world's registered vehicles. According to WHO Global Status report on Road Safety, about 114,590 people died in road accidents in India in 2007, which was highest in any country of the world i.e. 13 deaths every hour. These figures are expected to be an underestimation as many accidents go unreported and many severe injuries due to road accidents also lead to death after some time.

The causative factors of road accidents are well known and they can be classified into three groups. They are vehicle, road and driver. However the apportionment of these factors which leads to accidents is very difficult task. This requires exhaustive accidents representing each and every causative parameter. The process of accident data collection is still in its primitive stage in India. Recently, there has been increased awareness to reform the current accident data collection process and the proposal towards uniform data collection process has also been finalized and will be available to all

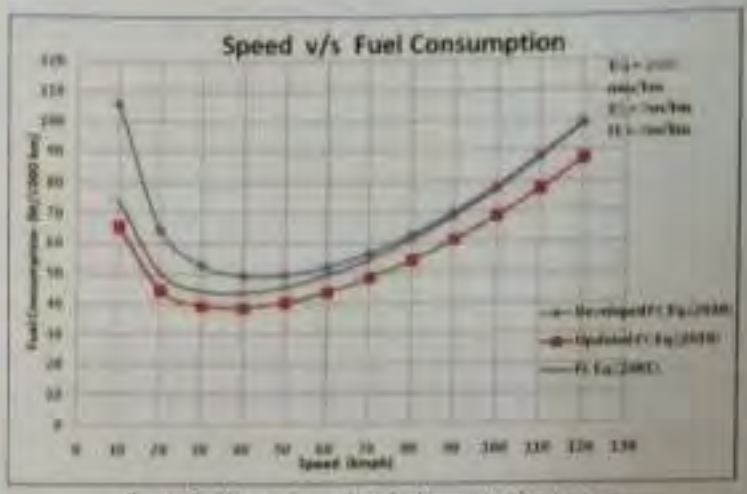


Fig. 115 Effect of speed on fuel consumption on cars

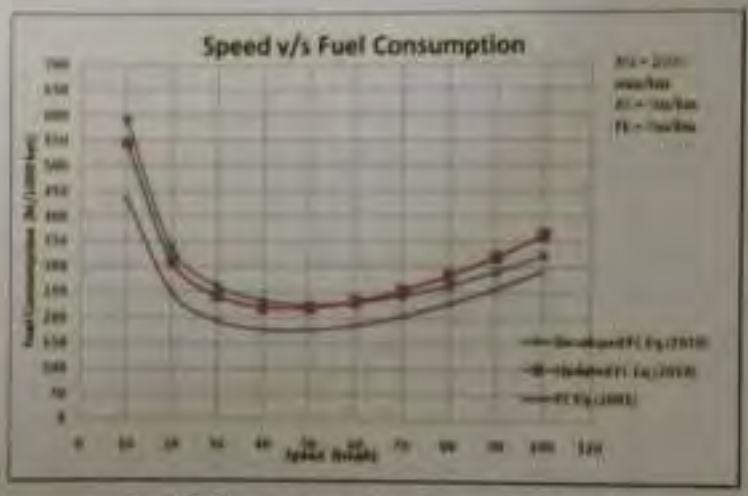


Fig. 116 Effect of speed on fuel consumption on HCVs

the involved agencies in near future. Currently National Highways Authority of India (NHAI), which is responsible for the development, maintenance and management of National Highways within India, entrusted to it and for matters connected or incidental thereto, has taken the initiative towards compilation of accident's details along the various National Highways running across India.

- From the available data the main cause of accident has been identified as over

speeding that is travelling at a speed higher than 80 kmph

- The hypothesis that the severity of accident and the type of vehicle involved in the accident are correlated is nullified by the data analysed using chi square test. The test elaborated that the severity of the accident does not depend of the type of vehicles involved in the accident.

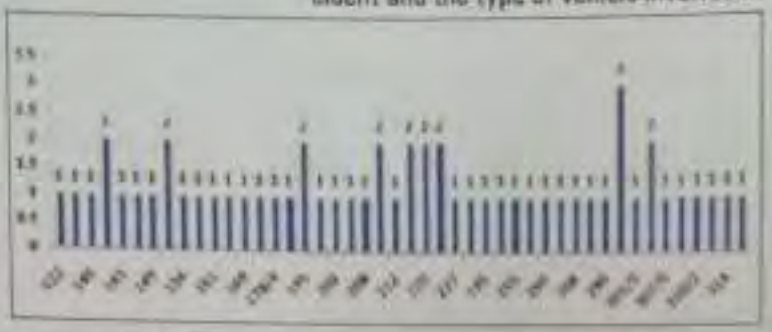


Fig. 117 Number of accidents along Right Hand Side of NH-1

Fig. 118 Number of accidents along Left Hand Side of NH-1

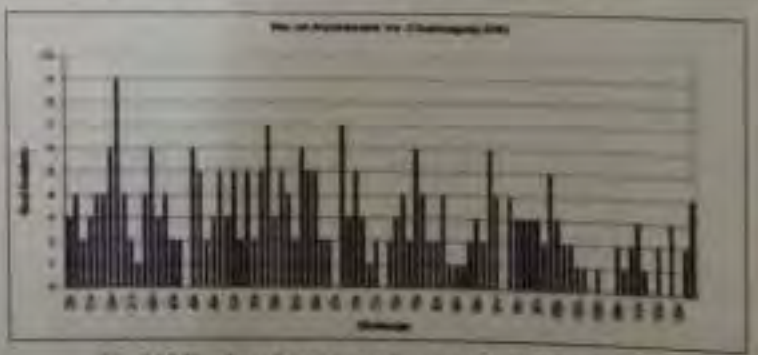


Fig. 119 Number of accidents along Left Hand Side of NH-45

Fig. 120 Number of accidents along Right Hand Side of NH-45

- However the data analysis also proved that in case of vehicles noted as "unknown" the hypothesis that the severity of accident depends on the vehicle type involved in the accident holds true. Hence the data involving "unknown" vehicles cannot be ignored.
- The analysis of the NH – 45 and NH – 1 data indicates that the 72 percent of the accidents were minor injuries on NH – 45 whereas 72 percent were grievous injuries along NH – 1.
- About 47 percent of accidents took place during the day along NH – 45 whereas 55 percent of the accidents took place during the day along NH – 1.
- The temporal trend of accidents along NH – 1 and NH – 45 are as shown in the Figs. 117, 118, 119 & 120.

Consultancy Assignments

Mobile Combustion: GHG Emission Inventory for Transport Sector in India

This study has been sponsored by MoEF/ UNDP/GEF facilitated through PMC at Winrock International India, New Delhi

As reported earlier, The United Nations Framework Convention on Climate Change (UNFCCC) has embarked on the process of monitoring/estimating the greenhouse gas

(GHG) emissions on continuing basis globally. The task of inventorying the contributions of transport sector in India towards GHG emissions was entrusted to CRRI as part of the India's Initial National Communication (NATCOM) in 2002. Comprehensive database (1980–2000) was generated on GHG emissions (CO_2, CH_4, N_2O, CO, NO_x and NMVOC) for transport sector in India covering road, rail, aviation and marine navigation. Part of the work on 'GHG Emission Inventory for Transport Sector in India' carried out at CRRI, has been reflected in IPCC (2006) Guidelines (Chapter on Mobile Combustion) for Estimation of National GHG Emission Inventory. The IPCC process has been awarded the Nobel Peace Prize 2007.

The present activity **Mobile Combustion: GHG Emission Inventory for Transport Sector in India** has been taken up as part of the Enabling Activities for Preparation of India's Second National Communication (SNC) to the UNFCCC with the following distinct objectives.

To refine the GHG emission estimates from road transport sector by apportioning fossil fuel used in various types of road transport vehicles and

To estimate greenhouse gas emission inventory for transport sector using IPCC default emission factors and country-specific emission factors (if available) for the period 1995-2007

The work involves apportionment of fuels used in road transport sector by different vehicle category groups. The fuel consumption information has been collected and collated from official publications besides inputs from external experts, input from various sources as well as using expert judgements. This exercise is essential in reducing the level of uncertainty in fuel consumption data, particularly for road transportation. The level and uncertainty in fuel consumption in road transport sector is large. The present work has provided improved information on the uncertainty in fuel consumption in road transport. Fuel consumption data for other modes of transport viz. rail, aviation and marine navigation/shipping has been gathered from appropriate sources and apportioned accordingly.

The National GHG emission inventory (CO_2, CH_4, N_2O, CO, NO_x and NMVOC) for transport sector in India has been generated using top-down approach for the period 1995-2007 using IPCC 1996 and 2006 methodology protocols. Fig. 121 shows the trend of energy consumption and Co_2 emission for road, rail, aviation and navigation.

The Draft Final Report was submitted in June 2009 covering segregated information on consumption of different fuel types for different modes of transportation as well as inventory of GHG emissions from road, rail, aviation and navigation. The final report has been completed and will be submitted after the Review Meeting.

Traffic & Air Pollution Survey on Road Network connecting Darlaghat - Ropar and Darlaghat- Naragarh (HP)-Air Quality Assessment Study

Gujarat Ambuja Cement Limited (GACL) popularly known as Ambuja Cement is one of the premier company engaged in production of cement. Ambuja Cements is having its cement plants at Kodinar (Gujarat), Rabriyawas (Rajasthan) Rawan

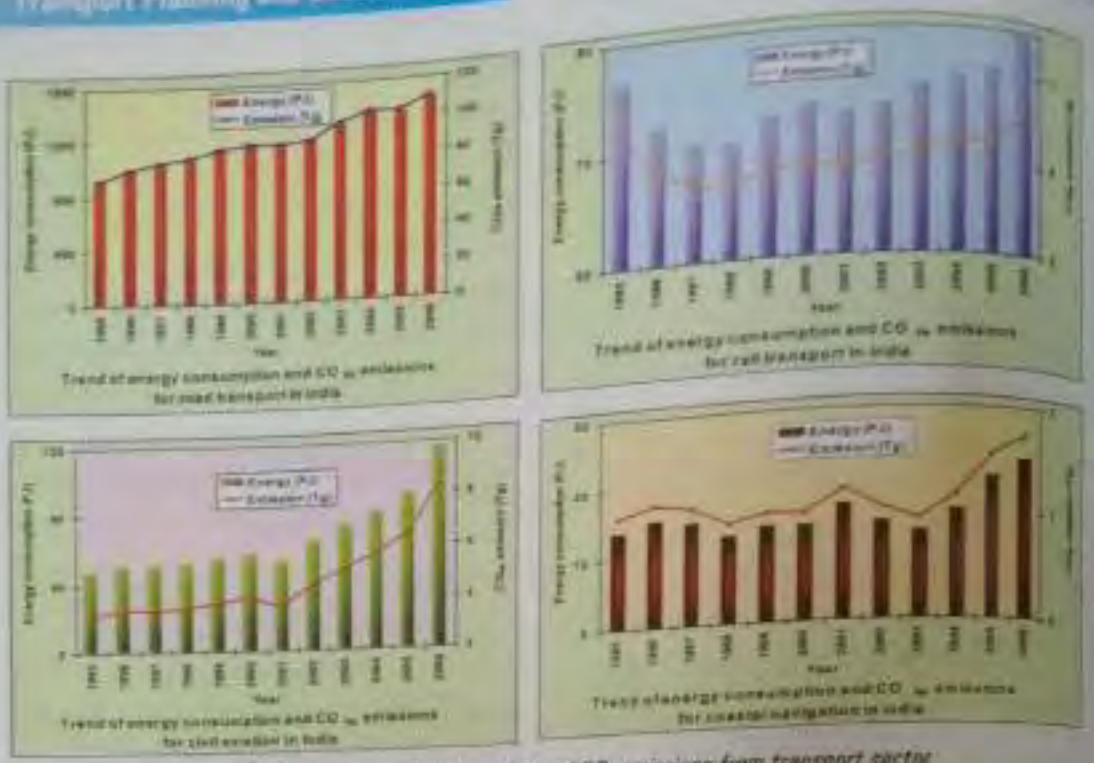


Fig. 121 Trend of energy consumption and CO_2 emissions from transport sector

(Madhya Pradesh), Chandrapur (Maharashtra) besides Darlaghat (Himachal Pradesh) and Ropar (Punjab). M/S Ambuja Cements limited has initiated expansion of one of its Cement plant at village Rauri, Darlaghat (HP), Clinker 1.8 MTPA to 2.6 MTPA. It is proposed to establish a new grinding unit at village Panjehra in Nalagarh (H.P.) which is situated at a distance of about 20 km from its existing grinding plant at Ropar (Punjab). The expansion of the capacity of the plant would impact the transport infrastructure and environment in the influence area to a large extent. In order to study the impact of the expansion of the capacity of the cement plant on local and surrounding transport infrastructure and the environment, M/S Ambuja Cement Limited has requested Central Road Research Institute (CRRI), New Delhi to conduct traffic and air pollution study.

As per the agreed TOR, following were the objectives and scope of the study:

1. Measurement of roadside (kerb side) air quality at 4 selected locations
2. To find relationship between vehicular traffic (emissions) and observed roadside air pollution levels
3. Use of Caline 4 model for predictive modeling (for CO) to determine the influence of vehicular traffic on air quality.

The purpose of the study was to measure the roadside (kerb side) air pollution concentrations at four selected locations (sites) and to evaluate the observed air pollution levels. The following measurement locations were identified for air quality assessment study.

- Darlaghat T-point near Ambuja Cement Plant in Himachal Pradesh
- Nauni T-point in Himachal Pradesh

- Nalagarh (Ambuja Cement Factory site) in Himachal Pradesh.
- Kiratpur (near Ropar) in Punjab

Continuous real-time measurements were carried out for air pollutants SO_2, NO_x, CO, HC, O_3 and particulate matter (PM_{10}) along with micrometeorological parameters at each of the selected locations on 24-hr basis. The measurements were carried out at the height of ~3m from the ground surface. In addition, micro-meteorological parameters such as wind speed, wind direction, ambient temperature and relative humidity are anticipated to be measured at each of the selected locations. Details of Dalaghat (one of the locations) comprising of Road Network, location, micro-meteorological parameters and pollutant distribution are shown in Fig. 122.

The pollutant distribution patterns indicate that besides motor vehicle emissions, other sources contribution predominates at few of the locations. Ozone levels were observed to relatively higher at hill locations (Darlaghat). PM10 levels were found to be lower at hill locations than for those along the planes (Nalagarh and Kiratpur). Contribution of natural roadside dust to PM and biomass burning to CO levels were observed.

The draft report was submitted to Ambuja Cement. Further work related to modelling (use of CALINE 4 model) is under progress.

Road Traffic and Air Pollution in Delhi

Delhi, the capital city of India is one of the most rapidly expanding mega cities and as per the Census of India (2001) it had a population of 12.7 million in 2001 (estimated to be around 16.64 million in 2007). Delhi is very rapidly growing with an average annual population growth rate of about 4.5 percent (India has national average growth rate of 2.1 percent per annum). Delhi is having total registered vehicles of more than 5.63 million in 2008 (more than 12 percent of India's automobile population) with the predominance of two wheelers and cars. The travel needs in Delhi are mainly met by road transport with a total road network of about 30,000 km, which includes all categories of roads.

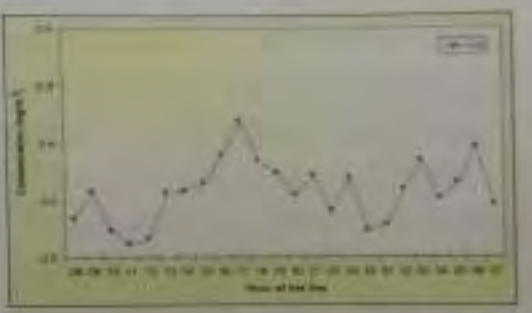
The recent past transportation studies (CRRI, 1984 and CRRI, 2002) revealed that the travel demand has tremendously increased in the last three decades by more than two times in terms of per capita trip rate (vehicular) in a day from 0.45 in 1969 to about 1.0 in 2001. Further the latest transportation study (GNCTD, 2009) found that the major modes of transportation are buses, private vehicles (namely cars and two wheelers), taxis, auto rickshaws and bicycles in the order of total trips made in a day. But the trips made by car and two wheelers were increased significantly as compared to year 2001 whereas bus trips were reduced and redistributed among the other modes such as Metro, Cycle Rickshaws etc. Further the average trip lengths have increased marginally for all modes of transport over years.

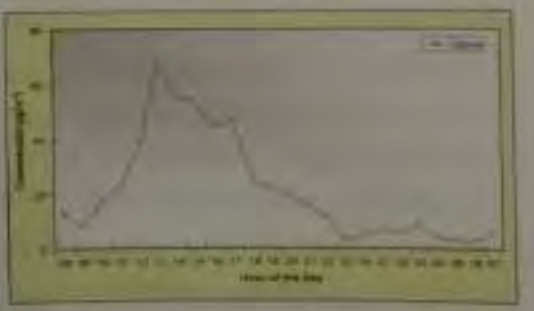
The increase in average trip lengths is clearly indicating that the compact city concept was gradually diminishing. Travelling longer trip lengths a day is further increasing the pressure on exiting road network and increasing vehicular emissions. In order to curb these traffic and

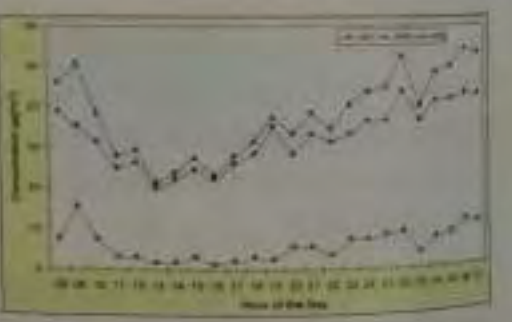
Road Network

Location: Darlaghat (HP)

Real-time Analysis of Meteorological Parameter Wind Rose







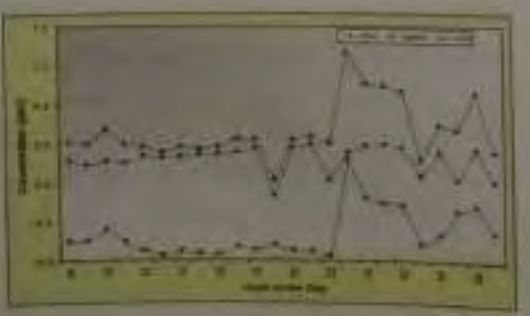


Fig. 122 Diurnal distribution of pollutants at Darlaghat (HP)

pollution loads, many different policies were proposed. However, a proper assessment of pollution loads from vehicular traffic is an essential requisite for any policy measures to enable to propose appropriate remedial measures to control the menace of congestion and air pollution. This aspect is very aptly emphasised in the CRRI study on Urban Road Traffic and Air Pollution (URTRAP) in 2002, which deals with the quantification of the travel demand and associated pollution loads in a scientific manner and thereby enabled in evaluating the impact of the proposed National Auto Fuel Policy apart from the devising road map for its implementation (CRRI, 2002). Considering the above facts, the present study aimed at estimating quantum of travel demand in terms of Vehicles Kilometres Travelled (VKT) by each mode and quantifies the associated pollution loads in Delhi and impact of National Auto fuel policy emission norms on vehicular pollution loads in Delhi.

Keeping the objectives and resources allotted for the present study in view, it was proposed to utilise the traffic database generated by URTRAP study (CRRI, 2002) as the datum. Thereafter, it has been proposed to carry out the defined scope of work based on the traffic studies carried out in the intervening period for the year 2009. The traffic studies, which are to be carried out and methodology to be adopted for the estimation of traffic and pollution loads is briefly explained in the paragraphs to follow.

In order to accurately estimate the pattern of traffic flows and spatial distribution of pollution loads from vehicles, the primary road network of the city would be identified and inspected physically through the field visits. As discussed earlier, the major arterial roads of Delhi carry more than 80 percent of traffic. Control points (location of survey points where traffic volumes to be measured) were selected based on previously available database on traffic volume, importance of road, adjoining

Fig. 123 Estimation of traffic pollution loads based on VKT and evaluation of impact of emission norms on vehicular pollution loads

land use and geographical distribution. The study methodology is presented in Fig. 123, which signifies both primary and secondary data sources to be used in this study.

To accomplish the study objectives, the traffic data was collected at selected 24 mid-block locations, 6 intersections in addition to interview surveys conducted at 9 outer cordon points and 30 fuel stations/ parking areas spread over the city as shown in Fig. 124. The traffic surveys at mid-blocks reveals that the maximum peak hour traffic was observed on I. T. O. Barrage Bridge with 19,000 vehicles/hr (total traffic about 1,66

lakh vehicles for 12 hours) and on Lala Lajpat Rai Marg with about 15,000 vehicles (total traffic about 1.54 lakh vehicles for 12 hours). From the intersections counts it was observed that Ashram intersection has the maximum intersection traffic flows about 3.65 lakh vehicles for 24 hours. The outer cordon surveys revealed that the maximum traffic was observed at NH-8 Toll Plaza with about 2.28 lakh vehicles for 24 hours and minimum traffic was at Apsara border on Old G. T. Road with about 50,000 vehicles for 24 hours. It was observed from traffic composition analysis that the proportion of two wheelers has shown a downward trend in inner and middle areas whereas in the outer areas it has remained more or less same during 2002 to 2009. SMVs have shown a downward trend in inner, middle and outer areas during this period. Over all, about two times increase in the traffic was observed as compared to URTRAP study in 2002.

Further from the commuter interview surveys at outer cordon points revealed that a total of about 4.3 lakh vehicles enter and about 4.6 lakh vehicles leave leave Delhi on an average working day. It can also be noticed that the goods traffic forms about 13 percent of the total traffic with

Fig. 124 Locations of different surveys on road network of Delhi

another 3 percent of traffic is composed of slow moving vehicles like cycles, animal carts etc. Of these vehicles, about 18 percent of the goods vehicles and 8 percent of passenger vehicles are found to be passing through the city. Further, these commuter interview surveys at fuel stations/ parking areas reveals that average age of the vehicles at the cordon points is slightly younger compared to the vehicles running in the city in case of autos and buses. Furthermore it can be seen that the average age of the vehicles in Delhi is considerably lower meaning thereby that they are less polluting and more fuel-efficient. The average age of vehicles observed in Delhi is shown in Fig. 125 .

For estimation of pollution loads from vehicles, the traffic loads in terms of vehicle kilometres travelled (VKT) on the entire primary road network of Delhi is first estimated. On the basis of the classified traffic counts conducted at 24 mid-block and 6 intersections, data on traffic flows on the road network of Delhi was generated. Employing this data, the traffic flows have been arrived at on the adjoining links in the neighbourhood of the count points. The traffic load is estimated as vehicle - kms by factoring the vehicular flows with the length of link.

By summing the link traffic loads, the total vehicle - km travelled on the city road network was estimated and it is around 1505.6 lakh VKT. Out of this, the maximum proportion of travel (81 percent) is made by two wheelers and cars.

This is followed by three wheelers constituting about 13 percent of the total VKT while buses have almost 1.8 percent and goods vehicles

Fig. 125 Average age of vehicles operating in Delhi in 2005

have share of almost 3.8 percent. As compared to the 2002 study (792.34 lakh VKT/day) the VKT observed in the present study was almost doubled. Employing the vehicle - kilometres travelled on the city roads, total pollution load have been estimated for each of the four pollutants namely CO, HC, NO_x and PM. The estimated daily pollution loads of CO, HC, NO_x and PM from vehicles is observed in tonnes per day to be 264.55, 127.54, 82.53 and 9.81 (Fig. 126). These pollution loads are significantly reduced compared to 2002 study and the reduction is 37, 31, 25 and 23 percent in CO, HC, NOx and PM respectively. These reductions in pollution loads can be attributed to vehicular technology in terms of emission

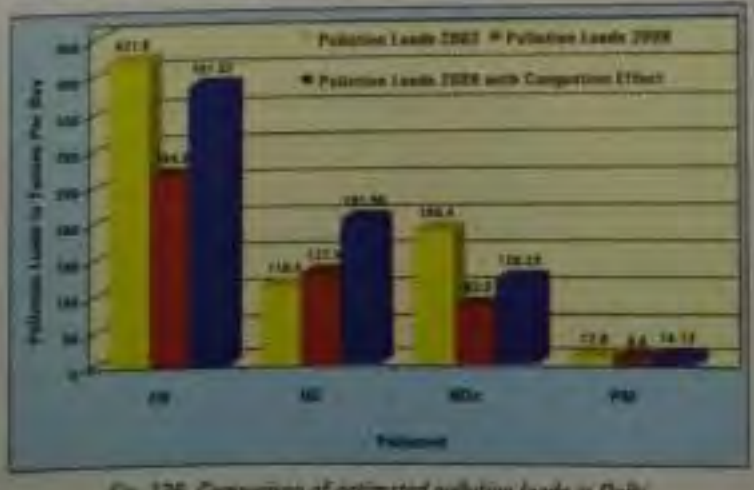


Fig. 126 Comparison of estimated pollution loads in Delhi

norms implemented in the country such as BS-II and BS-III and implementation of CNG in Autos and Buses.

The above pollution loads were calculated assuming the existence of typical Indian Driving Cycle (IDC) on Delhi roads by considering the CPCB emission factors (CPCB, 2000). However, as the traffic congestion is so acute for most part of the day on major arterials and sub-arterials of the city, the effect of congestion on Delhi road network was appropriately accounted by assuming that average travel times of various modes have increased by 50 percent due to congestion since the non-availability of emission factors due to congestion in our Indian conditions. Subsequently the pollution loads were estimated by increasing the loads by cars and buses with separate factor as they get affected more compared to two wheeler and autos. The estimated pollution loads of CO, HC, NO_x and PM with congestion effect is around 391.5, 181.9, 126.2 and 14.1 tonnes per day.

Impact of National Auto Fuel Policy Emissions

The pollution loads are estimated for the cases of Business As Usual (BAU) 2000 and BAU 2002 and subsequently compared with present study 2009 to assess the impact of National Auto Fuel Policy emission norms. BAU 2000 and BAU 2002 options are considered because these policy norms were implemented in Delhi during this period i.e between 2000 and 2009. Fig. 127 shows the BAU 2000, BAU 2002 and present study after implementing the Auto fuel

Fig.127 Impacts of policy interventions on pollution loads

policy emission norms. It can be clearly seen that the policy norms have successfully reduced all of the pollutants compared to BAU 2000 and BAU 2002.

Further from the analysis of results it was found that the major contributor in reducing CO is CNG Auto which reduces 44 percent followed by BS-I & II (34 percent) and BS-III (21 percent) as shown in Fig. 128. CNG Bus and CNG car are very insignificant in reducing CO loads. In case of PM, the major contribution is from BS-I & II (58 percent). BS-III, CNG Auto and CNG Bus are contributed about 14 percent each. CNG car has very insignificant contribution in reducing PM loads as they are very less in number. The other vehicle technology factors such as conversion of 2 stroke to 4 stroke engines in two wheelers and auto rickshaws and fuel quality also indirectly included under BS-I, II and III category.

The study results show that the policy interventions by implementing the Bharat Stage I, II and III, in addition to implementing the CNG Autos, CNG buses and conversion of some of the cars into CNG have reduced the pollution loads considerably. However, absence of proper travel demand management to tackle the increased travel demand has

Fig. 128 Contributors in reducing CO and PM loads

created frequent bottlenecks resulting in nullifying the benefits gained by the policy interventions. Hence it is equally important to focus on the policy measures in terms of travel demand management measures by removing the bottlenecks in the road network there by congestion reduction in addition to implementing the National Auto Fuel Policy emissions standards.

Through this study, it is recommended that National Urban Transport Policy should specify the ways and means to reduce VKT with a road map focussing on appropriate Travel Demand management measures/polices (TDM) to achieve the desired goals in terms of reducing the vehicle emissions. The National Urban Transport Policy should be in tandem with the National Auto Fuel Policy otherwise benefits gained by implementing the National Auto Fuel Policy will be nullified.

Environmental Clearance for the Proposed Construction of the Integrated Sushant Lok Metro Station, Gurgaon, Haryana.

The proposed Sushant Lok Metro Station will have built-up area of – 51242.46 m^2 and will have Basement + Ground Floor (GF) + One Mezzanine Floor + 6 Stories. The total cost of the project is expected to be approximately Rs. 150 Crores. The proposed Metro Station (along with serving as a metro station) will also be developed as a commercial complex, complete with a shopping and entrainment complex like in malls.

The building is proposed to be designed in a manner to reduce the overall impact of the built environment on human health and the natural environment. In this endeavour, Delhi Metro Rail Corporation, New Delhi (DMRC) proposes to voluntarily acquire at least one-star TERI-GRIHA (Green Rating for Integrated Habitat Assessment) Rating for the proposed Sushant Lok Integrated Complex. The rating criteria explicitly emphases on (i) maximizing the conservation and efficient utilization of natural resources (ii) protection of the health of the construction workers and prevent pollution (iii) enhancing the efficiency of the system and its operations by maximizing resource (e.g. , energy, water, material etc.) conservation.

Thus, keeping in view the above objectives, several environmental conservation and management measures have been proposed during the different phases of the project

Fig. 129 Proposed integrated Sushant Lok Metro Station (proposed view)

Fig. 130 Route alignment along the proposed Qutab Minar – Gurgaon corridor

(viz., Design or Pre- Construction Phase, Construction Phase and Operation Phase) by CRRI and same have been accepted by DMRC (Figs. 129 & 130).

Various measures including ECBC guidelines to reduce energy consumption of the building and optimizing the use of natural resources, recycle & reuse of the waste water to reduce the water consumption, rain water harvesting to replenish the ground water, minimizing the air & noise pollution during construction & operation phase of the project, provisions to preserve and protect the landscape during construction, development of Green Belt and use of solar energy have been proposed and integrated into the project.

Traffic and Transportation Study for Delhi Metro Phase - III

The scope of the work to be covered by CRRI under the present study would be confined to collection of data from secondary sources, road inventory and analysis of field data. Digitisation and verification of transport network map, calibration of speed flow models, application of transport modelling and generalised cost derivation application of transport modelling which include development of origin-destination (OD) matrix, traffic assignment and estimation of ridership at metro stations and link flows in terms of peak hour peak direction traffic (PHPDT), derivation of economic values of benefit components and EIRR. Sensitivity analysis with reference to change in travel demand and construction cost are also proposed to cover under the present study.

Traffic Study and Economic Analysis of Ahmedabad Metro

The scope of the work to be covered by CRRI under the present study would be confined to collection of data from secondary sources, road inventory and analysis of field data. Digitisation and verification of transport network map, calibration of speed flow models, application of transport modelling and generalised cost derivation Application of transport modelling which include development of origin-destination (OD) matrix, traffic assignment and estimation of ridership at

metro stations and link flows in terms of peak hour peak direction traffic (PHPDT), derivation of economic values of benefit components and EIRR. Sensitivity analysis with reference to change in travel demand and construction cost are also proposed to cover under the present study.

Environmental Clearance for Rehabilitation Work of Delhi Metro Rail Corporation (DMRC) Limited at Bhai Veer Singh Marg for Shopkeepers Displaced from Panchkuian Road, New Delhi

The Rehabilitation Centre at Bhai Veer Singh Marg near Gole Market, New Delhi, is being constructed to rehabilitate the shops of Panchkuian Road, which were displaced due to the construction of Metro line at Panchkuian Road (Fig. 131). As per the policy of Delhi Metro Rail Corporation Limited (DMRC), it took the responsibility of rehabilitate the displaced shopkeepers, whose properties were acquired during the course of construction.

The DMRC had initially planned to construct the whole project in two distinct Phases. The profile of the land was divided into two pockets (Pocket I & Pocket II). Initially, the Pocket II (Existing) was constructed and planned to be used for rehabilitation of shopkeepers, whereas the Pocket I was proposed to be constructed/ developed in future for rehabilitation and commercial purposes.

The existing Pocket II block comprises G+3 floors (which have already been constructed) were proposed to be allotted to displaced shopkeepers. Meanwhile, shopkeepers had moved to the Hon'ble High Court of Delhi, praying that they should be allotted shops only at the ground floor at the earliest. Consequently, as per

Fig. 131 Surrounding features including metro line & important buildings

(a) Pocket I-proposed

(b): Pocket II-Existing

Fig. 132 (a & b) Rehabilitation centre at Bhai Veer Singh Marg

the orders of Hon'ble High Court of Delhi, DMRC decided to construct (Pocket I) (Proposed) to provide shops to all the shopkeepers at ground floor. For the construction of Rehabilitation Centre plot area is of 21403.20m². Total Built up area is 53839.863m², which includes total

floor area of 26743.154 m^2 for Pocket I & II and total basement area of 27096.709 m^2 for Pocket I only. The building is divided into two pockets: Pocket I (to be constructed) and Pocket II (Existing) Fig 132(a&b).

Existing Pocket II (~ 7154.8 m^2) has GF + 3 Stories and has no basement. Pocket I (~ 19588.354 m^2) Fig 132(a) which is proposed to be constructed will have GF + 8 stories and has 3 basements. Total cost of the proposed project is Rs. 180 Crores.

Delhi Metro Rail Corporation Limited (DMRC) has engaged Central Road Research Institute (CRRI), New Delhi as their EIA consultant to carry out EIA Studies and to prepare Environmental Management Plan (EMP) to mitigate various environmental impacts which might arise during Pre- Construction/Design, Construction and Operation phase of the proposed project and help DMRC to get "Environmental Clearance" as per the provisions of the EIA notification dated September 14th 2006.

The objectives of the EIA study included assessment of environmental impacts related to location, Design, construction and Preparation of appropriate Environmental Management Plan (EMP) to minimize the negative impacts, during all the three phases namely, (i) Pre-construction (ii) Construction and (iii) Post Construction/ Operation phase of the project.

The methodology included base-line data collection related to traffic, air, noise, soil , water and prediction of impacts on different environmental components likely to be affected due to the proposed activity including air and noise environment by using appropriate mathematical models followed by the evaluation of impacts. Based on these an appropriate Environmental Management Plan (EMP) has been suggested to mitigate the adverse environmental impacts during different phases of the project.

Based on the Form I and Form IA, along with Environment Management Plan prepared as a part of EIA Study and Presentation made before the Delhi State Environmental Appraisal Committee (DSEAC) it is expected that the "Environmental Clearance" for the above project will be granted very soon as per the provisions of EIA notification of Sept. 14th, 2006.

New Infrastructure R & D Facility Developed

Fuel flow Detector for Petrol (MPFI) Vehicles

For fuel consumption measurement of Petrol (MPFI) vehicles under idling and in-use condition with an accuracy of 0.1 ml and flow rate measurement upto 120 Ltr/hr.

Fuel flow Data acquisition system which integrates

Fig. 133 Fuel flow data acquisition system mounted on a specially designed stand

distance data logged through GPS with fuel flow data logged through fuel flow Detector, with a speed accuracy of 0.1 km/hr Fig. 133.

Water Chemistry Laboratory

Fully furnished Atmospheric chemical laboratory has been established in for chemical characterization of various pollutants from road side dust, vehicular exhaust etc. A well equipped water quality testing laboratory has been developed for monitoring of water samples for Physical, Chemical and Bacteriological parameters. For the characterization of above parameters flame photo meter, turbidity meter, pH meter, conductivity meter, Calorimeter, BOD / COD incubators, reactors etc. are available in the laboratory Fig. 134.

Auto Sampler along with SUMMA Canisters

It has facility to collect ambient air for the detection of various trace species like non methane hydrocarbons, Benzene, toluene, Xylene etc.

This sampler has unique in-built system of vacuum and speed meter. Canister has special silonite coating to retard the decomposition of volatile organic compounds. This system is provided by ENTECH USA Fig. 135.

Fig. 134 Water chemistry laboratory

Fig. 135 Auto sampler with Summa canisters

Road Development Planning and Management

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report
2009-10

PROJECT TEAM MEMBERS OF ROAD DEVELOPMENT PLANNING AND MANAGEMENT DIVISION

Development of GIS Based National Highway Information System

As reported earlier (Annual Report 2008-09), the Ministry of Shipping, Road Transport and Highways (MOSRTH), Government of India proposes to develop comprehensive database for about 50,000 kms of National Highways (except the roads under NHDP) on a Geographical Information System (GIS) platform. The main objective of the project is the development of National Highways Information System in GIS environment which is to be achieved through collection and collation of road related information both from primary and secondary sources for 50,000 km long National Highways network. It is proposed to collect road inventory of all NHs and traffic data on selected locations only once during the period of implementation of the study. The project will be implemented through the following four modules:

Module I: Development of GIS based Highways Information System

The main emphasis of this module will be on the development of GIS based software through which data management system can be affected. The software will include various highway information sub-modules such as (i) Locational Referencing, (ii) Pavement Construction and Maintenance History, (iii) Pavement Inventory, (iv) Pavement Condition (v) Pavement Geometry, (vi) Pavement Crust and Strength details (vii) Environmental Condition, (viii) Traffic and Vehicle Information, (ix) Cross-Drainage details and (x) Integration with HDM-4 software. The software to be built on GIS environment will have diversified multi-tasking operations with computer hardware and software. A digital map for GIS spatial data has been prepared showing all the National Highways incorporated in the software. Pavement modules of the software have been completed and the traffic modules and integration with HDM-4 is in progress. About 29000 km of national highways data collected using NSV has been processed and integrated with the system. Km-wise locational referencing system has been generating using GPS data collected through NSV, a typical view of the software KM-wise query system is shown in Fig. 136.

Module II: Inventorisation of National Highways

This module covers a comprehensive inventorisation of about 50,000 km length of National Highways network. The inventory data will be collected by running the instrumented vehicle on a single run. Till now, about 35,000 km of National Highways has been surveyed using the NSV. The data collected is being processed to input to the GIS based Highways Information System software. The distress data being captured through video graphics from the NSV is analysed for about 10000 km length of National Highways. Fig. 137 shows the typical views of distress data processing and collection using the video graphics. The other secondary data related to pavement details, cross drainage structures, environmental parameters, etc. also being collected as per the formats devised for the purpose and will form inputs to the system. The secondary data for about 15000 km length of National Highways has been collected and is being processed to upload in the software.

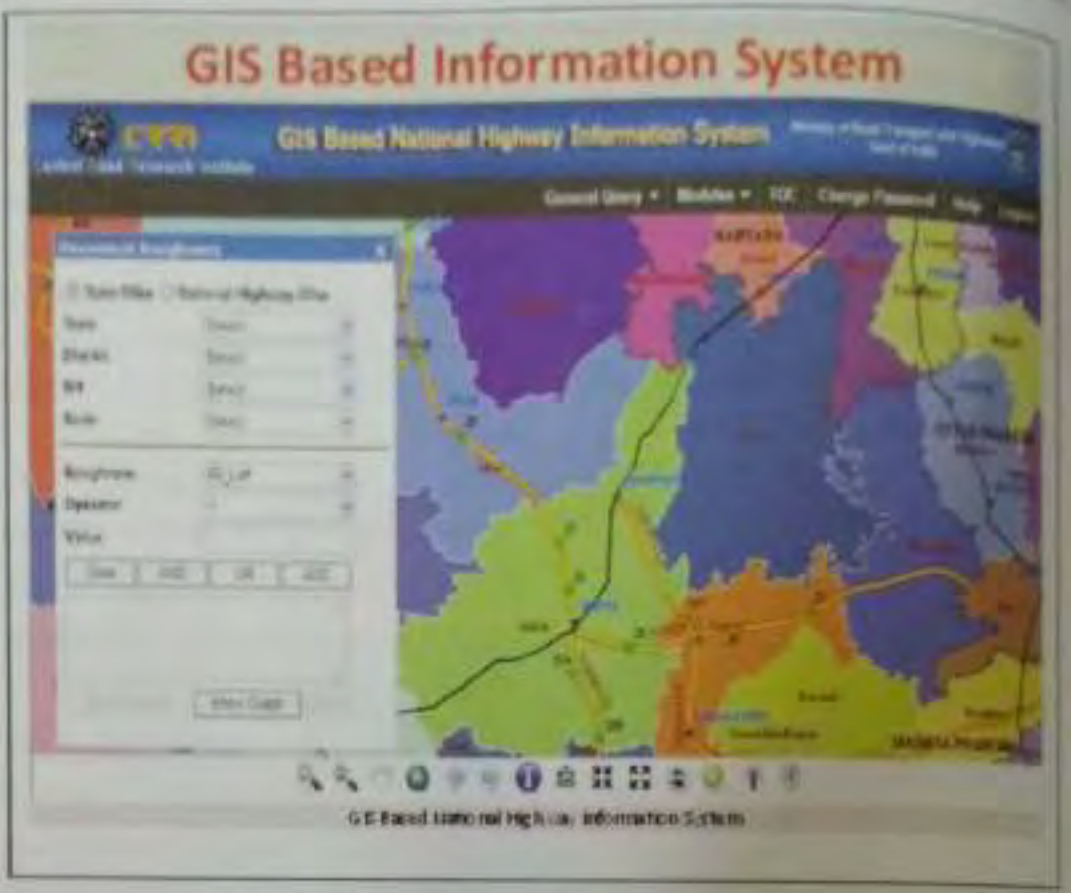


Fig.136 Map showing typical GIS based query system

Fig. 137 Distress data processing using the video graphics

Module III: Traffic Volume Surveys

It is proposed to collect traffic volume data for about 50 representative locations continuously for 7-days, using Automatic Portable Traffic Counters - cum-Classifiers (APTCC). Six number of infra-red technology based APTCC has been procured for the surveys. The survey has been completed for 10 locations (Fig. 138) and traffic volume data has been uploaded in the software. In addition about 900 locations of traffic data received from the Ministry will also being incorporated in the system.

Evaluation of Operational Efficiency of Highway Network using Travel Time Reliability Measures

Travel time reliability is an important attribute of transportation system affecting choice of mode and route of travel. It is a measure of any roadway service quality in transport network and efficiency.

Fig. 138 Map showing the locations of traffic surveys

The objectives and scope of the study are:

- To evaluate operational efficiency/ characteristics of highway transportation system by considering various travel time reliability measures.
- Analyse travel time variability under various uncertainty factors of transportation system from demand side factors, supply side factors and external factors.
- Selection and estimation of appropriate travel time reliability Indices for Indian Highways.
- Application of stochastic simulation modelling technique and Artificial Intelligence modelling techniques such as Stochastic Response Surface Method (SRSM) to predict the travel time reliability.
- Neural Network Models and Genetic algorithms models for modelling travel time distribution.

In this study empirical/data based oriented approach has been considered to measure the travel time reliability of an urban corridor in Delhi. The main performance indicators in this approach are simplest measure of travel time reliability in percentile, buffer index and planning time index. The percentile reliability indicates how bad delay will be on the heaviest travel days, for e.g. if 95th percentile travel time indicates that 19 out of 20 working days, traveler is in time to work place this can be expressed as planning time. The buffer time index explains the ratio of buffer time to average travel time. The buffer time is difference between 95th percentile travel time and average travel time. The planning time index is the ratio of 95th percentile travel time to free flow travel time.

Licence plate matching techniques have been considered for measuring travel time of the study area. Travel Time has been computed from the difference in arrival times of matching the licence plate between entry and exit points. One week consistent data from 24th to 28th August 2009 in the morning (8.30 to 10.30am) and evening hour (4.00 pm to 6.00 pm) have been collected. This study mainly focused on travel time variation of cars which includes small and big cars. It has been observed from the data, that averages of 12 per cent of vehicle license plate numbers were matched by considering entire license plate numbers of the cars.

The statistical parameters of travel time for the study area at various time intervals in the morning and evening hour was calculated and shown in Fig.139. Wide area between maximum profile travel time and mean profile travel time was observed. Such a big difference in these two profiles emphasizes the importance of travel time variation and also explains that average travel time parameter unable to explain travels experience on study area. This difference between these two profiles indicates that travellers have suffered during peak hours due to unexpected delay.

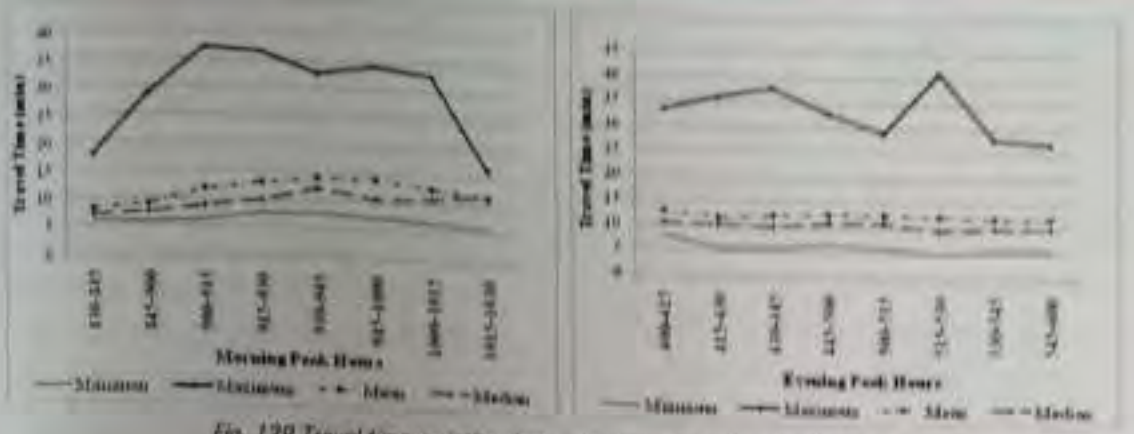


Fig. 139 Travel time variation during peak morning hour and evening hour

Travel Time Reliability Analysis

Planning Time (PT) and Planning Time Index (PTI): The planning time and planning time index for all the time periods in the morning and evening hours are calculated for 15 minutes interval and are shown in Fig. 140 . From the figure, it can be identified that in the morning hours before 9.00 am the planning time is around 12 minutes; where as between 9.00 am to 10.00 am it is around 25 minutes. This emphasises that the vehicle enter after 9.00 am has to plan double the travel time to reach the destination in time. In the evening hours the planning time is approximately 20 minutes for all the time intervals. From planning time index, it is observed that values are fugher in the morning hour between 9.00 am to 10.00 am. In the evening hours the PTI values are varies between 3 and 3.5 times than free flow travel (6 minutes).

Buffer Time and Buffer Time Index: The buffer time and buffer time index was calculated for each time interval and are presented in Fig. 141. It can be observed from the figure that morning hours have clear peak values for buffer time and buffer time index. Whereas for evening hours there is no such clear distinction between peak and off-peak values. Highest buffer time index value, i.e. 1.0 observed during morning period between 9.00 am to 9.15 am. This indicates that travellers should budget an additional 12 minutes buffer for 25 minutes

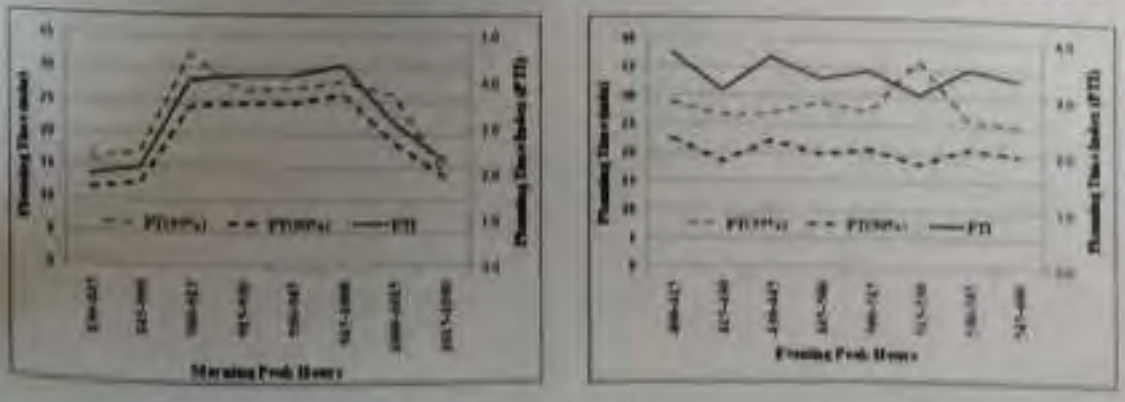


Fig. 140 Planning time and planning time index during morning and evening hour

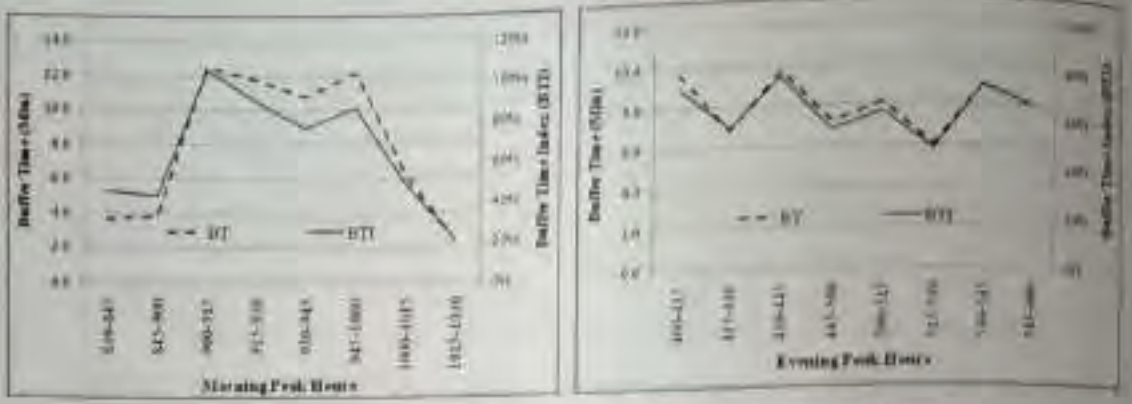


Fig. 141 Buffer time and buffer time index during morning and evening hour

planning time to ensure 90 per cent on time arrival at the destination.

Travel Time Reliability Measures Vs Congestion Measures

In this study an attempt has been made to find the relationship between the travel time reliability measurements and congestion level measurement interims of Travel Time Index (TTI), defined as the ratio of average travel time to the free flow travel time (Fig. 142).

From Figure, it can be identified that the severity order of congestion represented by the congestion index (TTI) may not be consistently followed with that of reliability index. This is mainly because of the congestion measure depends on average travel time of the route, where as travel time reliability indices such as PTI considers the travel time variation. This further indicates that travel time reliability measures are capable of measuring the variability in congestion level.

Application of Geographical Information System (GIS) in Traffic Congestion Management

Traffic congestion is normally measured using travel time, speed, and delay data and this factor has also been taken to evaluate various transportation projects. Travel time and delay studies are mostly used to document congestion and to monitor congestion over the road corridors. Various techniques are available to study congestion based on the above parameters. On such study using Global Position System (GPS) technology and application of GIS provides more

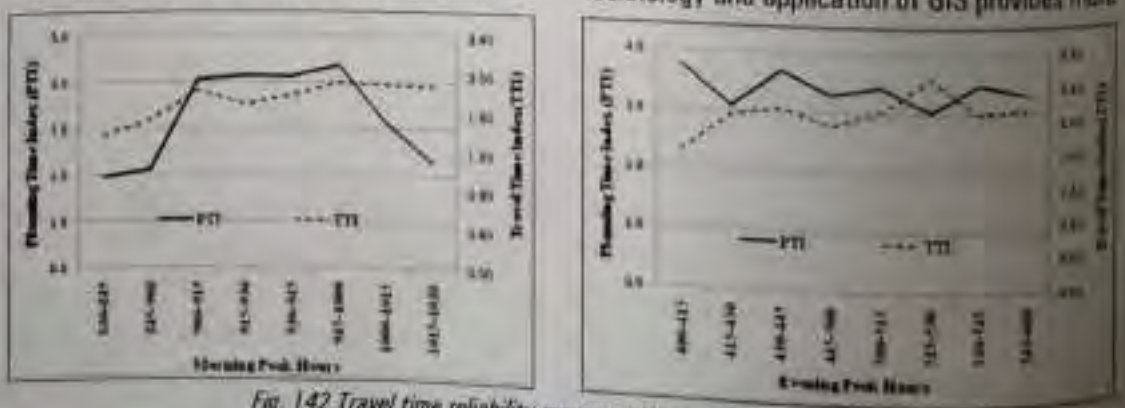


Fig. 142 Travel time reliability measures Vs congestion measures

accuracy and easy way of data collection and analysis. The literature survey also showed that utilization of GPS technology is the state of the art technology for the travel time and speed measurements. The main objective of this study is to use GPS to determine speed, travel time, and delay on arterial roads of Delhi and to identify an effective methodology for measuring the travel time through a particular urban corridor.

Methodology Adopted

- Measure travel time, running time and delay time for each segment of the corridor in working day and holiday travel times.
- Develop a systematic method to transfer the travel data collected by GPS into GIS environment
- Allow to identify segments that have consistent problems maintaining an average travel speed for the corridor.
- Allow the study to serve as a benchmark that could be repeated in the future to determine how travel times may change over time.
- Understanding the movement of traffic by measuring its time elements can facilitate traffic management and the prioritization

In this study, the data has been collected through Moving Observer Method using floating car method through conventional (manual recording) and also using GPS. A comparative analysis was carried out for these methods. Two teams independently deployed for data collection, one for conventional and the other for using GPS.

There are two ring roads (inner and outer) in New Delhi, which cater maximum inner city traffic. The entire inner ring road which is signal-free except few crossings and a portion of outer ring road has been selected for this study. In addition, two arterial roads diverging from CBD (CP) also has been studied. All these roads have six lanes divided carriageway and are shown in Fig 143.

The data were collected in the selected sections during a holiday and working day from 10:00 AM to 11:45 AM on inner ring road, 1:00 Pm to 2PM on outer ring road and 5:30 to 7:00Pm on CBD arterials. The data were collected from the GPS as well as using floating car method. A comparative analysis has been carried out for travel times and speed profile.

Based on the data, travel time and speed profile has been estimated for the two different methods shows the comparison between travel times captured by GPS and

Fig. 143 Corridors selected for study

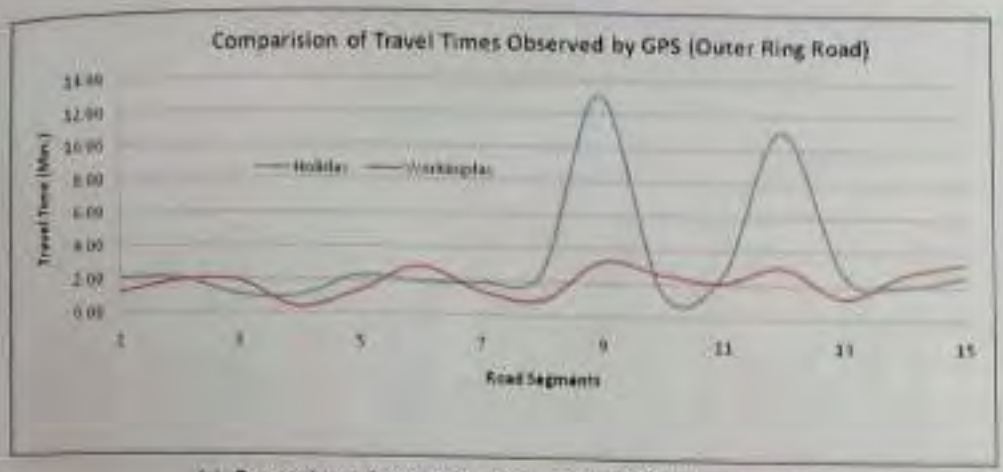
floating car method. Figs. 144 (a to d) and also show the travel times observed by GPS on outer ring road and CBD arterial respectively.

The speed profile data is essential data for studies of traffic flow quality analysis. Speed profile provides the basic information on trip quality for the calculation of the traffic congestion levels on the road corridors. GPS speed data facilitates the knowledge of the spatial location corresponding to each speed observations. GPS speed data can be displayed on GIS map, which thus enhances the interpretation capabilities. Figs. 145 (a & b) shows the comparison between the average speeds collected by GPS and floating car on various sections for working day as well as holiday. A GIS based thematic map on speed at different sections has been shown in Fig. 146.

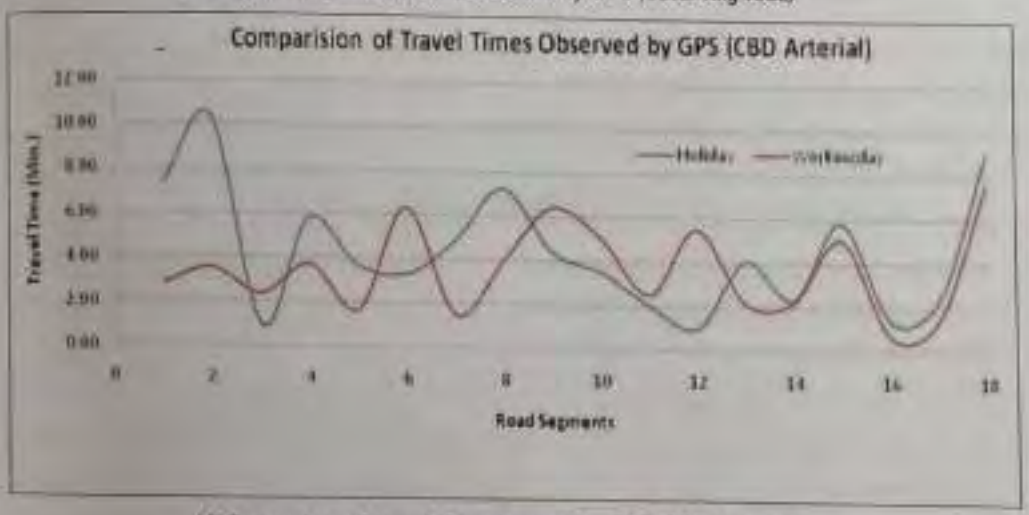
A statistical analysis was performed to see whether there are significant differences between the manual method and the GPS method. For this analysis, mean and variance of speed were used

(a) Comparison of travel time during a holiday (GPS vs. FC)

(b) Comparison of travel time during a Working day Vs. Holiday

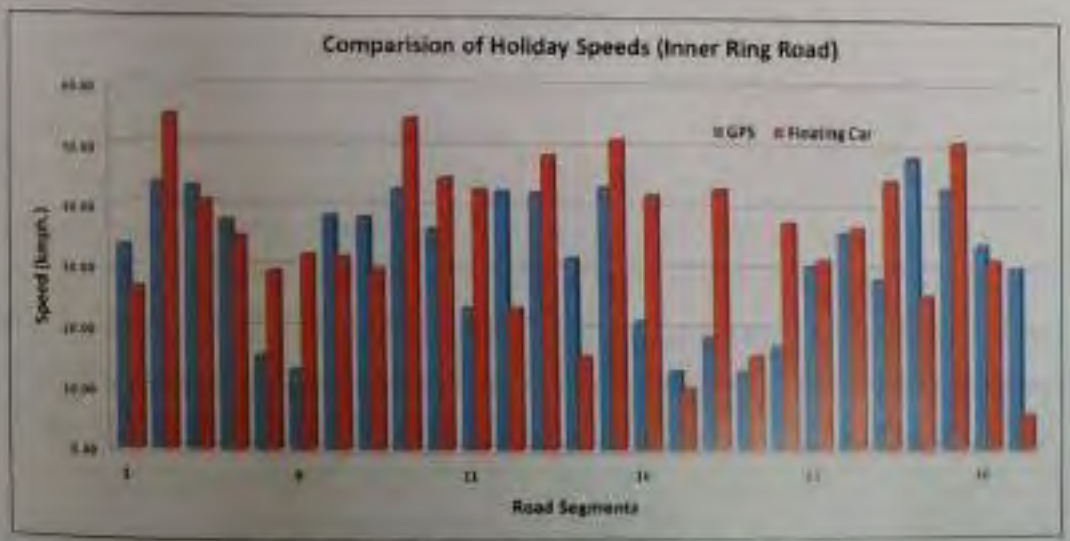


(c) Comparison of travel time observed by GPS (outer ring road)



(d) Comparison of travel time observed by GPS (CBD Arterial)

Fig. 144 Comparison between travel time captured by GPS and floating car method



(a) Comparison between the average speeds for holiday

Fig.145 (a&b) Comparison between the average speeds for working day

Fig.146 Speeds of Inner and Outer ring roads

to test the difference between the two methods. Evidently, when the variances and means have no significant difference, the two methods can be said to be statistically indifferent. Thus, they can be used interchangeably. The two-sample *t* test was used to compare the means of the samples collected. Prior to using the *t* test, the *F* test was used to determine whether we had to assume equal variances or not. The test results are shown in Table XV.

It is obvious that there is no statistically significant difference between the means and

Table XV. Test of Equality of Variance and Means for Speed Data

Test of equality of Variance and equality of means for Speed data collected by floating car and GPS method							
		F Test for equality of Variance			t Test for equality of means		
Section Name	Test of the Day	F (Calculated)	F (Table) at 95% of Significant Level (alpha 0.05)	Result	t (Calculated)	t (Table) at 95% of Significant Level	Result
Jaunpur Ring Road	Holiday	1.351	1.8898	Not Significant	0.660	1.96	Not Significant
	Working Day	2.170	1.3895	Significant	0.004	1.96	Not Significant
Outer Ring Road	Holiday	1.177	2.3879	Not Significant	0.022	2.048	Not Significant
	Working Day	1.422	1.3879	Not Significant	0.160	2.048	Not Significant
DJB Junction	Holiday	1.154	2.2304	Not Significant	0.434	1.96	Not Significant
	Working Day	1.193	2.2304	Not Significant	0.038	1.96	Not Significant

variances of the speed collected by the floating car method and GPS method. As result, we can conclude that the GPS method is as accurate as the conventional manual method. But using GPS it is possible to save time, and manpower costs of data collection. It is very simple method of data collection and easy to analysis in the system. The data so collected can be integrated in GIS environment and thematic maps can be generated to understand the congestion locations in term of delay.

Accessibility and Mobility Impact on Neighbourhoods due to Expressways/High Speed Corridor

Accessibility and mobility impact on neighbourhoods plays an important role in projects evaluation. Such parameters are important, especially for evaluating large scale projects where the impacts are spatially and temporally extensive. This study proposes an inclusion of neighbourhoods as a part of the project including the effect on their accessibility as well as mobility. The objectives of this study are:

- To identify the impact of expressway on neighbourhoods. This includes the impact on different users and non-users.
- To measure the change in accessibility and mobility of neighbourhoods due to expressway/high speed corridor through 'Before and after study' analysis.
- To develop the indicators and index for accessibility and mobility impact assessment to compare the effect of expressways on neighbourhood.

Geometric survey of the expressway and household surveys for neighbourhood will be used to understand the change in accessibility and mobility due to construction of an expressway. The expected outcome from this study is:

(i) A general methodology to assess the impact of transport project on neighbourhood.

(ii) Indicators development for accessibility and mobility measures.

The parameters for study, questionnaire for data collection and process of selection of study area is under progress.

Modelling of Driving Cycle for Road Network Development Plan in Urban Area and Suburban Area applying GPS – A Case Study in NCR

This study provides a platform for a large number of potential future applications for developing the driving cycle for minimising delays and congestion using different road network plan. Driving cycle is representative speed time sequence of vehicle

of the area for particular vehicle. Development of representative driving cycles is an important part for minimising travel delays as well as setting up emission standard of vehicle and developing fuel efficient road network. Numerous studies have been conducted to build up driving cycles in different contexts. Driving cycle is affected by many factors such as road geometry, traffic, time of traffic, speed limit, type of area (urban, suburban), and vehicle type. The driving cycle modelled for other city may not truly represent the driving cycle for other city like Delhi. The objective of the study included:

- Modelling the driving cycles and to develop the efficiency of road network plan by minimising the delays and congestion
- To find the effect of road geometry, traffic volume, speed-limit on driving cycle
- Scope of the work will be initially restricted to Delhi urban corridors (subzone) for cars only.
- Application of driving cycle to estimate pollution.

Normally, three different approaches are normally adopted for emission measurement using the driving cycle studies.

i) Onboard Experiment – GPS and emission analyser are installed in a vehicle for onboard emission measurement. The Onboard emission of CO, HC and NOx can be made during different phase of vehicle operation (idling, cruising, acceleration and deceleration phase of driving cycle).

ii) Laboratory Measurement - Chassis dynamometer tests is done to replicate the actual drive cycle of the vehicle journey route in terms of vehicle speed against time in laboratory. The exhaust emissions measured for the specified driving cycle (using a vehicle speed versus time trace) on a chassis dynamometer represent the tailpipe-out emission levels for a given route. The amount of emissions produced at every instant can vary largely over the duration of a journey and this depends upon the nature of driving traffic conditions, road network and road geometry. One major limitation of this method is that this is to carry out in the controlled environment of the laboratory.

iii) Micro-simulation Approach - The micro-simulation approach is useful to estimate the emissions in the absence of onboard measurement or laboratory measurement. Many inputs are required for example road, signal and traffic details (in-house model building) which can be collected directly from field and secondary sources. The model is calibrated and validated using the real-world speed– time data collected over the corridor. Other characteristics include dimensions, speed, composition in traffic, acceleration, deceleration, lateral and longitudinal manoeuvres, as well as other driving behaviour characteristics are useful parameters to derive the driving cycle. A number of trial simulation run of VISSIM are undertaken until stabilisations of the model results. The calibration and validation of model ensure the result very near to real world, however due to large number of factor, it is very difficult to get result near to field conditions.

HRD & Project Management

Planning, Monitoring & Evaluation

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report 2009-10

PROJECT TEAM MEMBERS OF PLANNING, MONITORING AND EVALUATION DIVISION

R&D and Knowledge Management are key activities of this Division, which inter-alia covers Planning, Monitoring & Evaluation of R&D projects and other externally funded projects, issues concerning Intellectual Property and Business Development, attending to technical queries, Parliament Questions and technical audit and assistance to Director in liasioning with CSIR, Management Council (MC) and Research Council (RC) on project related matters. Also undertaking In- House Research activities in the area of Knowledge Development and Management.

Major activities the Division carried out during the year are as follows:

Planning Activities

12th Plan Projects

PME is coordinating with Engineering Cluster as well as CSIR-800 cluster for 12th plan projects activities, which have been identified as Supra and Network projects. A series of brain storming have been done at Institute level as well as different R & D group levels. Supra project will be taken up by CRRI and Net-work projects will be developed jointly with other laboratories i.e, AMPRI, IMMT, NIEST, CBRI, CMERI, CSIO etc. Also review of available man power for development and co-ordination for the projects has been taken up. A draft, proposal on "Sustainable Road Transport System and Road Infrastructure" has been prepared. The other area of interest emerged from various brainstorming sessions are Robots for under water Inspection of Bridge Structure, Mobile Mixer System for Road Construction, Early Warning System for Landslide, Development of Drivers Simulator System, Use of Foam Material for Road Stabilizations and Materials to Save Kggregates etc.

Annual Plan 2009-10

The Annual Plan 2009-10 document for CRRI, which contained information related to research work plan to be carried out during 2009-10. The financial requirements for these projects were also identified and managed.

CRRI Budget

The financial requirements are defined on Plan and Non-Plan basis. Plan items included all research components whereas Non-Plan item's cover infrastructural support. The Plan requirements for the Institute for the years 2009-10 (Revised Estimate) and 2010-11 (Budget Estimate) has been prepared by the division.

Registration of Projects

Registration of all externally funded projects and allotment of specific identity in terms of a Project No. is effected at PME, soon after the money for the project is received along with In-Principle approval. Projects are registered in different modes viz sponsored Research, Grant-in-Aid, Collaborative, Consultancy, Technical Services and Testing. The total number of projects registered in different modes is given in Table- XVI. The total cash-in-flow generated is rupees 1110.00 lakh.

Table- XVI. Projects Details during 2009-10

Type of Project	New Projects	Completed Projects	Ongoing Projects	Total
CLP			1	1
CNP	82	30	132	162
GAP	1		11	11
SSP	3		28	28
TSP	90	50	121	171
Total	**194**	**80**	**293**	**373**
Inhouse R&D	26	10	55	65

Development and Maintenance of Project Database

A project database has been developed, which is regularly updated incorporating addition of new projects, modifications during their implementation stage and finally during their completion. The database includes project title, classification and technical and financial details, which help in tracking the technical and financial progress of the projects. PME also maintains the cash inflow of all the projects.

Intranet site for Information

Developed and hosted a web based (Intranet site) "Online Projects Information/ Query System" to facilitate the F&A section/Stores and Purchase section and R&D divisions for various purposes.

CRRI VISION 2021

Prepared a draft of "CRRI Vision 2021 Document" with the inputs from Committee members from different disciplines of the Institute.

Monitoring Activities

Research Utilisation Data (RUD)

Reporting on the performance and the status of various projects was carried out through preparation of Research Utilisation Data (RUD). Research Utilization Data (RUD) contains information related to various projects handled by the Institute.

Quarterly Performance Report (QPR)

Quarterly Performance Report (QPR) contains information about the performance of the Institute on various parameters on quarterly basis. These reports are sent to CSIR for their perusal on quarterly basis. These reports also help the Institute in reviewing its own performance as a monitoring tool.

PME Division also calls for progress report of all the on-going projects in the Institute for processing. This exercise is meant to monitor & ascertain the status of each of the projects with respect to adherence to time schedule and other milestones. Any deviation is intimated to the respective project leaders and remedial measures are taken to put the project on course. Completed projects, as reported by the respective Project Leaders are processed for closure.

Projects Monitoring

Externally Funded Projects

Externally funded projects were regularly monitored particularly for their adherence to time schedule, amount dues, if any, documentation, closure etc. through divisional reviews.

In-house Projects

"Projects Identification and Monitoring Committee" has been constituted to monitor the progress of the In-house projects. The committee also reviews the progress of the In-house projects periodically. The new Projects are taken up if approved by the Committee after the Presentation made by the Project Leader. Similarly at the time of completion of the projects a presentation is made by the Project Leader to incorporate suggestions if any from the committee members. The details of on-going and completed In-house projects during the year is given in page 247-249.

External Cash Flow (ECF)

The Institute undertakes projects sponsored by various external agencies such as Ministry of Road Transport & Highways (MORT&H), National Highways Authority of India (NHAI), Department of Science and Technology (DST), etc and Public Sector, Private Sector and Foreign Clients. The details of External Cash Flow i.e., money received from these agencies to carry out specified task was regularly recorded and monitored vis-à-vis target established by the Institute. During the year the ECF generated from Govt. department - 737.66 lakhs , Public Sector- 155.24 lakhs, Private Sector - 203.42 lakhs and Foreign Clients- 13.84 lakhs. The total ECF generated was 1110.16 lakhs.

Expenditure Monitoring

Efforts were made to keep track on the expenditure vis-à-vis budgeting allocations/ requirements on monthly basis so that performance/ working of the Institute could be made more effective.

Evaluation Activities

Issues related to the Technical Audit

Handling of issues related to Technical Audit is another important activity of the Division. It had been instrumental in providing information and necessary support to Audit Team. Annual and Periodical Audit was carried out by CAG and Internal Audit Team.

CRRI Outstanding Performance Award Scheme

The Institute, in order to appreciate efforts made by a division and also to promote healthy competition amongst various Divisions to do better each time, initiated the practice of awarding 'Best Performing Division' each year based on the annual performance. The scheme was revised to extend it to incorporate individual and team for their meritorious work.

RC Secretariat

Acted as Secretariat to provide full support to RC Secretary in carrying out activities for organizing RC Meetings. This includes Agenda, Information

for Action taken Report, Information for Director Presentation and other related logistics for conducting of meeting. Follow up actions were taken up as per the minutes of the meeting.

Other Activities

Project Summary for Management Council/Research Council

Responsible for preparing the up-to-date Projects' Summary and providing the information on the projects that are to be ratified by the Management Council. It also provides the necessary project related information for Research Council to decide the future programmes of R&D for the Institute.

Management of Various Project Proformae

PME designs, maintains, manages and modifies the proformae pertaining to various project related activities as per the need arises from time to time.

Parliament Questions

PME handles technical queries pertaining to various projects being handled by the various R&D Divisions of the Institute. These queries are related to Parliament Questions and CSIR guidelines, technical progress of projects etc. Also interact with various divisions of CSIR particularly PPD regarding the preparation of Annual Plans, Five Year Plans of the Institute, Management of Network Projects, ECF queries etc. During the year reply to 40 Parliament Questions were handled, the replies were prepared after collecting, compiling and collating information from Technical Queries from within/ or outside CRRI and CSIR, R & D and others division of the Institute.

Service Tax Payment

On receipts of amounts for externally funded projects, Service Tax is paid to the Government. Division regularly carries out activities for the payment of Service Tax on monthly basis.

CRRI–IRC Interface

Acted as an interface between CRRI Scientists and IRC so that concerted efforts could be made to incorporate relevant changes due to technological reasons in the prevalent IRC codes and Specifications.

CRRI-BIS Interface

PME Division had also acted as an interface between CRRI scientists and BIS. A member of CRRI scientists was nominated to various BIS Committees.

Post Graduation Research Programme in Engineering of Infrastructure and Disaster Mitigations.

CSIR has invited applications for two year full time residential Post Graduation Research Programme in Engineering of Infrastructure and Disaster Mitigation in the different area of cutting edge technologies. The Programme is designed to give in-depth exposure and hands on R&D experience to the Young Engineering Graduates to groom them as Future Technology Leader. Recognising the importance of both Housing and Roads, the two prime infrastructure required for the growth of the country, the Central Building Research Institute, Roorkee

(CBRI) and the Central Road Research Institute, New Delhi (CRRI), two prime laboratories of CSIR are jointly offering two year PG research Programme on "Engineering of Infrastructure and Disaster Mitigation (Buildings / Roads)" There are fifteen seats. The PGRPE activities are being coordinated by the division.

Power of Idea

"Power of Idea" is an initiative to encourage anyone and everyone with an Idea to realize his/her entrepreneurial dream. Power of Idea" could be an appropriate platform for CSIR scientist to share their technologies/ideas with entrepreneurs with support of CSIR and Economics Times partners, the entrepreneurs in turn can exploit those technologies/ ideas commercially.

OASIS

Database for Group IV Scientists was created after collecting information from all scientists fall under the category of CRRI for onward transmission to CSIR Headquarter. The exercise will help for Empowering the young scientist of CSIR to generate Innovative Ideas.

ERP

CSIR is in the process of development of Enterprise Resource Planning (ERP) for all CSIR laboratories. DRRI has constituted a Task Force and implementation team for successful implementation of ERP in the Institute. HoD, PME is Task Force leader for development of the ERP system.

R & D Projects

R & D Management

R & D Management is a continued activity of PME division. The Scope of the In-House Project include is to Design & Development of In-house R&D projects Databases & fetch the existing data into the database, Updation of Externally funded projects database, Checking & Verification of data entered with physical files, Streamlining of cash in flow database, man-days database, Automation of all new & existing data bases, Updation of OQS (Online Query System) and Report Creation using OQS (Such as Monthly Report, RUD and Quarterly Performance Report).

CRRI Research Compendium

The Compendium is a compilation of executive summaries of various projects and will be a reference publication for R & D work carried out by the Institute since 1984. The Compendium will be a knowledge based tool for business development in marketable in soft and hard form and accessible through Digital Medium.

Modern Practices in Bituminous Road Construction

The book shall include latest construction materials, equipments, specifications for road construction. Some of the chapters pertains to modified bitumen, modified emulsions, warm mixes, recycling and performance based specification.

Considering the need of effective management of technology portfolio of the Institute, TMBD Cell has been constituted. The objectives of the TMBD Cell are to:

- Document new and emerging technologies that are either developed or being developed by the Institute,
- Projecting the good work done by the Institute by implementing the Technology Management Plans,
- Integrating technology management aspects including IPR management with R&D and business development,
- Creating high performing network of R&D professionals and organisations,
- Ascertaining products development,
- Reaching out for the benefit of the North Eastern Region by extending appropriate technological solutions,
- Entering into productive partnership through MoU/Agreements,
- Interacting with user agencies for identifying challenging technical problems for progressive R&D, and
- Competency development.

Major activities carried out during the year are:

Technology Management Activities

Publication of CRRI Technical Reports

CRRI has started publication of CRRI Technical Reports with the following objectives:

- To reduce the time taken in translating R&D works into field usage through formulation of codes and specifications
- To project the good work carried out by CRRI
- To give clear recommendations on the topic to be utilized with confidence by the field engineers
- To bring out State-of-Art on important topics

Following three reports were published during 2009-10:

a. CR-01 – State of Art Report on Commercial Vehicle Axle Loading on Indian Roads

b. CR-02 – Design and Construction Methods of High Embankment on Soft Soil

c. CR-03 – Vehicular Passby Noise

Launching of Corporate Technological Responsibility Initiatives

CRRI has identified and launched three major areas to focus the efforts in a consolidated manner. These are "Save the Aggregates", "Reduce the Traffic Congestion", and "Road Safety". CRRI has taken these initiatives as Corporate Technological Responsibility initiatives reflecting our commitment to the profession. A brochure has been brought out.

The above initiatives are undertaken to project our good work done in these areas and to indicate to the profession that CRRI is committed on the objectives as technology mission. The initiatives will also add to the brand image of CRRI apart from projecting technical contribution to the objectives. Logos are to be designed for each initiative that would be printed on all our documents such as letterhead, envelopes etc.

Product Development initiatives

TMBD Cell has also undertaken development of various products as a systemic activity and worked on following products' development by involving various agencies:

a. Equipment to determine the density and/or moisture content of the given compacted fills through non-nuclear non-destructive method

b. Driving Simulator

c. Advanced parking Lot Management System

Technology Management Plans

TECH-D initiative was launched to discover and project technologies out of the work both carried out and being carried out by the Institute. For each technology, a Technology Management Action Plan (TMAP) is proposed for systematic handling of a technological work. Under the initiative, around eight TMAPs were prepared which are under different stages of implementation.

Business Development Activities

Interaction for Business Development

Interaction with various agencies was made to communicate the good work done by the Institute and also to trace newer and challenging technical problems for further R&D activities. It made reaching out to our stakeholders and associating them with our activities.

Interaction made with NEIST, Jorhat; NEC, Shillong; Rajasthan PWD, Jaipur; GDA, Ghaziabad; CDC, PWD Mizoram etc.

MoU / Agreements processed

Collaboration is the buzzword in today's globalisation scenario wherein the technology is changing very fast. Only through coming together and harnessing each other capabilities, we can develop newer products and technologies. A well-documented MoU/Agreement is the key for successful collaboration wherein all parties/ stakeholders are in the win-win situation. TMBD Cell processes such documents.

Development of Proposals

For possible project funding, proposals are to be submitted to prospective funding agencies for sponsorship. Efforts are made to develop several proposals both to exploit available technological knowledgebase as well as to work on new technological arena.

Road Transport R&D Network

At various forums, a need was felt to develop a network of R&D organisations and professionals. A meeting of R&D organisations during IRC Annual Session on Nov. 15, 2009 at Patna was also held. It was decided that the network shall be run and managed through a web portal with the following objectives:

- To establish the network of all R&D professionals in the roads and transportation sector
- To establish knowledge sharing mechanism
- To plan future course of action/studies for R&D purposes in the sector
- To derive output to convert into outcome as feeding mechanism for the professionals particularly to different IRC Committees

- To be a forum for technology management especially technology commercialization
- To disseminate technical knowledge and R&D findings
- To be a happening and one-stop site for all R&D professionals of the sector

Efforts are being made to develop the website for operation of website.

Intellectual Property Management Related Activities

For any R&D organisation, the most important asset next to human resource is its IPR portfolio. TMBD works to safeguard the intellectual property generated by the Institute through IPMD, CSIR. The related activities involve from sensitising R&D staff to take effective measures to safeguard their intellectual property to processing relevant documents and liaison with IPMD.

North Eastern Region Related Activities

There has been a strong felt need to support North-Eastern Region of our country through appropriate technologies for its overall growth. The region on one hand demands appropriate technological solutions but on other hand provides us with challenging technical problems that need to be solved and demonstrated. Accordingly CRRI interacted with NEIST, Jorhat so that it has a window to communicate with the prospective clients in NE Region. NEIST will work as a CRRI NODE in NER to interact with different road agencies of the region and will be the face of CRRI in NE Region. Interaction was also made to North-Eastern Council, Shillong, PWD Mizoram and PWD Assam to communicate the activities of CRRI and also to understand their technological requirements.

HRD & Project Management

Information, Liaison and Training

CENTRAL ROAD RESEARCH INSTITUTE

Annual Report
2009-10

PROJECT TEAM MEMBERS OF INFORMATION, LIAISON AND TRAINING DIVISION

Regular Training Programme

Imparting training to the engineers of the user agencies is an integral part of the research programme of the Institute. During the year, following refresher courses/training programmes for in-service engineers of the user organizations related to roads and road transportation in the Govt. Public & Private Sectors were organized. Through these programmes, the Institute imparted training to the junior, middle and senior level engineers of the user organizations and acquainted them with the latest research based information on various aspects of road and road transportation.

Special Training Programme

Besides the regular training programmes, the Institute conducted customer oriented programmes to meet the specific training requirements of the user agencies. During the year, the Institute conducted the following customer oriented training programmes :

Design, Construction and Maintenance of Hill Roads

On the request of Govt. of Meghalaya, a training programme was organized for the engineers of PWD (Roads), Govt. of Meghalaya at Shillong from June 8-12, 2009. Fifty five engineers attended the programme.

S. No.	Title of the Course	Duration with Dates
A.	**Pavement Engineering &Materials**	
	• Design, Construction and Quality Control of Flexible Pavements	August 24-28, 2009
	• Rigid Pavements : Design, Construction and Quality Control Aspects	Oct. 05-11, 2009
	• Pavement Evaluation Techniques and their Applications for Maintenance and Rehabilitation	Dec. 07-11, 2009
B.	**Geotechnical Engineering**	
	Geotechnical and Landslide Investigation for Highway Projects	Sept. 07-11, 2009
C.	**Bridges and Structures**	
	• Bridge Diagnostics, Performance Evaluation and Rehabilitation	June 15-19, 2009
D.	**Traffic &Transportation Planning**	
	• Traffic Management and Safety	July 27-31, 2009
	• Aspects of Transportation Planning and Environmental Impact Assessment Studies for Roads	Feb. 15-19, 2010

Material Selection and Job Mix Design for Flexible Pavements

A two-day training programme was organized for the engineers of RITES at CRRI from Aug.31, 2009 Sept 1, 2009. Twenty participants attended the programme.

Highway Development & Management (HDM-4)

The Institute organized a training programme on Highway Development and Management (HDM-4) for the engineers of Govt. of Karnataka at Bangalore from Sept. 3-10, 2009. Twenty participants attended the programme.

Material Testing, Laboratory & Quality Control

On the request of IRCON International Ltd, CRRI organized training programme for the Engineers of IRCON International Ltd. at CRRI from Sept 14-18, 2009. Twenty five participants attended the programme

International Course on Dissemination of Highway Development & Management (HDM-4)

A special training programme on HDM-4 was organized from Nov. 9-20, 2009. Seventeen participants from India & Sri Lanka attended the programme

Planning, Design, Construction and Maintenance of Flexible Pavements

On the request of Chief Engineer, Roads and Building Department, Govt. of Gujarat, the Institute organized training programme for the Engineers of Roads & Building Department, Govt. of Gujarat, Gandhinagar from Dec.15-19, 2009. Twenty five participants attended the programme.

Design, Construction and Maintenance of Flexible and Rigid Pavements for Rural Roads

The Institute organized a customized training programme for the engineers of Haryana State Agricultural Marketing Board (HSAMB), Haryana at CRRI from Jan 27-30, 2010. Thirty participants attended the programme.

Human Resource Development Programme

Human resource development is a philosophy of management and is purported to upgrade the capabilities and professional skills of the personnel working in an organization to match the changing work demands. To enhance the professional capabilities of scientists and scientific staff for undertaking the R&D work in frontline areas of highway engineering and with the urge to develop technologies which have competitive edge and marketable strength, CRRI has been devoted in human resources development.

Realizing the need for skill development and capacity building of the human resources, training programmes were selected. Staff members received specialized training in the areas of their expertise to cope up with the challenging assignments. The details of those who attended various training programme and the specialized areas of training are given at page 207-209.

Publications

CRRI Annual Report for the Year 2008-2009 – Bilingual

The Annual Report is the profile of achievements of the Institute during the year 2008-2009. It also serves as a medium to acquaint the user agencies, clients and the other related organizations in the roads and road transportation research with R&D and other concomitant activities of the Institute. Progress reports of the R&D work and other related activities during the year from the various divisions/sections of the Institute was collected, compiled, edited and brought out as Institute's Annual Report for the year 2008-2009.

General Report on Road Research Work Done in India during 2008-09

The progress reports on R&D and consultancy projects involving innovative ideas at the highway engineering, research and development and academic institutions from all over the country were received from the Indian Roads Congress for preparation and compilation of the General Report on Road Research work done in India during the year 2008-09. Based on the input received from organizations including CRRI, the report was compiled in six sections, namely, Highway Planning, Management, Performance Evaluation and Instrumentation; Pavement Engineering and Paving Materials; Geotechnical Engineering; Bridge Engineering; Traffic and Transportation and Research work done in Academic Institutions related to Thesis Work. The suggestions received from the scientists of the various R&D areas were incorporated and the report was finally compiled and edited by CRRI as the General Report on Road Research work done in India which was published as Highway Research Record Number 35 by Indian Roads Congress. The report was presented by CRRI in the 70th Annual Session of Indian Roads Congress at Patna, Bihar from Nov. 14-16, 2009.

CRRI Newsletter

During the year, four issues of CRRI Newsletter were brought out. The Newsletter contains information related to R&D activities and other general information related to the institute.

Other Activities

Mailing of Publications

The Institute's R&D publications such as CRRI Annual Report and CRRI Newsletter were sent to highway professionals, engineering & academic organizations in the country and abroad. The publications are meant to disseminate R&D based information to the highway engineering profession.

Technical Queries

Technical queries concerning the R&D activities and technical know-how of the Institute were attended. Information on various technologies developed by the Institute were sent to a number of organizations dealing with databases, technology transfer and consultancy assignments pertaining to roads and road transportation.

Press Publicity

Various local presses approached CRRI for information on research & developments and studies carried out by the Institute on roads, flyovers, bridges etc. The needed information was provided to the press for the purpose of publicity.

Press clipping pertaining to road and road transport in particular and Science and Technology in general were culled out from various National dailies and were brought to the notice of the Director and circulated to staff members for information, if needed. These were also compiled in the form of document.

Publicity and Advertisement

To popularise the Institute past R&D achievements and present R&D programmes, capabilities, facilities and expertise, the Institute issued various advertisements at various forums. The Institute got published its various advertisements in the documents brought out by the various organizations on the different occasions.

CRRI-A Profile

A multi colour brochure CRRI- A Profile was brought out with divisional profiles on separate sheets. A CRRI calender was also brought out.

Publisation of Research Outputs

Research outputs i.e. Research Papers emanating from the R&D work were processed for publication in various National & International Journals/Conferences through internal review system. Cases pertaining to deputation of CRRI Scientists to attend various Conference/ Symposia were processed and attended.

ISTAG Activities

The scientists of the Institute were deputed abroad under various collaborative, exchange and bilateral programme of CSIR to participate in various conferences/symposia/seminar/study programme and to attend advanced equipment training.

Intellectual Property

The division is responsible for drfting, scrutiny and execution of agreements/MoUs for various externally funded projects and cooperation with other organizations for undertaking joint projects. Disbursement of intellectual fee was made as per CSIR Guidelines.

Exhibitions

The Institute participated in the Technical Exhibition during 70th Annual Session of Indian Roads Congress organized by Public Works Department, Govt of Bihar, Patna, from Nov. 14-16, 2009

Technology Transfer and Business Development

The division is actively engaged in technology transfer and marketing of Institutes knowledge base through active coordination of promotional activities and professional channels.

Scrutinizing proposals of contract research and consultancy assignments of externally funded project as a active member of project scrutiny committee

Visitors

Visits of distinguished professionals and delegates from various organizations related to road transportation from India and abroad to CRRI were organized during the year.

Linkages with Professional Bodies

The Institute is represented as the Institutional Member on the various technical, executive and administrative committees and groups of various National and Foreign Organizations. The updated information on CRRI were provided to various organizations and the annual subscriptions were paid to continue the membership.

CRRI pavilion during technical exhibition at 70th Annual Session of Indian Roads Congress at Patna

A view of inaugural session of International course on Dissemination of HDM-4 from Nov. 09-20, 2009

A view of training session of customized training programme on Material Selection and Job Mix Design for Flexible Pavement for the engineers of RITES Ltd.

Inaugural session of the training programme on Aspects of Transportation Planning and Environmental Impact Assessment Studies for Roads, Feb. 15-19, 2010

Inaugural function of training programme on Rural Roads organised for the engineers of HAMB Jan. 27-30, 2010

Inaugural session of the Training Programme on Design, Construction and Maintenance of Flexible Pavements, August 24-28, 2010

Inauguration of Training Programme on Pavement Evaluation Techniques and Their Applications for Maintenance and Rehabilitation form December 7-11, 2009

A view of inaugural session of the Training Programme on Flexible Pavement organiseet for the engineers of R&B department, Govt. of Gujarat at Gandhi Nagar

A view of training session in progress

Glimpses of training workshop on Development of Technology Commercialisation and Transfer specialists organised by CDC from March 25-27, 2010

A view of inaugural session of the Training Programme on Bridge Diagnostics, Performance Evaluation and Rehabilitation form June 15-19, 2009

Inauguration of Training Programme on Rigid Pavements: Design, Construction and Quality Control Aspects from October 05-09, 2009

Inaugural session of the Certification Course on Road Safety Auditors Feb. 5-9 & 12-16, 2010

Management Information

Management Information (MIN) is entrusted with office automation programme and data management. It has undertaken the programme of upgradation of existing administrative software to the higher platform i.e. ORACLE of multi-user and multi-tasking and also new software development to this direction to create a mini ERP using the internal resources. An application in ORACLE which comprises different modules e.g. Inventory Management System, Manpower Information System, Leave Repository system, Online recruitment system, Paybill system and cheque writing have been developed. All administrative needs are catered and solutions are provided for fast information processes. It has provided the following services:

i) Inventory Management System.
ii) Manpower Information System.
iii) Online application training to the administrative staff.
iv) GPF accounitng.
v) Maintenance and operation of IMPACT, IMPRESS, MIS etc. software of CSIR.
vi) Income-tax compilation and filing of E-tax return.
vii) Data bank of various information of the Institute.
viii) Developed Web-based Information System.
xi) Regular system tuning, software problem solution, software installation and backup of data

Recent Developed Modules:

Inventory Management System is running in the store. User can indent and issue the material from the store through on line system. Upto 7200 records of PIR have been updated.

Manpower information system is running and used by the Controller Office, Establishment – I Section and Personal Cell. In this application user can query and get print format of their information like Basic information, qualification, family and assessment details of each employee of CRRI.

Pay Bill System : In this system the user can see their salary report, arrear bill etc.

PROF. S.R. Mehra Library

Prof. S.R. Mehra library provides documentation services to the scientists, engineers, planners and administrators in the field of highways and transportation. The library has a collection of over 88,500 publications including books, reference books, periodicals, conference proceedings, technical reports, standards specifications, microfilms, maps, CD-ROM databases, video cassettes etc.

Current Awareness & Other Services

Bibliographic Services

Literature searches and CD searches carried out and bibliographic service was provided on request to researchers of CRRI on topics related to highway engineering and transportation.

Reference Service

Specific information provided on more than one hundred reference queries.

User Education & Training

Hands on training on use of various information sources & services, information retrieval techniques to the Institute's users

Forthcoming Conferences

Information regarding forthcoming conferences in highway & transportation engineering displayed regularly to keep the researchers informed of the new conferences.

Collection Development

Publications like books, periodicals, conference proceedings, technical reports, CD-ROM databases, standards, related to roads, transport and related areas etc. were acquired for updating the library collection.

Technical Processing

Publications added to the collection were classified, catalogued, indexed and well maintained for efficient retrieval.

Circulation and Inter-Library Loan

Publications were circulated to the users for reading at their leisure. Publications not available in CRRI library were arranged from other libraries. Publications were also issued to other libraries on inter library loan.

Professional Development

Information on refresher and training courses and workshops etc. available in the field of highway engineering and related areas were recorded and displayed regularly for the benefit of the users.

Access to International and National Databases

Access to national and international databases like TRIS, IRRD, TRANSDOC from TRANSPORT CD, COMPENDEX, PIARC CD ROUTE, and All BIS (Indian) Standards including Civil Engineering, on line access to ASTM Digital Library were provided for quick retrieval of information. TRANSPORT CD ROM, BIS CD ROM are installed on Intranet.

Access to E-Journals

Access to full text E-Journals is being provided through Internet from various publishers like Elsevier, ASCE, Springer.

Computerisation of Documentation and Library Services

Database is being developed for the publications received in the library. WEB OPAC has been installed on Intranet to search the database of CRRI Library.

Library Statistics

Books added during the period (01.04.2009-31.03.2010)	388
Total No. of books as on 31.03.2010	54270
Maps	688
Microforms	655
Videocassettes	122
Periodicals titles received regularly	200

PROJECT TEAM MEMBERS OF DOCUMENTATION AND LIBRARY SERVICES DIVISION

LAN Hardware

Local Area Network (LAN) of CRRI uses Central Switch CISCO Catalyst 4507R-E (Layer 3 Redundant Supervisor I, CISCO 48 ports 2900 (Layer 2) work group switches, CISCO 2600 Router, CISCO ASA 5520 Firewall, Access Control Server and CISCO Net Manager IP for its functionalities and operationsHP Proliant ML 570 and ML 350 (Xeon Quad Processor) hardware platforms are used for server activities. More than 400 LAN I/O points are operational.

Softwares and IT Services

Intranet service (*http://CRRINET*) provides Online Library Search (Web OPAC) , BIS Searching facility, Transport Database, Links for E-Journal and Driver Testing Software. The information related with all the division including the equipment list are also available. Installation and configuration of Scientific Softwares like ARC-GIS, Mx-Road, HDM, NISA, Heads & SPSS also provided.The website of CRRI (*www.crridom.gov.in*) provides information related to CRRI such as scientific, administration, training programmes, events, tenders, history, recruitment and other activities, etc.The E-Mail facility for all the technical and administrative staff of this Institute is also available. The Trend Micro Corporate Antivirus Solutions is provided to all the servers, client nodes and roaming client laptops. LAN Switches have been upgraded during the year. A schematic diagram of CRRI LAN is shown in Fig. 146 and newly installed Central Switch and Firewall System is shown in Fig. 147.

Fig.146 A schematic diagram of CRRI LAN

Fig. 147 Newly installed central switch & firewall system

PROJECT TEAM MEMBERS OF COMPUTER AND NETWORKING DIVISION

Mechanical Engineering Support (MES)

Provided Technical Services in:

1. Design and Development of Mechanical Equipment required by R&D divisions
2. Repair of R&D equipment (Mechanical & electrical)
3. Air conditioner Repairs
4. Repair of Infrastructural Facilities including Furniture

I **Design and Development**

Development of BDI Tags for Bridges & Structure Division

II **Repair of R&D Equipment**

During the year, repair of following equipment has been carried out.

- Automatic Soil Compaction Machine
- Automatic Bitumen Compactors
- Marshall Hammer
- Core Cutting Machine
- UCS loading frame
- Compression Machine
- Direct Shear Machine
- CBR Moulds
- UTM
- Concrete Mixer

Figs. 148 & 149 show the job cards received (Month wise) for the year 2009-2010.

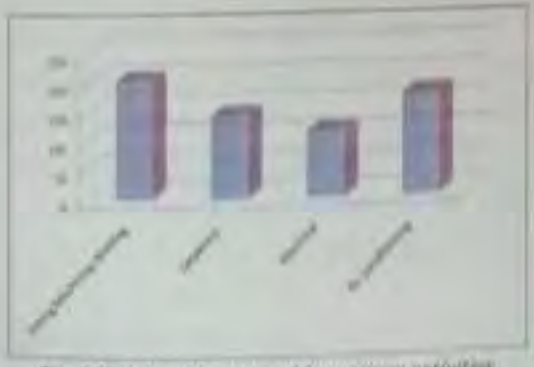


Fig. 148 Job cards received for various activities

Fig. 149 Job cards attended during 2009-10

Installation of APTF

Contributed in bringing the machine inside the campus of CRRI from narrow gate as well as created facilities of cabin at work site for smooth running of APTF.

Data on LAN

Following two manuals were developed and put them on CRRI Website.

- "State of the art R&D Equipment at CRRI"
- "Equipment Infrastructure and Testing Facility at CRRI"

Quality Management is responsible to ensure that the Quality Management System operates effectively and efficiently in the Institute. Besides, adopting higher level of quality standards in the working of the Institute is also the mandate of the division. This activities of the division includes internal quality audits; convening the management review meetings; preparing the Institute for the audits to be conducted by certification agency i.e. Bureau of Indian Standards (BIS) and getting the Institute certified for higher level of quality standards. During the year following activities were carried out.

Internal Quality Audits (IQA)

The Internal Quality Audits are systematic and independent examination of the system to determine whether the planned arrangements are implemented effectively and are suitable to achieve the objectives. The audits were carried out by trained quality auditors of the Institute with the following purpose:

To determine the conformity or non-conformity of the quality system elements with specified requirements.

- To determine the effectiveness of the implemented quality system in meeting the specified quality objectives.
- To provide the auditee with an opportunity to improve the quality system
- To meet regulatory requirements.

During the year two internal quality audits were carried out. During the audit, two aspects namely the requirements of the quality management system as defined in the Quality Manual and the Quality System Procedures were focused. The non-conformity reports (NCR) and corrective action report (CAR) were communicated to the auditees for ensuring the corrective and preventive actions. The actions taken by the auditees were verified during the subsequent audit and NC's were closed.

Management Review Meeting

The top Management reviewed and discussed the findings of the internal quality audits in detail during the Management Review Meeting. Management Review Meeting was chaired by Director, CRRI and attended by all the Heads of Divisions/ Sectional Heads. Besides the finding of the audits, the gray areas related to the functioning of the Institute were also discussed and resolved to ensure that Institute's work was carried out as per the planned arrangements. As a result of the Management Review, Quality Policies and Quality Objectives were reviewed to make them in line with each other keeping in view the mandate of Institute. The Quality Objectives were modified to make them quantifiable and measureable to meet the system requirement.

Awareness-cum-implementation Programme of ISO 9001:2008:

The division organized two training programmes for Internal Quality Auditors, Task Force Members, and Scientists B & C including Technical Officers of the Institute. The first programme was focused on ISO 9001:2000 and the second on ISO 9001: 2008. During both the programmes, the requirements of the Quality Management System, Management of Quality

Manual, Quality Documentation, Quality Policy, Quality Objectives, System Procedures, and Procedure Manual etc. were discussed.

The programme was on interactive mode to enable the participants to come out with their views and issues related to implementation of ISO 9001:2008 Quality Management System in the Institute.

Training Programme for Internal Quality Auditors

The division organized Internal Quality Auditors Training Programme for a batch of 20 officers and staff of the Institute. The purpose of the programme was to give them the detailed Quality Management System and the clauses which can be checked to know the level of effectiveness and implementation of the Quality Management System of the Institute.

The programme was conducted through the participation of the participant by involving them in exercises of the Quality Audit. This has created awareness about the Quality Management System implementation.

Switching over to ISO 9001: 2008

Since ISO 9001:2008 Quality Management System has been issued by Bureau of Indian Standards (BIS), the division initiated actions towards incorporating the clarifications related to ISO 9001: 2008 in the existing documentation to make it suitable for ISO 9001:2008 Quality Management Systems. The Quality Manual related to ISO 9001:2008 incorporating the latest changes and clarifications was issued and implemented in the Institute. The Institute will be audited by the certification agency for ISO 9001:2008 Quality Management System.

TEAM MEMBERS OF QUALITY MANAGEMENT

Rajbhasha Section continued in its endeavor to promote official language in day-to-day work. For this, Official Language Implementation Committee (OLIC) meetings were organized on quarterly basis and follow-up actions were taken on the decision taken in these meetings. Employees doing remarkable work in Hindi were given cash incentives as well as certificates of commendation. Hindi workshops were also organized to encourage staff to start work in Hindi. Hindi Day & Hindi Fortnight was celebrated to enhance official language use in day-to-day work. A large number of staff took participation in different competitions organized during the Hindi Fortnight. Cash prize and certificates were also distributed to the winners.

In accordance with the official language policy of Govt. of India, Rajbhasha section assisted other sections in the translation work of different types of documents. Assistance was offered to various areas with respect of Hindi correspondence and preparation of technical reports, abstracts, work report, etc. in Hindi. Scientists actively participated and presented their papers in Hindi at different seminars. Scientists were encourage to write their research papers in Hindi and as an incentive, they were given cash prize and certificated for their Hindi publications.

Rajbhasha section also helped scientists in preparing lecture/presentations related to their research work in Hindi. A series of Hindi lectures was organized on different topics. Rajbhasha section also continued publishing "Rajbhasha Jagran", the quarterly leaflet in Hindi to promote official Language Policy and to assist employees of the Institute to write and express themselves in Hindi. The seventh issue of the "Sadak Darpan", the scientific magazine in Hindi was also published.

Hindi Pakhwada Celebration at CRRI

Members of Rajbhasha

National Technology Day

CRRI celebrated National Technology Day on May 11, 2009. The Institute declared May 11 as an open day for the general public for visiting and interacting with the Scientists. Dr. P L. Bongirwar, Ex-Joint Director (MMRDA) & Chairman, CRRI Research Council graced the occasion as Chief Guest.

Shri T. K. Amla, HoD (ILT) briefed the background of National Technology Day. Dr. S. Gangopadhyay, Director, CRRI gave the welcome address and remind the importance of the celebration of National Technology Day. Dr. Bongirwar delivered the National Technology Day lecture on "Challenges of Road Sector".

To motivate the CRRI staff for better performance CRRI introduced Outstanding Performance Awards Scheme (COPAS). On this occasion the commendation certificates and cash awards were distributed to the best performers of the year 2008-09 by the Chief Guest.

World Environment Day

To create awareness about the environmental issues and concerns, World Environment Day was celebrated at CRRI on June 5, 2009. As a part of the celebration, Debate and Quiz competitions were organised for the staff members of Group I, II, III and IV on June 1, 2009. Ms. Anuradha Shukla, Head, Transport Planning and Environment Division made a presentation on "How to Reduce Carbon Footprints".

The main function was held on June 5, 2009. Shri T. K. Amla, HOD (ILT) introduced the Chief Guest and gave a brief background of the Environment Day Celebration. Dr. Sunil Bose Head, Flexible Pavements made the welcome address.

Dr. B. Sengupta, ex Member Secretary, Central Pollution Control Board, Ministry of Environment & Forests, Govt. of India was the Chief Guest. He delivered the Environment Day lecture on "Environmental Issues Related to Transport". The Chief Guest distributed the cash prizes and commendation certificates to the winners of the Debate and Quiz competitions.

Workshop on Mobile Mapping Technologies for Road Asset Information and Management

CRRI in association with M/s. Infotech Enterprise Ltd. organized a Workshop on Mobile Mapping Technologies for Road Asset Information and Management on July 17, 2009. The aim of the workshop was to share the mutual experience and evolve approaches and methodologies in application of mobile mapping technologies for development of road asset information and management.

The workshop was inaugurated by Dr. S. Gangopadhyay, Director, CRRI and chaired by Dr. P.K. Kanchan, Sci.-G, CRRI. Sh. Chandrasekhar Nori, M.D., Infotech, Geospatial (India) Ltd. delivered the inaugural address. Two technical presentations were made by Sh. A.M. Rao, Scientist, CRRI and Sh. Tarun Bhandari, Executive Infotech during the following two technical sessions respectively:

i) Road Asset Information and Management

(iii) Mobile Mapping Technologies and Road Asset Information.

Expert Interaction were made by Sh. Pankaj Taneja & Sh. Himan, from Infotech and Dr. Devesh Tiwari on Pavement Asset Information; Sh. R.K. Srivastava on Non Pavement Assets; Dr. P. Lakshmy on Bridges and Culvert Information; Dr. Kishore Kumar on Landslide investigation & Dr. K. Ravinder on Traffic and Urban Road Assets from CRRI.

Hindi Pakhwada (Fortnight)

Hindi fortnight was organized from Sept. 14 to 30, 2009. Competitions such as Essay writing, Hindi noting and drafting, Picture narration, on the spot Hindi speech competitions were organized during fortnight. About one hundred and twenty employees took part in these competitions.

Sh. Mahendra Sharma, famous Hindi Poet presided the inaugural function on Sept 14, 2009. He recited some of his humorous poems and couplets, which were widely appreciated by the audience.

Dr. Dangal Jhalte, Director, Central Translation Bureau, Deptt. of Official Language, Ministry of Home Affairs graced the occasion as Chief Guest on Sept 30, 2009. Prizes were given to winners of different competitions and also to those employees who have published research papers in Hindi and done commendable work in Hindi.

CSIR Foundation Day

The Institute celebrated CSIR Foundation day on Sept. 26, 2009. As a part of CSIR Foundation Day Celebrations, the Institute organised various competitions for CRRI staff and their wards. Competitions such as Area Wise Display, CRRI Web Page Designing, Debate for CRRI staff and Poem Recitation, Essay, Poster and Quiz Competitions were organized for the Children. The Institute declared it as Open Day for general public and students.

The main function was held in the afternoon. Sh. Nirmal Jit Singh, Director General (Road Development) & Special Secretary, Ministry of Road Transport and Highways, New Delhi was the Chief Guest. Sh. Nirmal Jit Singh delivered foundation day lecture on "Overview of Road Development Initiative by Ministry of Road Transport and Highways".

The programme was attended by many old colleagues of CRRI and invitees. The Chief Guest gave away prizes to the winners of various competitions organised earlier. The staff members who have retired during Sept. 2008 to Aug. 2009 and those who have completed 25 years of service in CSIR were also given mementos by the Chief Guest.

Workshop on Coordination of Research in Urban Transport

A half day workshop on Coordination of Research in Urban Transport in collaboration with Institute of Urban Transport was organized on October 28, 2009. Dr. S. Gangopadhyay, Director, CRRI chaired the session and gave key note presentation. The workshop was attended by experts from academic institutions and research organizations within India.

Vigilance Awareness Week

Vigilance Awareness Week was observed during Nov. 3 to 7, 2009 in the Institute. During the week, banners and posters were displayed. A pledge was taken by all the staff members. Speech competition on "Corruption in Public Life - Ways and Means of Preventing the Same /Role of Media in Prevention of Corruption" was organized for the staff members of the Institute.

Visit of Parliamentary Committee on Official Language

The Parliamentary Committee on official language headed by Dr. Satyavrat Chaturvedi, Honorable Member of Parliament (Rajyasabha) visited and reviewed the work done by the Institute in Official Language at Ashoka Hotel on Feb. 12, 2010.

In his welcome address, Dr. S. Gangopadhyay, Director CRRI gave a brief account of Scientific/ Technical/Administrative work carried out by the Institute in Hindi. The committee made point wise analysis and review the progressive use of Hindi in the Institute on the basis of inspection questionnaire related to official language.

Earlier, the committee went through the publications such as Sadak Darpan, Annual Report etc. brought out by the CRRI in Hindi. The Committee appreciated the work done by CRRI in official language.

National Get-together on Road Research & Its Utilization, March 5-6, 2010

Central Road Research Institute (CRRI), New Delhi organised the National Get-Together on Road Research & Its Utilisation (NGT/2010) on March 5-6, 2010 at New Delhi with the following objectives:

- To provide a forum for intensive interaction between road researchers and user agencies towards identification of R&D thrust areas required in the road and road transportation sector.
- To create an opportunity for in-depth discussion on various aspects of R&D findings available and on measures for their increased utilisation.

The Get-together was sponsored by 32 organizations from India and abroad and was attended by more than 425 delegates representing PWDs, NHAI, MORTH, RITES, DDA, DMRC and various R&D & academic institutions. In the inaugural session, welcoming the delegates and other Guests, Dr. S. Gangopadhyay, Director, CRRI brought out the objectives of National Get-Together and stated the need of an efficient infrastructure system in road sector.

Dr. Gangopadhyay also mentioned that with the ongoing highly ambitious programme such as NHDP, PMGSY, it is the opportune time to position ourselves into R&D activities on road and transportation sectors appropriately and effectively.

The Get-Together was inaugurated by Prof. Samir K Brahmachari, DG, CSIR and Secretary, DSIR. In his address Prof. Brahmachari emphasized the need to dedicate more efforts on R&D activities towards developing better / improved technologies which are economically viable. He further said that sustainable development, recycling of construction material, minimizing

vehicular pollution, reducing urban congestion are some of challenges, which needs urgent attention.

Dr. M.P. Dhir, Former Director, CRRI was the Chief Guest on this occasion. Dr. Dhir referred the need of massive R&D efforts to create road infrastructure which lasts longer, making optimal use of natural resources and where possible conserve construction materials using recycling technologies.

Sh. T.K. Amla, Organizing Secretary, NGT & Head, IUT read the messages of good wishes received from many important dignitaries for the success of the National Get-Together. Sh. Sudhir Mathur, Co-Chairman Organizing Committee & Head, Geotechnical Division proposed the vote of thanks.

During NGT-2010, a technical exhibition was also organised in which about 22 organisations including CRRI took part and displayed their products. On this occasion, a souvenir containing messages of good wishes from dignitaries and paper of general interest was released by DG, CSIR.

The two day-meet comprises eight technical sessions which included panel discussion and presentations on important themes viz pavement engineering and materials, innovation in traffic and transportation engineering, geotechnical aspects related to road construction, accelerated pavement testing facilities, technologies for faster construction of bridges. The interaction resulted in identification of a number of priority areas of R&D pertaining to road and road transportation.

Workshop on Slope Stability and Landslide

The Institute organized a workshop on "Slope Stability and Landslide" on March 15, 2010 at CRRI. Dr. S. Gangopadhyay, Director, CRRI inaugurated the workshop. Prof. Sharda Sharma, Imperial College, Prof. Yudhvir, ex Prof. IIT, Prof. R. K. Bhandari, Landslide expert, Dr. P.C. Nawani, Director, National Institute of Rock Mechanics, Dr. Kishor Kumar, Sci., CRRI were amongst the lecturers for the workshop.

About 60 delegates from public and private sector, consulting engineering and design engineering firms, educational institutions, geologists, highway and civil engineering consultants attended the workshop. A panel discussion was held after the workshop and suggestions were made for identification of areas so far neglected and needed immediate attention.

Workshop on Development of Technology Commercialisation and Transfer Specialists

Consultancy Development Centre (CDC) has organised a three days training workshop on Development of Technology Commercialisation and Transfer Specialists from March 25-27, 2010 for CSIR scientists at CRRI.

The workshop, covered lectures on various issues related to technology transfer, marketing, IPR, legal issues of commercialisation etc. Scientists and technical officers from R&D and infrastructure divisions of CRRI and other CSIR laboratories attended the workshop.

Hindi Workshops

Four workshops in Hindi were organized during the year. About 25 participants each attended the workshops. Well known Rajbhasha personnel and seniors officers from different ministries and department were invited to deliver lectures and impart training to the participants. Lectures related to letter writing, noting and drafting and communication in Hindi, mechanical facilities and software in Hindi Dictation, guidelines for filling up the quarterly Hindi report etc. were delivered during these workshops.

Celebration of Vigilance Awareness week

Awards / Recognition

Awards	Awardee (s)
• IRC Medal for the paper entitled "Estimation of Fuel Loss during Idling of Vehicles at Signalised Intersection in Delhi. The Award was given during 70th IRC Annual Session at Patna from Nov. 14 –17, 2009.	Dr. P. Parida, Scientist and Dr. S. Gangopadhyay, Director
• Indian Roads Congress – Pandit Jawaharlal Nehru Birth Centenary Award – 2009 for Conspicuously Important and Outstanding Contributions to Road Development in India during last five years. The Award was given during 70th IRC Annual Session at Patna from Nov. 14 –17, 2009.	Dr. S. Velmurugan, Scientist
• Fulbright Nehru Environmental Leadership Programme Fellowship by USIEF w.e.f. Sept. 1, 2009 to Dec. 31, 2009.	Ms. Anuradha Shukla, Scientist

Dr. P. Parida, Scientist, Dr. S. Gangopadhyay, Director and Dr. S. Velmurugan, Scientist receiving Award during IRC Session at Patna

Glimpses of National Get together on Road Research & its Utilisation (NGT-2010)

Prof. Samir K. Brahmachari, DG, CSIR & Secretary DSIR inaugurating the technical exhibition during NGT

A visit to stall by DG, CSIR

Release of Technical Report by DG, CSIR during NGT 2010

Prof. Samir K. Brahmachari, DG, CSIR delivering inaugural address

Release of Souvenir by DG, CSIR

A view of Dias during NGT 2010

Prof. Samir K. Brahmachari, DG, CSIR delivering inaugural address

Release of Souvenir by DG, CSIR

A view of Dias during NGT 2010

Workshop on Coordination of Research in Urban Transport, Oct. 28, 2009

Meeting of scientists with delegation from TRL, UK

A delegation from sultanate of Oman comprising Dr. Hilal AL-Hinai, Secretary General, The Scientific Research Council of Oman (TRC), Jan. 12, 2010

A delegation from Australia India Council (AIC) at CRRI, Jan. 15, 2010

A foreign delegation at CRRI

Prof. Moshe Ben-Akiva, Professor, MIT, Centre for Transportation and Logistics at CRRI

Dr S. Gangopadhyay, Director Speaking during Workshop on Slope Stability and Landslide, March 15, 2010

Dr S. Gangopadhyay, Director welcoming the chief Guest on the occasion of CSIR Foundation Day, Sept. 26, 2009

Shri Nirmal Jit Singh, DG (R&D), MoRTH & Chief Guest delivering CSIR Foundation Day Lecture

Shri P. L. Bongirwar, Chairman RC delivering National Technology Day Lecture on May 11, 2009

Celebration of World Environment Day on June 5, 2009

Shri P. L. Boogirwar, Chairman RC with Director CRRI

CRRI RC Meeting in Progress

Celebration of New Year Day on Jan. 1, 2010

Visit of Parliamentary Committee on Official Language visiting CRRI

S. No.	Topic	Place	Presented by
1	Conventional Bituminous Mix Design	Delhi State Industrial & Infrastructure Development Corporation, Bawana, April 6, 2009.	Abhishek Mittal
2	Efficacy and Utility of Jute Geotextiles for Construction of Rural Roads	Workshop on Jute Geotextiles, NRRDA, Delhi, June 3, 2009	Sh. U K Guruvittal
3	GIS/GPS Application in Highway Planning	National Institute of Training for Highway Engineers (NITHE), Noida, June 8-9, 2009.	Dr. B K Durai
4	Remote Sensing, Photogrammetry, Mapping Application and Map based Application in Modern Surveys	National Institute of Training for Highway Engineers (NITHE), Noida, June 8-9, 2009.	Sh. A M Rao
5	Modern Surveying Techniques and Applications in Highway Projects	National Institute of Training for Highway Engineers (NITHE), Noida, June 8-9, 2009.	Dr. Ch Ravi Sekhar
6	Road Research: Perspective of CSIR, India	Built & Environment Unit, CSIR Pretoria, South Africa, July 24, 2009.	Abhishek Mittal
7	Structural and Functional Evaluation of Flexible Pavement	National Institute of Training for Highway Engineers (NITHE), Noida, August 24, 2009	Sh. K Sitaramanjaneyulu
8	Status on Use of Plastic Waste in Road Construction and its Potential Prospect in India	National Conference on Environmental Impact through Management of Solid Waste: Technology Impetus & Policy Transformation, IIT, Delhi, MOEF, New Delhi, September 10, 2009	Dr. Sangita
9	Understanding Success and Failure of Geosynthetic Application in Roads Works	Workshop TECHNOTEX-2009, September 23, 2009	Sh. U K Guruvittal
10	Use of Plastic Waste in Road Construction	NRRDA, New Delhi, September 2009.	Dr. Sangita
11	Cold Mix Technology for Construction of Bituminous Roads	Annual Session of Indian Roads Congress, Patna, Nov. 16, 2009.	Dr. N K S Pundhir
12	Use of Non-conventional Materials in Road Construction	Annual Session of Indian Roads Congress, Patna, Nov. 16, 2009.	Sh. U.K. Guruvittal
13	Climate Change and Transportation : US and India Perspective	Seminar on Transportation Engineering Texas A & M University, Nov. 18, 2009.	Ms. Anuradha Shukla

S. No.	Topic	Place	Presented by
14	Engineering Aspects in Road Safety	Seminar on Road Safety and Urban Traffic Management, TNPA, Chennai, Nov. 30, 2009.	Dr. E Madhu
15	Air Quality Issues in Delhi, India	Society of Women Engineers, Mercer University, Georgia, Dec. 4, 2009.	Ms. Anuradha Shukla
16	Concrete Technology and Mix Design	National Power Training Institute (NPTI), Faridabad, Dec.15, 2009.	Sh. Binod Kumar
17	Design of Bridge and Culverts	National Power Training Institute (NPTI), Faridabad, Dec.17, 2009.	Dr. Lakshmy P
18	Urban Road Traffic and Air Pollution in Major Metropolitan cities	College of Engineering, Anna University, Chennai, 2009	Dr. S Velmurugan
19	Landslide Prevention and Control due to Floods, Earthquakes, Cloudburst and Mitigation Measures	National Institute of Training for Highway Engineers (NITHE), Noida, Feb. 24, 2010.	Dr. Kishor Kumar
20	Road Safety Education and Capacity Building	National Institute of Disaster Management, Ministry of Home Affair, March 16, 2010.	Dr. Nishi Mittal
21	Urban Road Transport and Pollution in City of Delhi	Virginia Tech. Transportation Institute, Virginia.	Anuradha Shukla
22	Do's and Don'ts of Landslides	National Institute of Disaster Management, New Delhi	Dr. Kishor Kumar
23	Application of Intelligent Transport System for Parking Management	Workshop on Computer Aided Transportation Planning and Traffic Engineering, IISC, Bangalore.	Dr. S Velmurugan
24	Road User Cost Study in India	Workshop on Recent Trends in Sustainable Transportation Planning IISC, Bangalore	Dr. S Velmurugan

S. No	Area of Training	Staff Nominated	Date	Venue
1	Programme for Life after Retirement	Sh. Rajinder Singh, Sh. D P Verma, Sh. Narain Singh, Sh. Sohan Lal Dabral	April 15 - 17, 2009	HRDC, Ghaziabad
2	"Office Procedure" for Assistant (General)	Ms. Neeta Kumari Sh. Chander Kant	April 17 - 18, 2009	HRDC, Ghaziabad
3	Hindi Computer Training Program	Sh. Ajit Kumar Singh, Sh. Bhawesh Paswan, Sh. Vinod Kumar, Sh. Babban Singh, Sh. Tarachand	April 27 – May 1, 2009	NPTI, Badarpur, New Delhi
4	Interpersonnel Skills Development through Transactional Analysis	Sh. A K Sinha Sh. Dinesh Gaiwe	April 28 - 30, 2009	HRDC, Ghaziabad
5	MCSD.Net training for (i) 70-305 Web Application Development (ii)70-229 Server SQL.	Sh. Alind Saxena	May 04, 2009 for 2.5 Months	New Horizons India Ltd., New Delhi
6	General Management Programme for Senior Scientists.	Sh. R S Bhardwaj Dr. B Kanga Durai	July 27 - August 7, 2009	ASCI, Hyderabad
7	"Induction Training Programme" Newly Recruited Scientists (B & C)	Ms. Padma	July 27 - August 01, 2009	HRDC, Ghaziabad
8	Design Traffic and Deflection Analysis	Sh. Abhishek Mittal	July 28 - 29, 2009	Pavement Modelling Corporation and Built & Environment, CSIR, Pretoria, South Africa
9	Leadership Development Programme	Sh. A Mohan Rao	August 9 - 21, 2009.	HRDC, Ghaziabad
10	Hindi Computer Training Programme (M.S. Office)	Smt. Kamlesh Kapoor, Sh. Gaya Ram	August 17 - 21, 2009	NPTI, Badarpur, New Delhi

S. No.	Area of Training	Staff Nominated	Date	Venue
11	Design and Development of Digital Libraries using DSpace	Ms. Neera Agarwal	August 17 - 21, 2009	National Institute of Science Communication and Information Resources, New Delhi
12	Leadership Development Programme,	Dr. Neelam J Gupta	September 6 – 18, 2009.	HRDC, Ghaziabad
		Sh. A. Saurikhia		
13	CUBE Base and Voyager: A Transport Planning Software,	Dr. E Madhu,	September 8 - 10, 2009.	CITI Labs, School of Planning and Architecture (SPA), New Delhi
		Dr. K Ravinder,		
		S. Padma		
14	ISO 9001:2008	Sh. R S Bhardwaj,	September, 2009	Quality Council of India, New Delhi
		Sh. T K Anita,		
		Sh. Y C Tiwari,		
		Mrs. Anita Arora,		
		Sh. Naresh Kumar,		
		Sh. R C Agarwal		
15	Photometry & Colorimetric	Dr. Surinder Mohan	October 5 - 9, 2009	National Physical Laboratory, New Delhi
16	Hindi Computer Training Programme	Sh. Alok Ranjan,	October 12 -16, 2009	HRDC, Ghaziabad
		Sh. S N Dwivedi,		
		Sh. Harcharan Singh Nagar		
17	83rd Annual Transportation Short Course,	Ms. Anuradha Shukla	October 13 – 14, 2009.	Texas Transportation Institute, Texas
18	Technology Diplomacy	Sh. A Saurikhia	November 02 – 06, 2009	DST, Jaipur
19	Geographical Information System (GIS) Software (Arc GIS)'	Sh. A K Sagar	November 09 – 13, 2009	ESRI India, New Delhi
		Sh. Pradeep Kumar		
20	Project Management	Sh. Alind Saxena	November 10 -13, 2009	HRDC, Ghaziabad
		Sh. D Ravinder		
21	Leadership Development Programme,	Dr. Ch. Ravi Sekhar	December 5 – 12, 2009.	HRDC, Ghaziabad

S. No.	Area of Training	Staff Nominated	Date	Venue
22	Hindi Computer Training Programme	Sh. Dinesh Prakash, Sh. Ved Prakash	December 14 -18, 2009.	HRDC, Ghaziabad
23	Project Appraisal and Management	Ms. Gurmeet Kaur	December 17-18, 2009	ICFAI, New Delhi
24	Leadership Development Programme.	Sh. A Saurikhia, Dr. Neelam J Gupta	December 19 – 22, 2009.	HRDC, Ghaziabad
25	Certifecation Course on Road Safety Auditors	Dr. Nishi Mittal Ms. S. Padma Dr. Surinder Mohan Dr. S Velmurugan Dr. J Nataraju Dr. Mukti Advani Dr. E Madhu Dr. K Ravinder	February 8 – 12, 2010	IRF (India Chapter) & ARRB Australia, CRRI, New Delhi
26	CSIR-US Patent office Programme on IPR	Sh. A Saurikhia	February 22 – 23, 2010	HRDC, Ghaziabad
27	Atmospheric Chemistry and Air Pollution	Ms. Rina Singh	March 2 -22, 2009	NPL, New Delhi
28	Leadership Development Programme	Dr. Ch. Ravi Sekhar	March 7-11, 2009.	HRDC, CSIR, Ghaziabad

- Dr. Sunil Bose, Scientist 'G', Sh. Naresh Kumar Sharma and Sh. Meshram, Technical Officers were deputed to Boksburg, South Africa for technical training on Accelerated Pavement Testing Facility (APTF) and Factory Acceptance Test (FAT) during May 14 to 19, 2009.
- Dr. Kishor Kumar, Scientist was deputed to Budapest, Hungary to present a paper in ITA/AITES World Tunnel Congress-2009 during May 23 to 28, 2009.
- Ms. Ambika Behl/S/Sh M.N. Nagabhushan, Sanjay Deori, and Abhishek Mittal Scientists were deputed to South Africa for Technical Training on APTF from May 30 to August 1st "2009
- Sh. J.K. Goyal, Scientist was deputed to Sweden to attend training programm on Road Sector Management sponsored by Sweden International Agency Corporation, at Stockholm, Sweden, from Aug. 16 to Sept. 5, 2009.
- Ms. Anuradha Shukla, Scientist was deputed to USA during Sept. 1, 2009 to Dec.31, 2009 under Prestigious Fulbright – Nehru Environmental Leadership Program (FNELP) at Texas Transportation Institute, USA.
- Dr. Ravinder Kumar Scientist was deputed to Bahrain to attend 7th International Conference on WASO from November 9 to 11, 2009.
- Ms. S.Padma, Dr. Ch. Ravi Sekhar and Dr. J. Nataraju, Scientists visited Subrabaya, Indonesia to present their papers at 8th EASTS Conference From November 16 to 19 2009
- Sh. A.K. Sinha, Scientist was deputed to Singapore to present a paper in the International Symposium on Ground Improvement Technologies and Case Histories at Singapore from Dec. 9 to 11, 2009.
- Dr. E. Madhu, Scientist, was deputed to Hong Kong to present a paper in the International Conference of Hong Kong Society for Transportation Studies (HKSTS), Hong Kong, Dec. 10 to 12, 2009.
- Dr. Surinder Mohan, Scientist was deputed to Los Angeles, USA for Certification and Customisation of Computerised Retro Reflectometer System from March 6 to 13, 2010.
- Sh. J.K. Goyal, Scientist was deputed to Tanzania to attend training programme on Road Sector Management 2009 (RSM 2009) at Arusha (Tanzania) from March 21 to 28, 2010.

Student Name	Course Being Pursued	Title of the Training/ Research Project
IIT Guwahati		
Alok Mani Singh	B. Tech (Civil)	Road Traffic and Air Pollution in Delhi.
Karan Virani	"	"
NIT Durgapur		
Jitender Arya	B. Tech (Civil)	Environmental Impact Assessment (EIA) for Building Projects
Rupak Sahui	"	Condition Assessment Aspect of Flexible Pavement
Mecabai Polytechnic		
Neha Sharma	Diploma in MOP (H)	Modern Office Practice Hindi
Anju Kumari	"	"
Pratibha Sharma	"	"
Renu	"	"
Neelam Kumari	"	"
GIS Institute, Noida		
Smita Nooreen Khan	P.G. Diploma in Remote Sensing and Geo Informatics	Application of GPS Technologies for the Development of GIS based Information System
Shishupal Tomar	"	Road Database Management System Using GIS & GPS Tools.
IIT Kharagpur		
Nitin Sharma	B. Tech.	Prevention of Reflection Cracking in Flexible Pavement Using Jute Geofabric
Santosh Kumar	"	Effect of Lane Change Behavior on Highways using Microscope Simulation
NIT Calicut		
M. Vijay Balaji	M. Tech. in Traffic and Transportation Planning	Analysis of Lane Change Behavior Using Microscopic Simulation
Neena M. Josph	"	"
Ramya S.R.	"	Driving Characteristic & Assessment of Drivers
B. Dili Prathap	"	Field Evaluation of Retro Reflective Road Sign
BITS, Pilani		
Kavita Jain	B. Tech. (Civil)	Roll of Transport Planning in Environmental Pollution
Bengal Engg. & Sci. University, Shibpur.		
Debabrata Palit	B. E. (Civil Engg.)	Parametric Study on the Design of T- Beam Girder Superstructure
Prabir Adhya	"	"
HBTI Kanpur UP		
Mayank Rathore	MCA	Development of Software for computation of International Roughness Index Using Pavement Surface Profile Data
Narendra Kumar	"	"

Student Name	Course Being Pursued	Title of the Training/ Research Project
Delhi College of Engineering Kunal Soni Rahul Singh Ankur Babbar Bharat Singh	B. Tech " " "	Development of Computer Program for IRC: 37:2001 " " "
Gyani Zail Singh College of Engineering and Technology, Bhatinda Mohit Singla	B. Tech	Study on use of Coal Fly Ash in Bituminous Layers
Institute of Building Science and Technology, CEPT University, Ahmedabad Virendra Chavda	B. Tech (Civil)	A Pavement Type Selection Procedure
Maharaja Suraj Mal Institute of Technology (IP University) Nidhi Lamba	B. Tech (CS)	Application of DBMS for Highways
Chandigarh College of Engineering and Technology Bhaskar Joshi	B. Tech (Civil)	Design Aspects of Steel Pedestrian Bridges
DAV College of Engineering and Technology Jallandhar (Punjab) Himanshu Tyagi	B. Tech (Civil)	Guidelines for Design of Welded Bolted Riveted Joints for Steel Bridges
Indian Institute of Technology Guwahati Alok Mani	B. Tech (Civil)	Guidelines for Design of Welded Bolted Riveted Joints for Steel Bridges

S.No.	Name of Visitor	Date of Visit	Purpose of Visit
1	A fourteen member delegation led by Mr. Zerfu Teksema, Dy. Director General, Ethiopian Road Authority	May 18, 2009	Discussions with Senior Scientists regarding Labour Oriented Training on Flexible Pavement
2	M/s TA Instruments, Waters (India) Pvt. Ltd., Bangalore	May 19, 2009	Presentation on Rheological Characterisation of Asphalt and Polymer Techniques
3	Prof. Ashish Verma, Indian Institute of Technology, Guwahati	May 27, 2009	Presentation on Influencing Traffic Problem Parameters through Improved Driver Education and Licensing
4	Dr. S. Roy and Dr. S. Kar, Eminent Scientists and Editor, Science and Culture	July 10, 2009	Discussion with the Scientists for mutual areas of Co-operation
5	A team of Experts of FAYAT Germany	July 18, 2009	Discussion with the Scientists on Recycling, Soil Stabilization and Micro surfacing
7	M/s. ASI Solutions, UK,	Dec 14, 2009	Technical Presentation on Technical Aspects and Benefits from the Use of Rhinophalt Preservative in Bituminous Surfacings
8	M/s. AE&C, New Delhi & Ms. Erica Utsi, the current Chairperson of European GPR Association and Director, Utsi Electronics Ltd., UK.	Dec 11, 2009	Technical Presentation on Ground Penetration Radar (GPR) System followed by live Demonstration
9	Prof. Moshe Ben-Akiva, Professor, MIT, Centre for Transportation and Logistics	Dec. 21, 2009	Presentation on Dynasmit: A Real Time Congestion Prediction Model
10	A delegation from Sultanate of Oman comprising Dr. Hilal Al-Hasai, Secretary General, The Scientific Research Council of Oman (TRC), Dr. Mohamed Al-Mughairi, Asstt. Secretary General for Innovation & Capacity Building (TRC) and Dr Abdullah Al-Zakwani, Director of Innovation & Research Centre, Public Establishment for Industrial Estates (PEIE)	January 12, 2010	Visited CRRI
11	An Australia India Council (AIC) delegation	January 15, 2010	Discussions with senior scientists to explore possibilities of collaboration in the field of road safety and related issues
12	Prof. Ashish Verma, Indian Institute of Technology, Bangalore	January 22, 2010	Presentation on An Integrated Approach for Optimal Road Transport Corridor Identification using Geographical Information System
13	A delegation from Federal Highway Administration (FHWA) comprising Shri Shailen Bhatt, Associate Administrator, Office of Policy and Government Affairs and Mr. Stephen Kern, Global Technology Exchange Leader visited CRRI	Feb. 18, 2010	Discussions with Scientists to Explore Possibilities of Co-operation, Training and Exchange Programme with FHWA
14	Shri Dinesh K. Goyal, Principal Secretary, PWD, Rajasthan	March 31, 2010	Visited CRRI

Membership of the Staff on Various Technical Committees

S.No.	Committee	Representative's Name	Position held
Highway Research Board of IRC			
1	Highway Research Board	Dr. S. Gangopadhyay	Member
2	HRB Identification, Monitoring &	Dr. S. Gangopadhyay	Convenor
	Research Application Committee	Sh. U. K. Guruvittal	Member-Secretary
3	Highway Research Board Core Group	Dr. S. Gangopadhyay	Member
4	Accredation of New Materials and	Dr. S. Gangopadhyay	Chairman
	Techniques	Sh. U. K. Guruvittal	Member Secretary
Indian Roads Congress, New Delhi			
1	Council of Indian Roads Congress	Dr. S. Gangopadhyay	Member
		Dr. Purnima Parida	Member
2	H-1 Transportation Planning,	Dr. S. Gangopadhyay	Co-convenor
	Traffic Engg. & Road Safety	Dr. S. Velmurugan	Member-Secretary
	Committee	Dr. Nishi Mittal	Member
3	H-3 Rigid Pavement Committee	Dr. Renu Mathur	Member
		Sh. Binod Kumar	Member
4	H-2 Flexible Pavement Committee	Dr. Sunil Bose	Co-convenor
5	Highway Specifications & Standards Committee	Dr. Sunil Bose	Member
6	Bridge Specification & Standards	Dr. Ram Kumar	Member
	Committee		
7	B-2 Load and Stresses Committee	Dr. Lakshmy P.	Member Secretary
8	Managing Committee of Indian National	Dr. Ram Kumar	Member
	Group of the International Association of		
	Bridges & Structural Engineering		
9	Chief Engineer Committee	Director	Member
10	G-2 Human Resource Development	Sh. T.K. Amla	Member
11	G-7 Official Language Committee	Dr. S.D. Sharma	Member
12	G-6 Disaster Mitigation Committee	Dr. Kishor Kumar	Member
13	G-4 Mechanization Committee	Sh. R. S. Bhardwaj	Member
14	H-4 Embankment, Ground Improvement and Drainage Committee	Sh. Sudhir Mathur	Member-Secretary
15	H-6 Road Maintenance and Asset Management	Sh. B. M. Sharma	Member
16	H-5 Rural Roads Committee	Dr. P. K. Jain	Member
17	H-8 Urban Roads, Streets &	Dr. S. Gangopadhyay	Member
	Transportation Committee	Dr. Purnima Parida	Corresponding Member
18	H-9 Composite Pavement Committee	Dr. Sunil Bose	Member

S.No.	Committee	Representative's Name	Position held
19	B-4 Concrete (Reinforced & Prestressed) Structures	Dr. Rajeev Goel	Member
20	B-5 Steel and Composite Structure	Dr. Lakshmy P.	Member
21	B-6 Bearings Joints & Appurtenances	Dr. S. S. Gaharwar	Member
22	B-8 Maintenance and Rehabilitation Committee	Dr. V. V. L. K. Rao	Member
23	G-3 Environment Committee	Ms. Anuradha Shukla	Member
24	G-5 Instrumentation Committee	Dr. Lakshmy P.	Member
		P. Prasanna Kumar	Co-convenor
		Dr. R. K. Garg	Member-Secretary
Bureau of Indian Standards, New Delhi			
1	Civil Engineering Division Council, CED	Director	Member
2	Standards Advisory Committee	Director	Member
3	Executive Council	Director	Member
4	Cement & Concrete Sectional Committee, CED 2.1	Dr. Ram Kumar	Member
5	Building Lime & Gypsum Products Sectional Committee, CED4	Sh. Sudhir Mathur	Member
6	Flooring, Wall Finishing & Roofing Sectional Committee CED5	Dr. S. D. Sharma	Alternate-Member
7	Stones Selection Committee CED6	Sh. B.M. Sharma	Member
8	Soil Engineering Sectional Committee CED23	Sh. Sudhir Mathur	Member
		Sh. U.K. Guruvittal	Alternate-Member
9	Rock Mechanics Sectional Committee, CED18	Dr. Kishor Kumar	Member
		Dr. Pankaj Gupta	Alternate-Member
10	Geo-textile and Industrial Fabrics Sectional Committee, TXD30	Sh. Sudhir Mathur	Member
		Sh. U.K. Guruvittal	Member
11	Freight Containers Sectional Committee, HMD 12	Dr.S.Gangopadhyay	Member
12	Soil Construction Sub-Committee CED 13:6	Sh. Sudhir Mathur	Member
		Sh. U.K. Guruvittal	Alternate-Member
13	Soil and Foundation Engineering Sectional Committee, CED 43	Sh. Sudhir Mathur	Member
		Sh. U.K. Guruvittal	Alternate-Member
14	Geo-Synthetics Sectional Committee, CED 46	Sh. Sudhir Mathur	Member
		Sh. U.K. Guruvittal	Alternate-Member
15	Concrete Reinforcement CED54	Dr. Ram Kumar	Member

Membership of the Staff on Various Technical Committees

S.No.	Committee	Representative's Name	Position held
16	Geotechnical Investigation, Testing and Instrumentation (43.1)	Sh. U.K. Guruvittal	Member
17	Interlocking Block Pavement (ICBP) Committee	Dr. S. D. Sharma	Corresponding Member
18	Earthquake Engineering Sectional Committee CED 39 in drafting group PG7	Dr. Ram Kumar	Member
19	Bitumen, Tar & Their Products Sectional Committee, PCD - 6	Director	Convenor
		Dr. Sunil Bose	Alternate Convenor
		Dr. P.K. Jain	Member
20	Method of Test for Bitumen, Tar & Their Products Sectional Committee, PCD 6:1	Dr. Sunil Bose	Member Convenor
		Dr. P.K. Jain	Alternate Convenor
21	Bitumen & Bituminous Product Sub-Committee, PCD 6:2	Dr. Sunil Bose	Member Convenor
		Dr. P. K. Jain	Convenor
22	Hill Area Development Engineering Sub-Committee, PCD-56	Dr. Kishor Kumar	Member
		Sh. Sudhir Mathur	Alternate Member
23	Cyclone Resistance Design of Structures, CED-57	Dr. R.K. Garg	Member
24	Cement Matrix Products CED-53	Dr. Ram Kumar	Member
25	Environment Protection and Waste Management	Ms. Anuradha Shukla	Member
		Dr. Neeraj Sharma	Corresponding Member
26	Special Structures Sectional Committee CED 38	Dr. Ram Kumar	Member
		Dr. Suraj Prakash	Alternate Member
27	Expert Group on Modified Bitumen Emulsions	Dr. P. K. Jain	Convenor
28	BIS FICCI Task Force to Formulate Specifications for Major Technical Areas of Textiles	Sh. Satish Pandey	Member
29	Export Group Specifications for Cold Bitumineous Ready Mix for Pavement Maintenance	Dr. P. K. Jain	Convenor
30	Export Group and Round Robin Testing of Modified Binder for Viscosity Test for Modified Bitumen (Revision of IS 15462:2006)	Dr. P. K. Jain	Convenor
Ministry of Road Transport & Highways (MoRT&H) New Delhi			
1	Research Application Committee	Director	Member
2	Transport Statistics Committee	Dr. S. Gangopadhyay	Member
3	Committee on Upgradation of NH from 2 lane to 4 lane	Dr. S. Gangopadhyay	Member
4	Traffic Engineering & Safety Committee	Dr. S. Gangopadhyay	Member

S.No.	Committee	Representative's Name	Position held
Delhi Traffic Police			
1	Central Traffic Advisory Committee	Dr. S. Gangopadhyay	Member
New Delhi Municipal Corporation			
1	Traffic Advisory Committee	Dr. S. Gangopadhyay	Member
Delhi Development Authority			
1	Sub-group for Examination of various projects in Delhi	Dr. S. Gangopadhyay	Member
Indian Society of Wind Engineering (ICWE)			
1	Executive Committee	Dr. Rajeev K. Garg	Member
Institution of Engineers, Ghaziabad Local Centre			
1	Executive Committee	Sh. A. Saurabha	Honorary Secretary
Ministry of Rural Development, Govt. of India			
1	PMGSY Empowered Committee	Dr. R. K. Dwivedi	Member
Central Building Research Institute, Roorkee			
1	Research Council	Director	Member
School of Planning & Architect, New Delhi			
1	Review of Project Work of PG Student	Dr. S. Gangopadhyay	Jury Member
MCGB, Mumbai			
1	MCGB, Mumbai Standing Advisory Committee	Director Dr. Sunil Bose	Member Alternate Member
Delhi Pollution Control Committee for Ambient Air Quality Systems (AAQS)			
1	Delhi Pollution Specification Committee	Dr. Anil Singh	Member
IEI, Ghaziabad Chapter			
1	Executive Committee	Dr. Ram Kumar	Chairman
National Institute of Disaster Management			
1	Committee to Formulate Guidelines for Construction of Saline Embankment	Sh. U. K. Guruvittal	Expert
Advanced Materials and Process Research Institute, Bhopal			
1	Management Council	Dr. S. Gangopadhyay	Member
Bombay Textiles Research Associate			
1	Committee for Compiling Specifications for Technical Textiles	Sh. U. K. Guruvittal	Expert

Membership of the Staff on Various Technical Committees

S.No	Committee	Representative's Name	Position held
CAG, Govt. of India			
1	Committee for Audit of NHAI	Sh. U. K. Guruvittal	Expert
Thana Municipal Corporation			
1	Science & Technology Advisory Committee	Dr. S. Gangopadhyay	Member
Konkan Railway Corporation			
1	Technical Advisory Group (TAG)	Dr. S. Gangopadhyay	Member
FICCI			
1	Task Force on Technical Textiles	Sh. U. K. Guruvittal	Member
Centre for Development of Stones (DOS)			
1	Group on Roads and Mass Concrete Work	Dr. A. K. Misra	Member
National Rural Roads Development Authority (NRRDA)			
1	Governing Body	Dr. P. K. Kanchan	Member
2	Committee for Selection of National Quality Monitors (NQMs)	Sh. B. M. Sharma	Member
3	Expert Advisory Committee to Review Standards, Specification and Design of Rural Roads Under PMGSY	Dr. P. K. Kanchan	Member
National Highways Authority of India			
1	Committee to Review of All Toll Related issues	Dr. B. K. Durai	Member
2	Technical Appraisal and Review Committee for Development of Fibre Reinforced Plastic Roadside Barriers	Dr. Nishi Mittal	Member
World Bank Aided Project to Uttar Pradesh State Highway Authority (UPSHA)			
1	Technical Scrutiny	Sh. Sunil Jain	Member
		Dr. Devesh Tiwari	Member
2	GIS Expert	Sh. Pradeep Kumar	Member
Public Works Department			
1	Committee on Subway	Sh. Subhash Chand	Technical Member
National Physical Laboratory			
1	Management Council	Dr. S. Gangopadhyay	Member
National Institute of Science, Technology and Development Studies			
1	Research Council	Dr. S. Gangopadhyay	Member

- Australian Road Research Board (ARRB)
- Bureau of Indian Standards, Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi
- Indian Institute of Bridge Engineers (IIBE), New Delhi
- Indian National Group of the International Associations for Bridge & Structural Engineering, Jamnagar House, Shahjahan Road, New Delhi.
- International Road Federation (IRF), Washington
- Indian Association of Special Libraries and Information Centres, Kakugachi, Kolkata
- Indian National Group of International Society for Rock Mechanics, Central Board of Irrigation and Power, Malcha Marg, Chanakyapuri, New Delhi.
- Indian Society of Desert Technology, College of Engineering, Jodhpur, Rajasthan.
- Asian Information Centre for Geotechnical Engineering, Bangkok, Thailand.
- Permanent International Association of Road Congress, 43, Avenue D4, President Wilson 75116, Paris, France
- Indian Scientific Translators Association, New Delhi.
- Transportation Research Board of the National Academy of Science, National Research Council, 2101, Constitution Avenue, Washington D.C., U.S.A.
- Indian Geotechnical Society, C/o Central Soil and Material Research Station, Olof Palme Marg, Hauz Khas, New Delhi.
- Indian Roads Congress, Jamnagar House, Shahjahan Road, New Delhi.
- Government of Indian Librarians Association (GILA (Regd.) C/o Planning Commission Library, Yojna Bhawan, Sansad Marg, New Delhi.
- Society of Information Science, NISCOM Building, Hillside Road, New Delhi.
- Indian Group of Geo-textiles, Central Board of Irrigation & Power, Malcha Marg, Chankyapuri, New Delhi.
- Institutional Membership of Belgium Road Research Institute, Belgium.
- Associate Membership of Current Science Association, Bangalore.
- Asian Institute of Transport Development (AITD), New Delhi
- Institutional Membership of Consultancy Development Centre, New Delhi.

Intellectual Property (Patents)

Patented Process Released so far to the Industry

- Bitumastic jointing composition (Pat.No. 50474).
- Improvement in or relating to pitch mastic composition

  (two Patent No. 92526 and 95305).
- A process for the treatment of styrene pitch (Pat. No.96710).
- Improvements in or relating to the manufacture of lime-Surkhi mixture (Patent no. 90470).
- Improvements in or relating to the manufacture of reactive Surkhi (Patent No. 93276).
- Fatigue testing machine (Pat.No. 11142).
- Unevenness indicators (two patent No.121776 & 121777).
- A Profilograph for checking pavement unevenness (Pat. No. 121114).
- Automatic road unevenness recorder (three Pat. No. 146517,146572, 146543)
- Rotiller (developed jointly by MERADO & CRRI)
- Pavement paint marking machine (developed jointly by CMERI Durgapur and CRRI)
- Verticle Profile Meter
- Polymer modified bitumen
- SBS modified bitumen
- Crumb rubber modified bitumen
- Waste plastic modified bitumen
- Axle mounted system for measuring road roughness
- Impact tester
- A device for sensing and measuring moisture in soil and other porous materials (Pat. No.173089)
- Improved bullock cart technology

Processes Ready for Exploitation

- A Process for the production of Magnesium Phosphate Cement for emergency repair of concrete pavement.
- A new paving system for desert area
- Electronic probe
- Process know-how for construction of Roads in Sandy Area using soil stabilization technique with Magnesium Oxy-chloride
- Indigenous Weigh-in-motion and Vehicle Classification System
- Automated Benkelman Beam
- Concrete Abrasion Resistance Tester
- Ready made mix for patch repair
- Bitumen Emulsion
- Potable Ponding-cum-Debris Expulsion Equipment
- Design of a Mobile Visual Inspection Unit

All the patented and a few other processes of the Institute are being exploited directly by the Institute and the Industries interested in commercial exploitation of these processes may contact Head Information, Liaison and Training Division of CRRI. (e-mail: (kamla.crri@nic.in)

Marketable Software

- Pavement Deterioration Model (PDM)
- Asphalt Concrete Mix Design (ASCOMID)
- Planning Model for Rural Roads
- Landslide Analysis.
- Stability Analysis of Embankments with stone Columns.
- Expert System for structural Optimisation of Trussed Girder Bridges
- Bridge Deck Analysis (BDAN)
- Software for the accident analysis
- Copyright for software package for design of trail suspension bridges
- Software "CRASH" for prediction of strains induced in concrete due to Effects Creep and Shrinkage

Services Offered

Contract Research

- Collaborative Projects
- Sponsored Projects

Consultancy Services

Training Programme

Testing & Calibration

(for further details see website : www.crridom.gov.in)

Training Programmes Organised

For capacity building in human resources in the area of highway engineering to undertake and execute roads and runway projects, CRRI organises following regular training programme each year for the in-service highway, traffic and transportation engineers and planners. The details of the training programme organised are as follows:

TITLE OF THE COURSE	DURATION	COURSE FEE
A. PAVEMENT ENGINEERING & MATERIALS		
• Design, Construction and Maintenance of Airfield	(5 days)	Rs. 6000/-
• Design, Construction and Maintenance of Flexible Pavements	(5 days)	Rs. 6000/-
• Rigid Pavements: Design, Construction & Quality Control Aspects	(5 days)	Rs. 6000/-
• Pavement Evaluation Techniques and their applications for Maintenance and Rehabilitation	(5 days)	Rs. 6000/-
B. ROAD DEVELOPMENT PLANNING & MANAGEMENT		
• International Course on Dissemination of HDM-4	(10 days)	Rs. 25,000/-
• GIS Application in Planning and Management of Rural Road Network	(5 days)	Rs. 6000/-
C. GEOTECHNICAL ENGINEERING		
• Planning, Design, Construction & Maintenance of Rural Roads (PMGSY)	(5 days)	Rs. 6000/-
• Geotechnical and Landslide Investigations for Highway Projects	(5 days)	Rs. 6000/-
D. BRIDGES & STRUCTURES		
• Bridge Diagnostics, Performance Evaluation and Rehabilitation	(5 days)	Rs. 6000/-
E. TRAFFIC & TRANSPORTATION PLANNING		
• Traffic Management and Safety	(5 days)	Rs. 6000/-
• Aspects of Transportation Planning and Environmental Impact Assessment Studies for Roads	(5 days)	Rs. 6000/-

Customized Tailor Made Programmes:

In addition to the above, CRRI also organises customized tailor made programmes as per the clients requirements.

Course Fee: The course fee as indicated above is payable in advance by crossed bank draft in favour of Director, Central Road Research Institute, New Delhi".

FOR FURTHER INFORMATION & SENDING NOMINATION CONTACT:

Shri T.K. Kanda, Head & Course Organiser, Information, Liaison & Training Division, Central Road Research Institute, PO:CRRI, Delhi-Mathura Road, New Delhi – 110 025 (India). Phone: 91-11-26921939, Fax: 91-11-26845943, 26830480 Telefax: 91-11-26921938, E-mail: tkanda.crri@nic.in, mkmeena.crri@nic.in

Papers published in Journals

S.No.	Topic	Author	Journals
1	Vehicle Axle Loading Pattern on State Road of Uttar Pradesh	Dr. Neelam J. Gupta, Dr. P K Kanchan	Highway Research Journal, IRC, Vol.2, No.1, Jan-June 2009.
2	Analysis of Mode Choice Behaviour for Access Trip For Public Transport System Using ANN	Kanika Kalra, P K Sarkar, Dr. Ch. Ravi Sekhar	Highway Research Journal, IRC, Vol.2, No.1, Jan-June 2009.
3	Analysis of Embankment Slope from Failure Point of View Using Stress Behaviour obtained from Finite Element Method Using Elasto-Plastic Model	Dr. Sukumar Saha	Highway Research Journal, IRC, Vol. 2, No. 1, pp 107-117, Jan.-June 2009.
4	Operational Load Testing and Evaluation of Reinforcement Corrosion of Span P 5 of Zuari Bridge in Goa	Dr. S K Sharma, Dr. Ram Kumar, Dr. V V L Kanta Rao, J K Goyal, Dr. S Saha	Indian Highways, IRC, Vol. 37, No. 4, pp 9-22, April 2009.
5	Modeling of Road Pricing Considering Local Emissions of Road Transportation Network	Yasuo Asakur, Dr. J Nataraju.	International Journal of ITS Research, June 2009.
6	Geosynthetic Usage in Road Works - few Case Studies	Dr. S Gangopadhyay, U K Guruvittal, Sudhir Mathur	Indian Highways, IRC, pp 39-46, June 2009.
7	Skid Resistance Aggregate in Wearing Courses	Sudesh Kumar, S P Pokhriyal, R K Srivastava, B M Sharma	Highway Research Bulletin, IRC, Vol.2, No. 2, July-Dec. 2009.
8	Interlocking Concrete Blocks An Easy Approach for Road Constuction Pavement	Dr. S D Sharma	New Building Materials & Construction World, Vol. 15, Issue 3, Sep. 2009.
9	Right Grade of Bitumen for Flexible Pavements - Indian Perspective	M N Nagabhushana	New Building Materials & Construction World, Vol. 15, Issue 3, Sep. 2009.
10	Time to Change the Fabric of our Roads	Sudhir Mathur, U K Guruvittal	Journal of Construction Week, pp 52-55, Sept.-2009
11	पर्यावरण संरक्षण और हमारा दायित्व	संजय चौधरी	ज्ञान गरिमा, अंक 23, जुलाई–सितम्बर 2009
12	A Comparative Study of Psychophysical Abilities of Specially Trained Vs Normal Driver.	Dr. Nowlena Chakraborty	Psychological Assessment and Selection of Personnel, ISBN, 818651420-1, DIPR, DRDO, Nov. 2009.
13	Innovative Methods and Appropriate Technologies for Development of Rural Roads	Dr. S Gangopadhyay	Indian Highways, IRC, Dec. 2009

S.No.	Topic	Author	Journals
14	Modelling Passenger Mode Choice Behaviour for Medium Cities in India	A Mohan Rao, Dr. P K Kanchan, Dr. B K Durai	Indian Urban Transport Journal, Vol. 8, No.1, Dec. 2009.
15	Application of GPS for Traffic Studies	Dr. K R Kalaga, A Mohan Rao,	Indian Urban Transport Journal, Vol. 8, No.1, Dec. 2009.
16	Advanced Sensor Technology Used for Development of Electronic Toll Collection System	Pradeep Kumar, P Prasanna Kumar	Journal of Instrument Society of India, Vol. 39, No. 4, Dec. 2009.
17	Polyster Fibre Waste as Reinforcing and Mixture in Concrete for use in Road Works	Dr. V V L Kanta Rao, Dr. P Lakshmy, J B Sengupta, Dr. S Gangopadhyay	New Building Materials and Construction World, Vol. 15, No. 6, pp 174-187, Dec. 2009
18	Present Scenario of Overloading of Commercial Vehicles on Indian Roads - Two Recent Case Studies	Dr. P K Kanchan, M N Nagabhushan, Dr. P K Nanda	SAARC Journal of Transport, Vol. X, No. 12, PP 09-13, Dec. 2009
19	Understanding Road Rage and Promising Mitigation Measures	Dr. Neelima Chakraborty, H. Singh, Arun Lal, Huma Tariq, Vijayanthee.	Delhi Police Website http://www.navchetns.com, Dec. 2009.
20	Road Rage: Implementation Plan for Mitigation Measures in an Indian Scenario	Dr. Neelima Chakraborty, Anuradha Shukla	Journal of Psychological Studies, National Academy of Psychology and Springer (India) Pvt. Ltd. 54: No. 4, 267-309, Dec. 2009.
21	दुर्घटना के बाद	हरमदन सिंह नागर डॉ नीलिमा चक्रवर्ती	विज्ञान प्रगति, दिसम्बर 2009
22	Environment and Social Behaviour	Dr Neelima Chakraborty, Anuradha Shukla	Journal of Psychological Studies, Vol 54, No. 4, Dec. 2009.
23	An Approach to Shorten the Construction Period of High Embankment on Soft Soil Improved with PVD	A K Sinha, Dr. Vasant G. Havanagi, Sudhir Mathur	Journal of Geotextiles and Geomembrane, Vol 27(6), pp 488-492, Dec. 2009.
24	A Cover Article on Theme-Safety and Efficient Management of Road Network in Landslide Prone Area	Dr. S Gangopadhyay, Dr. Kishor Kumar	Journal of Science and Culture, India Science News Association, Kolkata, Vol. 75, No. 11-12, Dec. 2009.
25	Control of Landslide Hazards through Slope Stability Analysis - Case Studies	Dr. Sukumar Saha	Indian Highways, IRC, Vol. 37, No. 2, pp 23-31, Dec.-2009.
26	Real World Driving Cycle for Motorcycle in Edinburgh	W. Saleh, Dr. Ravinder Kumar, Howard Kirby	Transportation Research- Part D, 14, PP. 326-333, 2009.

S.No.	Topic	Author	Journals
27	Performance Evaluation of Waste Plastic/ Polymer Modified Bituminous Concrete Mixes	Sabina, T A Khan, Sangita, D K Sharma	Journal of Scientific and Industrial Research, Vol. 68, PP 975, 2009
28	Impact of Variable Message Signs on Motorist Behaviour on an Urban Highway Stretch: A Case Study	Dr. S Velmurugan, Dr. K Ravinder, Dr. K V Ganesh Babu, Dr. S Gangopadhyay	Urban Transport Journal, Vol. 8, No.-1, PP 29-34, 2009
29	In-situ Performance of Self Compacting Concrete in T Beams.	Dr. Rakesh Kumar, Dr. Ram Kumar, Narendra Kumar.	Journal of Material in Civil Engineering, ASCE, Vol. 22, No. 3, PP 303-309, 2009.
30	Use of Foundry Silica-Dust in Manufacturing Economical Self-Consolidating Concrete.	Rudolph N Kraus, Tarun R Naik, Bruce W Ramme, Dr Rakesh Kumar	Construction and Building Materials, Vol. 23, No. 11, PP 3439-3442, 2009.
31	पर्यावरण प्रभाव मूल्यांकन एवं पर्यावरण प्रबंधन	डॉ0 नीरज शर्मा, पी. देवदत्त, डॉ0 एस. गंगोपाध्याय, आर. ध्यानी	भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान पत्रिका 17 (2), 101-107, 2009
32	यातायात एवं ध्वनि प्रदूषण	अनुराधा शुक्ला, रश्मी शुक्ला, नीलम रानी, डॉ0 एस. गंगोपाध्याय,	भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान पत्रिका 17 (2) 1108-116, 2009
33	सड़क एवं राजमार्ग का पर्यावरण प्रभाव मूल्यांकन	डॉ0 नीरज शर्मा, पी. देवदत्त, डॉ एस. गंगोपाध्याय, आर. ध्यानी	भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान पत्रिका 17 (2) 2009
34	Economic and Equity Evaluation of Delhi Metro	Dr. Kirti Bhandari, H Kato, J Black, Y Hayashi	International Journal of Urban Science,13(2),187-203, 2009
35	Performance Study of Rubber Modified Bitumen in Structural Layers of Flexible Pavements - A Case Study	Dr. P K Jain, C Kamraj	Highway Research Journal, IRC, 2009
36	Geotechnical Classification of Rocks for Hill Slope Failure at k.m. 45.00 on NH-150, Mizoram	R K Panigrahi, U K Guruvittal, P S Prasad, Dr. Pankaj Gupta, Sudhir Mathur	Indian Mining and Engineering Journal, Vol. 47, No.9, 2009

S.No.	Topic	Author	Journals
37	Effect of Desk Supports on Buffeting Response of Cable Stayed Bridges using Time Domain Analysis	Dr. Lakshmy P Krishen Kumar, P N Godbole, D N Trikha	Journal of Wind and Engineering, Vol. 6, No. 1, pp 19-31, 2009.
38	Frequency Domain Buffeting Analysis of a Cable Stayed Bridge	Dr. P Lakshmy, Krishen Kumar, P N Godbole, D N Trikha	The Bridge & Structural Engineer, Vol. 39, No. 2, pp 15-25, 2009.
39	Flyash in Highway Embankment	J K Goyal	New Building Materials and Construction World, Vol. 2, No. 8, pp 108-116.
40	Wind Induced Interference Effect on Pressure Distribution Around a Cooling Tower in a Group	Dr. Lakshmy P	The Bridge & Structural Engineer, Vol. 39, No. 2, pp 31-42, 2009.
41	Review of Environmental Laws and their Applicability to Road/Highway Projects	Dr. Niraj Sharma, R. Dhyani, Dr. S. Gangopadhyay	Journal of Indian Roads Congress, 70(2): 165-185
42	दृढ़ कुट्टिम सड़कों की गुणवत्ता परख	जी. के. टिक, सतेन्द्र कुमार, डॉ रेणु माथुर	सड़क दर्पण, अंक 7, फरवरी 2010
43	सीमेन्ट कंक्रीट सड़कों हेतु गैर पारम्परिक सामग्री	सुशील कुमार, डॉ0 राजेश कुमार, डॉ0 राम कुमार,	सड़क दर्पण, अंक 7, फरवरी 2010
44	दिल्ली की सड़कों पर फ्लाई ओवर की प्रभावोत्पादकता	पंकज गोयल	सड़क दर्पण, अंक 7, फरवरी 2010
45	सड़क सूचना के तंत्र के विकास हेतु ज्ञान प्रबंधन सिद्धांत	डॉ0 नीलम जैन, डॉ0 बी बनर्जी दुरई, डॉ0 पी के जैन, डॉ0 पी के नन्दा	सड़क दर्पण, अंक 7, फरवरी 2010
46	सड़क निर्माण हेतु कोयले की राख का गुणात्मक विश्लेषण	आलोक रंजन, यू.के. गुरुविटठल, आर. के. स्वामी, सुधीर माथुर,	सड़क दर्पण अंक 7 फरवरी 2010
47	काठगोदाम –नैनीताल महामार्ग : भूस्खलन संकट अनुक्षेत्र वर्गीकरण का एक विधि – परक अध्ययन	पी. जगन्नाथ राव, डी. मुखर्जी,	सड़क दर्पण, अंक 7, फरवरी 2010
48	सेतु की रेलिंग का अभिकल्प : अनुप्रयोग एवं प्रचलन	डॉ0 सुलतान कायल, चन्द्र कुमार, सुशील कुमार,	सड़क दर्पण, अंक 7, फरवरी 2010
49	प्रधानमंत्री ग्राम सड़क योजना का राष्ट्र के सामाजिक–आर्थिक विकास पर प्रभाव	रीता बाजी	सड़क दर्पण, अंक 7, फरवरी 2010

S.No.	Topic	Author	Journals
50	यातायात के सन्दर्भ में समयबद्धता और गति	हरचरन सिंह नागर, डॉ0 नीलिमा चक्रवर्ती, डॉ0 एस गंगोपाध्याय	सड़क दर्पण, अंक 7, फरवरी 2010
51	प्रदूषण के परिप्रेक्ष्य में खनन गतिविधियों का पर्यावरणीय मूल्यांकन	संजय चौधरी, डॉ0 अनंग पाल,	सड़क दर्पण, अंक 7, फरवरी 2010
52	Power Based Inorganic Stabiliser for Construction of Sub-base and Base Layers of Road Pavement	A K Sinha, Dr. Vasant G. Havanagi, Sudhir Mathur	Indian Highways, IRC, Vol. 39(1), pp 33-44, Feb. 2010.
53	Recent Trends in Road Construction in India	Dr. B K Durai	Civil Engineering and Construction Review, March 2010.
54	Lasers in Highway Engineering	Y C Tiwari, Usha Kiran	Indian Highway, IRC, Vol. 38, No. 2, March 2010
55	A Pilot Study of Benzene in Delhi	Rina Singh, Anuradha Shukla, Dr. S Gangopadhyay	Journal of Air Pollution Control, March 2010.
56	Assessment of Policies towards Environmentally Sustainable Urban Transport System: Case Study of Delhi, India.	J Han, Kirti Bhandari, Y Hayashi	Journal of Urban Planning and Development, ASCE, Vol. 136, No. 1, 86-93, March 2010.
57	Determination of Arsenic and Mercury Metals in Suspended Particulate Matter by Flame/Flameless Atomic Absorption Spectrophotomer	Naher Singh, Sippy K Chauhan, Trailokya Saud, Mohit Saxena, Daya Soni, Khem Chand, Alok Mukherjee, T K Mandal, J K Bhasin, Prabhat K Gupta	Atmospheric Pollution Research 1, 112-117, 2010.
58	Environmental Impact Assessment and Environmental Clearance Process for Road & Highway Projects in India	Dr. Niraj Sharma, Anuradha Shukla, R Dhyani, Dr. S Gangopadhyay,	Civil Engineering and Construction Review, 23 : 86-96, 2010.
59	भारतीय शहरों में मेट्रो प्रणाली की मांग	डॉ0 गौतम तिवारी, मुकेश अग्रवाणी,	जिज्ञासा, आई.आई.टी. -दिल्ली
60	Rock Mass and Slope Mass Characterisation of Kaliasaur Landslide Area on National Highway 58 and Correlation of Results with Deformation Conditions(Uttarakhand)	Shivashish Kimothi, Dr. Kishor Kumar, Sudhir Mathur	Himalayan Geology, Vol. 31(2), pp 133-143, 2010.

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
1	Seminar on Sustaining Growth through Investment in Infrastructure, Bentley Systems Ltd., New Delhi, April 13, 2009.			Dinesh Ganvir, Abhishek Mittal
2	Third Workshop on Creation and Dissemination of Knowledge, IMI & IIT, Madras, April 2010			T.K. Amla
3	Workshop on Aggression Management, Delhi Traffic Police, New Delhi, April 15-17, 2009.			Dr. Neelima Chakraborty
4	Rastriya Vigyan Avm Prodhogiki Hindi Sangoshty, NAL, Bangalore, 16-17, April 2009.	Anusandhan Avm Vikash Sangosty Main Rajbhasa Hindi ka Priyog.	Dr. Anang Pal	Dr. Anang Pal
		Bhartiya Arogyavardhak Padhatiya Avm Sambandh Vigyan	Sh. Sanjay Choudhary, Dr. Nityanand Choudhary, Dr. Anang Pal	
5	National Seminar on Emerging Trends in Ground Improvement, Kolkata, May 22-23,2009	Ground Improvement Techniques Development as Road Infrastructure	Jai Bhagwan, A K Sinha, Sudhir Mathur	Jai Bhagwan T K Amla Dr. S Gangopadhyay
6	CSIR Workshop on Advances and Application of Mathematical Modelling (AAMM 2009), C-MMACS, Bangalore, May 23-25, 2009.	Application of Fuzzy Logic in Developing Microscopic Traffic Simulation Model for Urban Road Network.	Dr. E Madhu	Dr. E Madhu Dr. Pramada Valli Dr. S Haba
		Application of Numerical Modeling to Solve some Problems of Geotechnical Engineering	Dr. S Saha	
		Numerical and Mathematical Modelling for Road Research and Development Activities	Dr. Pramada Valli	
		Computer Simulation and Mathematical Modelling for Road Research and Development Activities	Dr. Pramada Valli	
7	World Tunnel Congress (WTC), 2009, Budapest, Hungary, May 23-28,2009.	Mitigation and Management of Slope Hazards on Mumbai-Pune Expressway	Dr. Kishor Kumar, P.S. Prasad, Sudhir Mathur	Dr. Kishor Kumar Dr. Niraj Sharma
8	Seminar on Management of Hazardous Chemicals, Prevention of Accidents in Industries and Creating Environment Safety Concern, Lucknow, May 27-28, 2009.			

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
9	Workshop on New Technologies for Rural Development Having Potential of Commercialization, Advanced Materials and Processes Research Institute, Bhopal, May 29, 2009.	Upgradation of Unevenness Indicator A Low Cost Device for Measuring Roughness of Rural Roads	Dr. S D Sharma,	Dr. S D Sharma, Dr. P K Kanchan
		Potential Use of Marginal Material in Construction of Rural Road Towards Achieving Economy.	Dr. P K Kanchan, M N Nagabhushan	
10	Seminar on Rehabilitation of Airfield Airforce, Allahabad, May 2009.	Evaluation of Pavement Classification Number and Rehabilitation Design of Airfield Pavements	S P Pukhriyal, R K Srivastava, B M Sharma	
11	Workshop on Jute Geotextiles Usage in PMGSY Roads, JMDC & NRRDA, New Delhi, June 3,2009			Sudhir Mathur, U K Gunivittal, R K Swami
12	Advances in Chemical Engineering and Process Technology (ACEPT), NCL, Pune, June 4-6, 2009.			J. B. Sen Gupta
13	Hindi Seminar, NIO, Goa, June 5-6, 2009.	Vaikalpik Nirman Samagry Tatha Global Warming Ke Sandarbh Main Satat Vikas	Mukesh Kumar, Krishan kant, V K Tyagi, Jai Bhagwan	V K Tyagi, Harcharan Singh
14	Round Table Conference on Pedestrian Safety, CSE, New Delhi, June 12, 2009.			Dr. Nishi Mittal
15	IRC Council Meeting, Kodaikanal, June 2009.	Impact of Road Transportation on Climate Change	Dr. S Gangopadhyay	Dr. S Gangopadhyay Dr. S Bose
16	Workshop on Mobile Mapping Technologies for Road Asset Information and Management, CRRI & Infotech Enterprises Ltd. July 17, 2009			No. of Scientists
17	National Conference on Promoting Excellence in Governance, New Delhi July 21-22 2009			Dr. P K Jain
18	28th Annual South African Transport Conference, CSIR, Pretoria, South Africa, July 2009.			M N Nagabhushan, Abhishek Mittal, Anshika Sahl,
19	Indo-US Workshop on Recent Developments in Highway and Airport Pavement Engineering, IIT Kanpur, & IIT Chennai, Aug. 7-8, 2009.			T.K. Amla K Sitaramanjaneyulu, Pradeep Kumar
20	Workshop on Cold Mix Technology, Assam PWD, Jorhat, Aug. 10 2009.			Dr. P K Jain

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
21	Workshop Road Safety, NHAI, Lucknow. August 17,2009.			Dr. Nishi Mittal
22	Annual Convention- Auto Industry Revival, Restructuring & Sustainable Growth, Society of Indian Manufactures, New Delhi, Aug. 28, 2009.			Dr Anil Singh
23	Public Private Partnership in Highway Sector, IRC, New Delhi, 28-29, August 2009.	Electronic Toll Collection Technologies A Review	Y C Tiwari	Dr. B K Durai, Dr Renu Mathur, Dr. A K Mishra, J B Sengupta, Dinesh Ganvir, T K Amla, B M Sharma, K Sitaramanjaneyulu, A Mohan Rao, Dr. Ch Ravi Sekhar, Dr. P K Jain, U K Guruvittal, A K Sinha, Kamini Gupta, Abhishek Mittal
		Toll System Design Based on Travel Time Reliability for High Speed Corridars.	Dr. Ch Ravi Sekhar, Dr. B K Durai, A M Rao, K Sitaramanjaneyulu	
		Public Private Partnership Road Project Some Pertinent Issues	Dr. S Gangopadhyay, U K Guruvittal, Sudhir Mathur	
		Financial Analysis of the PPP Projects- Review of Concepts	Kamini Gupta, A M Rao,	
24	12th IFAC Symposium on Control in Transportation Systems, Los Angeles, Sept. 2-4, 2009.	Accuracy of Optimum Road Pricing Considering Local Emission of Road Traffic Networks	Dr. J Nataraju, Yasuo Asakura	
25	Workshop on Eurocode-8 Seismic Design of Building and Bridges, ICI New Delhi, September 7-9, 2009.			Dr. Lakshmy P, Dr. Rajeev Goel, Dr. Rajeev Garg
26	11th JSCE International Symposium, Tokyo, Sept. 11, 2009.	Comparison of Environmental Road Pricing Using different Emission Factors	Dr. J Nataraju	

Papers published in

Seminars / Conferences

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
27	Workshop on Geosynthetics TECHNOTEX-2009 -Providing Better, Secure & Sustainable Life, Ministry of Textiles & FICCI, September, 23, 2009.			U K Guruvittal
28	Ist Conference on "Systems and Management Innovation" for R & D, NISCAIR, New Delhi, October 9, 2009.			Dr. P K Jain, Dr. Rekha Sharma
29	EPO Seminar on Intellectual Property, New Delhi, Oct. 15, 2009			A. Saurikhia
30	Workshop on Landslide in Uttrakhand, HNB Garhwal University, Srinagar, Garhwal, Oct. 30-Nov. 2, 2009			Dr. Kishor kumar
31	NATCOM-II and National Workshop on Review of Implementation of Work Programme Towards Indian Network of Climate Change Assessment (INCCA), New Delhi, Oct. 13-14, 2009.			Dr. Anil Singh
32	4th IRF Regional Conference on Road Safety Measures, New Delhi, Oct. 23-24,2009.	Mobility and Accessibility Problems of Children with Disabilities	Dr. Neelima Chakraborty, Dr S Gangopadhyay	Dr. Nishi Mittal, Dr. Surinder Mohan, Dr. S Velmurugan, Dr. Neelima Chakraborty, Dr. B K Dorai, Dr. E Madhu, Dr. K Ravinder, S Padma, Dr. Niraj sharma T K Amla
33	National Dissemination Cum Advicacy Meeting on Traffic Calming Strategies to improve Pedestrian Safety in India, CUTS International and IIT Delhi, Oct. 27, 2009.			Dr. Nishi Mittal
34	National Conference on Consulting Services: Contributing towards Building Nation, CII, New Delhi, October 20, 2009			Dr. P K Jain, Dr. Lakshmy P

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
35	Ist International Conference on Advances in Concrete and Geotechnical Engineering, BITS, Pilani, Oct. 25-27, 2009.	Assessment of Present and Future Rating of Existing RCC Bridge	Dr. Rajeev Goel, Dr. R K Garg, Dr. Ram Kumar	Dr. Rajeev Goel, Dr. R K Garg, Dr. Ram Kumar
36	Workshop on Road Drainage, ICI, Nov. 5,2009.			Sudhir Mathur, U K Guruvittal
37	2nd India Disaster Management Congress, New Delhi, Nov 4-6, 2009.			Dr. Kishor Kumar
38	7th International Conference on World Association for Sustainable Development (WASD), Bahrain, Nov. 8-13, 2009.	On Board Mission Measurement Using Driving Cycle in Air Quality Management Area of Edinburgh	Dr. Ravinder Kumar, Wafaa Saleh, Colin Boswell	Dr. Ravinder Kumar
		A Comparison of Delhi Motorcycle Driving Cycle and Edinburgh Motorcycle Driving Cycle	Dr. Ravinder Kumar, Wafaa Saleh, Anil Sharma	
39	Meeting cum Workshop, Consultative Group for Mid-Term Appraisal of 11th plan projects, Urban Affairs, Planning Commission, Nov. 12 2009.			Dr. P K Jain
40	INDOROCK Conference, CSMRS, New Delhi, Nov. 12-13, 2009.			Dr. Kishor Kumar
41	70th Annual Session of Indian Road Congress, Patna, Nov. 13-14, 2009.			40 no. of CRRI Scientists
42	8th International Conference of Eastern Asia Society for Transportation Studies (EASTS 2009), Surabaya, Indonesia, Nov 16-19, 2009.	Application of Neural Network in Mode Choice Modelling Second Order Metropolitan Cities in India	Dr. Ch Ravi Sakhar, Dr. E Madhu, Dr. B K Durai, Dr. S Gangopadhyay	
		Evaluation of Traffic and Air Quality during Incidents on an Urban Freeway Corridor Using Microscopic Simulation	Dr. S Velmurugan, Dr. Rocco Zito	Dr. Ch Ravi Sekhar, Dr. J Nataraju, S Padma
		Comparative Evaluation of Mode Choice Modelling by Logit and Fuzzy Logic	S Padma, Dr. E Madhu, Dr. D Mukhopadhyay, Dr. S Gangopadhyay	

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
		Comparison of Road Pricing of Optimum and Descriptive Approaches Considering Local Emission of Road Transportation Network	Dr. J. Nataraju Yasuo Asakura	
43	India R & D 2009 - Geospatial Technologies for Utilities and Infrastructures, FICCI, Nov. 20-21, 2009			Dr. B.K. Dora
44	Multi District Seminar on Road Safety, Rotary Club of Cuttack, Greenfield, Cuttack, Orissa, Nov. 22, 2009.	Drinking Driving on Psychological Impairment	Dr. Neelima Chakraborty, Dr S Gangopadhyay	Dr. Neelima Chakraborty
45	First Asian Carbon Conference, New Delhi, Nov. 25-27, 2009.	Studies on Waste Plastic Polymer Modified Bitumen Using Conventional Test Methods	Dr. Sippy K Chauhan, Sabina T A Khan, D K Sharma, Dr Sangita	
		Investigation on Immobilization of Lipase on Carbon Nanotubes for the Improved Production of Biodiesel	Dr. Sippy K Chauhan, Shalini Sharma, Anuradha Shukla, Dr. S Gangopadhyay, L M Bharadwaj	
46	Conference on Urban Mobility in India, IIT, New Delhi, Dec. 3-5, 2009.			Dr. Nishi Mittal, Dr. Surinder Mohan, T.K. Arora Dr. Neelima Chakraborty, Dr. S Velmurugan, Dr. B K Dutai, A M Rao, Dr. Kirti Bhandari, Rina Singh, Dr. P Panda, Dr. L Madhu, Dr. K Ravinder, S Padma, Dr. Niraj Sharma
47	Physics of Semi conductor Devices (IWPSDI, SSPL, DRDO, New Delhi, Dec. 14-18, 2009			Rina Singh

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
48	National Conference on Corrosion Assessment and Control (NCACC09), Thiagarajar College of Engineering, Madurai, Dec. 21-22, 2009.	Corrosion Monitoring of Prestressed Concrete Bridges- Current Status and On Going Research	Dr. V V L K Rao, Dr. Lakshmy P, Dr. S Gangopadhyay	
49	All India Seminar on Modernization in Construction Industry by Mechanization, The Institute of Engineers, Ranchi, Dec. 28-29, 2009.	Influence of Crusher on Shape of Aggregate	N K Sharma, J B Sen Gupta, R S Bhardwaj, Pradeep Kumar	Dr. S D Sharma A. Savitkha
		Mechanisation in Highway Engineering	Dr. S D Sharma	
50	14th International Conference of Hong Kong Society for Transportation Studies, (HKSTS), Hong Kong, Dec. 2009.	Speed Flow Characteristics of High Speed Corridors in India	Dr. E Madhu, Dr. S Velmurugan, Dr. K Ravinder, Dr. S Gangopadhyay	Dr. E Madhu
51	Workshop on Solid Waste Management, ICPE and IPI, Chandigarh, Dec. 2009.			Anshika Behl
52	Indian Geotechnical Conference, IGS Guntur Chapter, Guntur 2009.	A Geomorphological Appraisal of Patalganga Landslide on National Highway 58, Garhwal Himalaya, Uttaranchal	Dr. Kishor Kumar, P S Prasad, Shivashish Kenoth, Sudhir Mathur	
53	International Symposium on Ground Improvement Technologies and Case Histories, Singapore, pp 345 351, Dec. 2009	Settlement of Soft Clays Using Prefabricated Vertical Drain	A K Sinha, Dr. Vasant G Havanagi, Sudhir Mathur	A.K. Sinha
54	Indo Italian Conference on Emerging Trends in Waste Management Technologies, Dec. 3-4 2009	Municipal Waste Information Database for Use in Highway and Geotechnical Related Applications	Pramada Valli, Sudhir Mathur	
55	KU-US Joint Seminar, Kumamoto University, Japan, 2009.	Environmental Road Pricing Considering Local Traffic Emissions of Road Transportation Network	Dr. J Nataraju, Yasuo Asakura	
56	International Conference on Challenges and Application of Mathematics in Science and Technology (CAMIST), NIT, Rourkela, Jan. 11-13, 2010.	Simulation and Mathematical Modelling on Flow Past Fixed Body	Dr. Pramada Valli,	
57	"Petroleum Udyog - Vision - 2030" Sangoshti, India Habitat Centre, New Delhi, Jan. 11-12 2010.	" Damar Udyog Mein Naveen Prodhyogikiyen ki Bhari Sambhavnayen".		Dr. Pramod Kumar Jain

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
58	High Powered Seminar on Roads National Urban Affair, New Delhi, January 13, 2010			Dr. Nishi Mittal
59	Estimation of Road and Special Infrastructure Expenditure Requirements for Urban Indian, Ministry of Urban Affair, New Delhi, Jan. 13,2010			Dr. E Madhu
60	2nd National Conference on India Roads 2010, ASAPP, Hyderabad, Jan. 13 2010			T.K. Amla
61	National Seminar on Concrete Highway Projects, CII & Industrial Policy and Promotion, Ministry of Commerce & Industry, New Delhi, January 14, 2010.			Dr. Renu Mathur, Dr. A K Mishra
62	Symposium on Public Transportation in Indian Cities with Special Focus on Bus Rapid Transit, Asia Pacific International Association of Public Transport, New Delhi Jan. 20-21, 2010			T.K. Amla
63	Map India 2010 - 13th Annual International Conference and Exhibition on Geospatial Information Technologies and Applications, GIS Development Ltd., Gurgaon, Jan. 19-21, 2010.	Landslide Hazard Potential Analysis of Patalganga Valley, Garhwal, Western Himalayan Region of India	Dr. Kishor Kumar, Shivashish Kimothi, P.S Prasad, Kanwar Singh, Sudhir Mathur	Dr. B. K. Durai A K Sagar, Pradeep Kumar, Dr. E Madhu, Dr. Kishor Kumar, Neelam J. Gupta, A.M. Rao, Kamini Gupta T K Amla
64	Carbon Footprint of Urban Energy, TERI, New Delhi, Feb. 4, 2010.			Dr. Kirti Bhandari
65	Geotechnical Workshop Delhi NCR Chapter of Indian Society of Engineering Geology, Faridabad, Feb. 8, 2010.			Dr. Kishor Kumar
66	ISBA Conference on Technology Incubation, New Delhi Feb. 8-10, 2010			A. Senthi

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
67	Conference on Image Processing (NCIMP 2010), Deptt. Of Computer Science & Applications, The Gandhigram Rural Institute, Gandhigram, Tamil Nadu, February 12-13, 2010.	A New Approach Using Image Processing Technique for Highway Applications	S Kanan, I Kasparraj, Pradeep Kumar, R S Bhardwaj, Dr. Naqvi,	
68	Erdas User Interface Meet, Gurgaon, Feb. 18, 2010.			Dr. Kishor Kumar
69	Indian Geotechnical Conference, IGS, Warangal, Feb. 18-20, 2010	Remedial Measures for Lowering Ground Water Table at Pantnagar Airport	U K Guruvittal, P S Prasad, Sudhir Mathur	
70	Seminar on Roads in High Precipitation Area, Indian Roads Congress, Guwahati, February 19-20, 2010.	Suggestion for Selection of Appropriate Roughness Measuring Equipment in Different Operating Conditions	Pradeep Kumar, B M Sharma, Y V Rao,	Dr. S D Sharma, Sanjay Deori,
		An Approach for Management of Bridge Vulnerable to Floods	Dr. Lakshmy P	
		Maintenance of Roads in Small Islands with Heavy Rainfall Conditions - Andamans, A Typical Case.	Dr. P K Jain, M N Nagabhushan	
		Green Emulsion Based Cold Mix Technologies for Maintanace of Flexible Pavement in High Precipitation Area.	Dr. N K S Pundhir	
		Performance of Modified Binder in High Precipitation Areas - Synthesis of Pilot Studies	Dr. P K Jain, M N Nagabhushan, Y V Rao, C. Kamraj	
71	International Conference on Advancements in Polymeric Materials (APM 2010), CIPET, Bhubaneswar, Feb. 20-22, 2010.	Study of Microstructure of Bitumen/ Plastic Blends Using Scanning Electron Microscope for Waste Minimization.	Sabina, Dr. Sangita	
72	DST Sponsored Workshop, New Delhi, March 2, 2010.	Methodological Choices: Estimation of GHG Emissions From Road Transport Sector	Dr. Anil Singh	Dr. Anil Singh

S.No.	Name of the Seminar	Title of Paper	Author	Attended by
73	National Get Together on Road Research and Its Utilization (NGT 2010), CRRI New Delhi, March 5-6, 2010.	Safety and Management of Road Network in Landslide Prone Areas	Dr. S Gangopadhyay, Dr. Kisher Kumar	No. of CRRI Scientist
		Application of Intelligent Transportation System (ITS) for Traffic Management System Under Indian Traffic Conditions	Dr. S Velmurugan, Dr. K Ravinder	
		New and Innovative Technologies for Bituminous Construction Specifications in India	Dr. Sunil Bose, M N Nagabhushan, Abhishek Mittal, Ambika Behl	
		Innovative Use of Waste Materials for Road Infrastructure	U K Guruvittal, Sudhir Mathur	
		Impact of National Auto Fuel Policy Emission Norms on Vehicular Pollution in Delhi	Dr. K. Ravinder Dr. E. Madhu	
		Emerging Trends of R&D in Bridge Engineering	Dr. P. Lakshmy	
74	Conference on Trends & Advances in Transportation Engineering (TREAT 2010), Bangalore University, Alumni Association Bangalore, March, 10-12, 2010	Construction of Road Embankments Over Marine Clay Deposits Sigoificance of Instrumentation for Monitoring Consolidation	U K Guruvittal, P S Prasad, Sudhir Mathur	K Sitaraman Janeyulu, Dr. E Madhu, U K Guruvittal T K Amla
75	Workshop on Slope Stability and Landslide, CRRI, March 15, 2010			No. of CRRI Scientists

Staff of the
Central Road Research Institute
As on 31st March, 2010

Director

Gangopadhyay S. (Dr.), M.Tech. (Transportation System), M.Sc. (Transportation), Ph.D. Acting Director upto May 28, 2009.

Director w.e.f. May 29, 2009.

Road Development Planning and Management (RDM)

Kanchan P.K. (Dr.), Ph.D (Maths) Scientists-G

Kanaga Durai B., (Dr.), M.A. (Eco), M.R.P. (Regional Planning), Ph.D **(Head)**

Scientists/Technical Officers

Advani Mukti (Dr), M.E. (Transportation Engineering), Ph.D.

Chander Subhash, M.A (Eco.)

Dwivedi S.N., M.A.

Gupta Kamini, M.Tech. (Transportation Engineering)

Gupta S.K, Diploma in Draughtsmanship (Mech.)

Gupta Neelam J. (Dr.), M Sc, M. Phil (Computer Application), Ph.D (Numerical Analysis)

Poonam Singh, B.E. (Civil), MBEM.

Rao A. Mohan, M.Tech (Transportation Engineering)

Ravi Sekhar Ch. (Dr.), M.E (Transportation Engineering), Ph.D.

Ravinder Kumar (Dr.), M.E (Transportation Engineering), Ph.D. On study leave upto Oct. 28, 2009.

S&T and Supporting Staff

Jeet Ram, Non Matric

Kumar Ashok, B.A.

Kumar Narendra, Matric

Ram Sagar, Matric, (Joined on Oct. 29, 2009)

Singh Satyabir, SSC, ITI (Printing)

Bridges & Structures (BAS)

Ram Kumar (Dr.), M.E., Ph.D.,

(Area Advisor & Head) (on Deputation)

Lakshmy P. (Dr), M.E., Ph.D. **(Head**, w.e.f. Aug. 13, 2009).

Scientists/Technical Officers

Bhushan Shashi Kumar, Diploma in Civil Engg.

Dhal A. K., M.Tech. (On Deputation)

Garg R. K. (Dr.), M.Tech. Ph.D.

Gaharwar.S. S., M.E. (Structure) (On Deputation)

Goyal J. K., M.E. (Structures)

Goel Rajeev, M.E (Structural Engineering)

Kumar Narendra, B.Sc.

Pradeep Kumar, Diploma in Civil Engg, A.M.I.E.

Prakash Suraj (Dr.), M.E. (Earthquake Engineering), Ph.D.

Rao U.S., M.Tech. (Structure)

Rao V.V.L.K. (Dr.), M.Sc., Ph.D.

Saha Sukumar (Dr.), M.Sc, Ph.D (Applied Maths.).

Sahu G.K., M.E. (Structure) (On Deputation

Singh W.P., ITI

Sharma S.K., (Dr.), M.E. (Structure), Ph.D

Sushil Kumar, B.Sc., Dip. in Civil Engg., AMIE

Yogender K. Singh, Dip. Electronics

S&T and Supporting Staff

Dharam Vir, Non Matric

Rana, M.S, ITI

Ram Lakhan (Joined on Nov.) 3, 2009

Rajveer Singh, Non Matric

Satish Kumar, B.A.

Verma Surender Kumar, (Joined on Sep. 30 2009)

Traffic & Transportation Planning (TTP)

Gangopadhyay S. (Dr.), M.Tech. (Transportation System), M.Sc. (Transportation), Ph.D. **(Area Adviser)**

Traffic Engineering & Road Safety (TES)

Mittal Nishi (Dr.), M.A. (Eco.), Ph.D. **(Head)** (w.e.f. Dec. 10, 2009)

Ramalingaiah, A.N., M. Tech. (Traffic & Transportation System Planning) (Head), Retired on Oct. 31, 2009)

Scientists/Technical Officers

Bajpai R.K., M.Tech (Transportation System) (Retired on April 30, 2009)

Biswas S.K., Draughtman

Chakraborty Neelima (Dr.), M.A., (Psycho.), P.G. Dip. (Environmental Psycho.), Ph.D

Gautam S.P., B.A., LLB

Nataraju J. (Dr.), M.E. (Highways), Ph. D.

Sher Singh, B.Sc.

Singh Harcharan, M.A (Eco), B.Ed.

Subhash Chand, ME (Highways)

Surinder Mohan (Dr.), M.Sc. (Physics), PG Diploma in Ecology & Environment

Unmat S.K., B.Com

Velmurugan, S. (Dr.) M.E., Ph.D. (Transportation Engineering)

S&T and Supporting Staff

Bhel Sushma, Intermediate

Chopra Raj Rani, Non Matric (Retired on April 30, 2009)

Mehto Jag Lal, Non Matric

Mutreja Daleep, B.Com.

Raj Bala, Non Matric

Verma Ranjan (Joined on Oct. 5, 2009)

Transport Planning & Environment (TPE)

Shukla Anuradha, M.Sc., M.Tech. (Corrosion Science), P.G. Diploma in Ecology & Environment Science **(Head) w.e.f. April 16,2009**

Scientists/Technical Officer

Akhtar Nasim, M.Tech. (Environmental Engg.)

Bhandari Kirti (Dr.), M.Sc. (Environmental Engg.), Ph.D.

Chander Bhan, M.A. (Eco.)

Chauhan Sippy K (Dr.), M.Tech. Ph. D. (Chemistry)

Errampalli Madhu (Dr.), M. Tech (Transportation Planning) Ph.D.

Padma S, M.Tech.

Parida Purnima (Dr.), M.A. (Economics), M.Tech., Ph.D

Paswan R.N., B.A. (Retired on Feb. 28,2010)

Pradeep Kumar P. V. M.E. (Mech.), MBA

Ravender K., (Dr.), M. Tech. (Transportation Engg.), Ph.D.

Singh Anil, (Dr.), Ph.D. (Environmental Science)

Singh Hawa, Matric

Singh Jagdish, Intermediate

Singh Rina, M.Tech.

Sharma Niraj (Dr.), M. Tech., Ph.D.

Suthar H.H., B.Sc (Hons.) (Physics), (Retired on Nov. 30, 2009)

S&T and Supporting Staff

Daya Ram, B.A.

Kumar Devender, Matric, ITI (Motor Mech.)

Devi Shakuntla, Non Matric

Kumar Sanjay, M.A. (Pub. Admn.), B.Lib.

Sethi Sarita, B.A.

Singh Brij Mohan, Matric

Pavement Engineering & Materials (PEM)

Flexible Pavement (FP)

Bose Sunil, (Dr.) M.Tech (Highways), Ph.D. **(Head)**

Scientists/Technical Officers

Behl Ambika,M.Tech(Chemical Engineering)

Gajendra Kumar, Diploma in Civil Engg

Jiwan Lal, Intermediate

Kamraj C., B. Tech, (Civil), (on Study Leave)

Mittal Abhishek, M.Tech. (Transportation Engg.)

Nigam B.S., BA.

Nagabhushana M.N., M.Sc. (Highway Engg.)

Kumar Narendra, B.A.

Pandey Satish ,BE (Civil), (On Study Leave)

Punithir N. K. S. (Dr.), PhD (Chemistry)

Sangeeta (Dr.), Ph.D. (Polymer Chemistry)

Sharma Girish, B.E (Civil)

Shukla Manoj, M.E. (Transportation) (on deputation)

Singh Surender, ITI

Staff of the
Central Road Research Institute
As on 31st March, 2010

S&T and Supporting Staff

Amit Kumar, (Joined on Sep. 23, 2009)

Hembram Panchanan, (Joined on Oct. 5, 2009)

Rishi S. K., B.Com., Diploma in Book Keeping & Accountancy

Raghusaran, (Joined on Nov. 3, 2009)

Saini Karuna B.A.

Rigid Pavement (RP)

Mathur Renu (Dr.), M.Sc., Ph.D. (Head)

Scientists/Technical Officer

Binod Kumar, M.E. (Hill Area Development Engineering)

Dinesh V. Ganvir, M.E. (Highways & Transportation)

Goel Pankaj, B.E. (Civil Engg)

Jain A. K., M.E. Hons. (Transportation Engg.) (on Deputation)

Maheshwari R. K. (Dr), M.Sc. (Chemistry), PhD

Mishra A. K. (Dr.), M.Sc. (Chemistry), Ph.D .

Pant Ashok, Higher Secondary

Rakesh Kumar (Dr.), M.Tech, Ph. D (Civil Engg)

Sengupta J.B., M.Sc. (Applied Chemistry)

S&T and Supporting Staff

Choudhary Asif Hussain, B.Com

Singh Bhajan, B.A.

Singh Balbir, Non Metric

Singh Manoj Kumar, (Joined on Sep. 11, 2009)

Singh Nihendra, B.A

Pavement Evaluation (PE)

Sharma B. M., M.E. (Transportation Engg.), (Head)

Scientists/Technical Officers

Deori Sanjay, M.Tech., (Transportation Engg.)

Jain Sunil, M.E. (Transportation Engg.)

Kumar Shanta, B.Sc., LLB

Pokhriyal S. P., M.Sc. (Maths & Statistics)

Pradeep Kumar, M.Sc. (Physics), M. Phil (Instrumentation)

Rampal, B.Sc.

Rao Y. V., M.Sc. (Maths)

Rastogi Sarita, Higher Secondary, Dip. in Commercial Art

Pardesi R C , B Sc

Sagar A. K., B.Sc. Engg. (Civil), MBA, M.Tech. (Environmental Engg.)

Sharma S.D. (Dr.), M.Sc. (Chemistry), Ph.D

Singh Ajay Pal, Diploma in Civil Engg.

Singh Attar, Diploma in Civil Engineering

Singh Madan Pal, B.Sc.

Singh P. R., B.Sc.

Sitaramanjaneyulu K., M.E. (Highway Engg.)

Srivastava R. K., M.Tech.

Sudesh Kumar, M.Sc. (Chemistry)

Tiwari Devesh (Dr.), M.E (Transportation Engg.), Ph.D

S&T and Supporting Staff

Kumar Prashant, Diploma in Civil Engg, AMIE (Civil) (On Study Leave)

Ram Lal, Non Matric

Sharif Md. Ibrahim, Intermediate

Singh Mahinder Prasad

Singh Pratap , Metric ,ITI

Verma Pushpa, M.A.

Geotechnical Engineering (GTE)

Sudhir Mathur, M.Tech (SM & FE) (Head)

Scientists/Technical Officers

Arun Uma, M.Sc. (Chemistry)

Beg Raj, B. Sc

Ganesh J., M.Tech.(Geotechnical Engg.)

Goel Nitesh, M.Tech (Transportation) (On Deputation)

Gupta Pankaj, (Dr.), Ph.D (Engg. Geology)

Guruvittal U. K., M.E. (Highway)

Jai Bhagwan, M.Sc. Physics

Khan Farhat Zahoor M.Tech. (Geo Technical)

Staff of the Central Road Research Institute

As on 31st March, 2010

Kumar Kishor (Dr.), Ph.D. (Geology Engineering)

Mukherjee Deepak, M.Sc. (Applied Geology)

Murugesan.V., SSLC

Panigrahi R. K., M.Sc.Tech. (Applied Geology)

Pramada Valli P. (Dr.), M.Sc. (Applied Geology), Ph.D (Applied Maths)

Prasad Prema M.A.

Prasad P. S., M.E (Geotechnical Engg.)

Ranjan Alok, M. Tech. (Engineering Geology)

Sharma N. K., B.Sc. (Retired on Nov. 30, 2009.)

Singh Kanwar, M.Tech. (Geotechnical Engg.)

Sinha Anil Kumar, M.Tech. (Geotech. Engg.)

Soni S. K., M.E. (Civil)

Swami B. K., M. Sc. (Chemistry)

Vasant.G.Havanagi, (Dr.), M.Tech, Ph.D (Highway & Geotech Engg).

Yadav O. P., M.Sc. (Physics)

Kanaujia V. K., B.E. (Civil)(on Study Leave)

S&T and Supporting Staff

Hari Ram, Non Matric

Jamdar Mehto, Non Matric

Saha Sunil Chander, Matric

Surinder Kumar, Non Matric

Ved Prakash, Inter

Vijay Singh, Non Matric

Vinod Kumar, B.A.

HRD & Project Management (HRP)

Sudhir Mathur, M.Tech (SM & FE) **(Area Advisor)**

Planning Monitoring & Evaluation (PME)

Jain P.K. (**Dr.**) Ph.D (Chemistry) **(Head)**

Scientists/Technical Officers

Aggarwal Nidhi, M.Sc. (Chemistry)

Ravinder D., Diploma in Computer Engg.

Saxena Alind, M.A (Eco), P.G. Diploma in Computer Science, MS (Software System)

Sharma Rekha (Dr.), M.Sc., Ph.D.

Saurikhia A., M. Sc. (Env. Engg.), PGDPM, AMIE

S&T and Supporting Staff

Dhingra, S.K., B. Com.

Santosh, Non-matric

Sri Lal, HSC

Technology Management & Business Development Cell

Saurikhia A., M.Sc. (Env. Engg.), PGDPM, AMIE **(In-charge)**

Information, Liaison & Training (ILT)

Amla T. K., M.Sc. (Chemistry), Associateship in Information Science, M. Phil. Science Communication & Journalism **(Head)**

Scientists/Technical Officers

Agarwal R. C., B.E. (Mechanical Engg.), AMIE, PG-PDOM (TQM), C. Engr. (I)

Arora Anita, M.Sc. (Chemistry)

Jain Kavita, M.Com

Meena M. K., B.Tech. (Civil)

Nair P. R. N., B.A. (Retired on Jan. 31 2010)

Singh Rajbir, B.A, ITI

S&T and Supporting Staff

Batra Bhupinder Singh, B.Com.

Deep Chand, Non Matric

Khan Amin Ali, M.A (Political Science)

Sumitra Bai, Non Matric

Photo Section

Kumar Ashok, Certificate Course in Colour Photography

Singh Rajbir, B.A.

Management Information Network (MIN)

Ghosh B. N., M.Com., M.B.A., CWA (I), Diploma in Computer **(Head)** (Retired on April 30, 2009)

Masih Kamla, MCA (In Charge) (w.e.f. June 3, 2009)

S&T and Supporting Staff

Staff of the

Central Road Research Institute

As on 31st March, 2010

Kapoor Kamlesh, M.A.

Prakash Dinesh, Non Matric

Sinha Preeti

Quality Management

Bharadwaj, R. S., M.Sc. Associateship in Information Science, M.Phil (Science Communication & Journalism) **(Head)**

S&T and Supporting Staff

Kannan S., M.Sc.

Kumar Sunil, B.A.

Computer and Networking

Mukhopadhyay D. (Dr.), Ph.D (Applied Maths) **(Head)**

Scientists/Technical Officers

Dutta R. N., M.Sc. (Operational Research)

Mariappan S., Diploma in Computer Technology

Raghav T. D., B.Sc., PGDCA (retired on June 30, 2009)

Rajasekhar B., B.E. (Electronics & Communication)

Rani Reeta, Dip.in Computer, MBA, M.Sc. IT

S&T and Supporting Staff

Kumar Anil, Intermediate and Computer Course in FC Hardware and Computer Operation

Kaushal Vijay Kumar (Joined on Sep. 14, 2009)

Manpreet, B.Tech. (on study leave)

Shiv Lal, Non Matric

Instrumentation (INS)

Prasanna Kumar P., M.Sc. (Physics) **(Head)**

Scientists/Technical Officers

Chadda Renu, M.Sc. (Botany)

Janggangi Lalita, B.Sc. (Engg.)

Kapoor K. J. S., B.Com, ITI

Meshram P.C., M.Tech. (Digital Communication Engg.)

Saini R. P., B.Sc., Diploma (Electronic Engg.)

Satish Kumar, Diploma (Electronics & Communication)

Sharma D. C, B.E. (Elect), M.Tech (Computers)

Sharma V. P., Matric, ITI, Diploma in Electrical Trade

Singh Gurmeet, Matric, ITI and Radio and TV Trade (Retired on April 30, 2009)

Tiwari Y. C., M.Sc. (Physics)

Usha Kiran, M. Tech. (Transferred)

S&T and Supporting Staff

Shukla Jai Prakash, Matric

Paswan Bhawesh

Singh Lokeshwar, M.Sc. (Electronics)

(on study leave)

Mechanical Engineering Support

Bharadwaj, R. S., M.Sc, Associateship in Information Science, M.Phil (Science Communication & Journalism) **(Head)**

Scientists/Technical Officers

Arora Ashok Kumar, M.A., Dip in Auto Engg.

Harish Kumar, ITI

Sharma N. K, Diploma in Mechanical Engg.

Sharma Ashok Kumar, Inter, ITI (Motor Mech.)

Singh Bir, ITI

Singh Gurdeep, Non Matric

Singh Bhim, Non Metric

Singh Satnam

Mohd. Irshad, Dip in Draftsmanship (Mech.)

S&T and Supporting Staff

Gola Kewal Krishan

Kishan Swroop, ITI (Electrical/Wireman Course)

Kumar Om, B.A., ITI

Meena Babu Lal, Non Matric

Om Prakash, ITI (Fitting)

Panicker K. R. C. Matric

Ram Pal, Non Matric

Sachdeva H. L, ME (Mech. Engineering)

Singh Lakhbinder, H.Sc, ITI (Motor Mech.)

Singh Mohan, Higher Secondary

Staff of the
Central Road Research Institute
As on 31st March, 2010

Sunil Kumar,

Sunil Datt, Non Matric

Verma D. P. Non Matric (Retired on Sep. 30, 2009)

Documentation & Library Services (DLS)

Ashok Kumar, (Dr.) MSc, M.L.I.Sc. Ph.D., **(Area Advisor & Head)**

Scientists/Technical Officers

Aggarwal Neera, MA, BLISc, Associateship in Information Science

Chhabra Pavan, M.Sc. (Physics), M.L.I.Sc

Ravinder Kumar, M.A. (Pub.Adm) Dip. in Offset Print. Tech.

S&T and Supporting Staff

Des Raj, Non Metric (Retired on Oct. 31 2009)

Ishwar Singh, Matric (Retired on June 30 2009)

Rangarajan R, Dip.in Mech. Engg.

Sharma Dev Dutt, Matric

Sharma Rashmi, M.A. (Hindi) B.Ed. Dip. in Russian Language (Retired on July 31, 2009)

Rajbhasha Unit

Anang Pal Singh (Dr.), M.A. Hindi, B.Ed., Ph.D dip. in Translation **(In-charge)**

Choudhary Sanjay, M.A., B.Ed. Adv. Dip. in Computer

Dinesh Kumar, Non Matric

Khuttan Santosh, B.A.

Lohani G.C. B.A., L.L.B.

Estate Services (ESS)

Bose Sunil, (Dr.) M.Tech (Highways), Ph.D. **(Area Coordinator)**

Civil Section

Jai Bhagwan , M.Sc. Physics **(Head)**

Scientists & Technical Officers

Dass Shankh, Diploma (Civil Eng) (on Deputation)

Grover Sunil, B.E. (Civil) (On Study Leave)

Krishna Kant, Dploma (Civil Eng)

Mukesh Kumar, M.Tech. (Construction Engg. & Management)

Tyagi V. K., Dip in Civil Engg

S&T and Supporting Staff

Dass, R. C., Non Matric

Gautam Pandey, Non Matric

Harish Kumar, B.A.

Kailash Kumar, Matric

Manjhi Raja Lal, Non Matric

Mehto Raj Kishore, Non Matric

Singh Bhanwar, Non Matric

Varsh Vaibhav (Joined on Sep. 25, 2009)

Vinit Kumar (Joined on Sep. 30, 2009)

Vinod Kumar, Non Matric

Horticulture

Scientists & Technical Officers

Ashok Kumar, M. Sc. (Hort.) **(In-charge)**

S&T and Supporting Staff

Raj Pal Singh Gautam

Tek Chand

Electrical Section

Sharma D. C, B.E. (Elect), M.Tech (Computers) **(Head)**

Scientists & Technical Officers

Subodh Kumar, MS, MBA

Suresh Chandra, B.E (Electrical Engg.)

S&T and Supporting Staff

Mitthan Lal, Non Matric

Sant Ram, B.A.

Satpal Rana, ITI

Maharani Bagh Staff Quarters (MBSQ)

Sharma, B. M. M.E. (Transportation Engg.) **(Area Advisor)**

Tripathi A. K., Dip.in Civil Engg **(Head)**

Scientists & Technical Officers

Singh D. V., M.Sc

S&T and Supporting Staff

Staff of the

Central Road Research Institute

As on 31st March, 2010

Bhatt Pankaj (Joined on Sep. 17, 2009)
Hari Om, Non Matric (Retired on Jan. 31, 2010)
Jille Ram, Non Matric (Retired on Oct. 31, 2009)
Meena Moni Raj, B. Tech (Electrical)
Mohan Lal, Non Matric.
Prem Chand, Non Matric
Singh Babban, B.A
Shababuddin Khan, Non Matric
Sheonandan Prasad, Matric
Tara Chand, Dip.in Civil Engg.
Vikram Singh, Non Metric

Directorate

Gauba A. K, Intermediate
Jetly Pushpa, B.A.
Singh Kartar, Matric
Singh Narain, Non Matric (Retired on Feb. 28, 2010)
Singh Madhu Sudan, Non Matric
Saini Sunita, HSc

Administration

Jitender Parasar (Controller of Administration)
Verma Simesh (Administrative Officer)
Bhoga Balmiki, Non Matric
Kumar Vijay, HSc
Mehto Yoginder, Non Matric
Rakesh Kumar, Intermediate
Ravi Kumar, Non Metric
Sachdeva Priti, B.A. (Hons) & Diploma in Secretarial Practices, **(Receptionist)**
Singh Karam, Matric
Singh Kiran Pal
Thakur Suresh Prasad, Matric

Establishment-I

Budh Singh, Inter
Chopra Rajeev, Sr. Sec.
Devi Sumitra, Non Matric
Joon R. C., M.A. (English) (Section Officer)
Kaur Satinder, B.A.
Kumar Anil, B.Com, Diploma in Management (on Deputation)
Mehto Sri Ram, Matric
Nita Kumari, B.A.
Paswan Krishna, Matric
Saini A. K., B.A.
Singh Rajender, M.A. (Section Officer) (Retired on Nov. 30, 2009)
Verma Kamlesh, M.A., Certificate in Library Science

Establishment-II

Kumar Anil, B.A.
Desraj
Kant Chander
Madhu Bala, B.Com
Malhotra R. K., HSc
Sharma Ramesh Chand, H.Sc.
Singh Gajai, Non Matric
Singh Narender, M.A.
Talwar Baldev
Verghese Kunjumol, Senior Secondary

Personnel Cell

Singh Vandana D., (Section Officer)
Bhatia Parveen, B.A., Certificate in Lib. Science
Dharam Pal, Non Matric
Meena Murari Lal, B.A.
Rajan Tirkey,B.A.(Hons.)
Rawat Sanjay, B.A., PGDIRPM

Vigilance Cell

Chauhan Purushotam Lal, B.A.
Dhamija Aruna, B.A
Kurian Sam,SSLC
Singh Hoshiar, Matric.

Cash

Bhambota V.K., Matric

Kishan Ram, Non-Matric

Thapa Take Chand, B.A.

Finance & Account Section

Bidalia Rakesh, F&AO (Transferred w.e.f. June 15, 2009)

Indora Jai Prakash, F & AO (Joined on July 1, 2009)

Gurmeet Kaur, Section Officer, F&A

Jain M.K.,Controller of Finance & Accounts

Malik Neelam, Matric

Pawan Sameer Lakra, B.A., LLB (Resigned Nov. 9 2009)

Phool Chandra, M.A.

Sharma Bishan Dass, B.A.

Singh Ajit Kumar, B. A.

Singh Balbir,

Singh Dheeraj, Section Officer, F&A

Singh Jagdish, Matric

Singh Maharaj, B.A.

Shiv Narain, Non Matric

Purchase Section

Dussy, Virender Kumar (Joined on Nov. 3, 2009)

Kumar Vijender, Matric

Marwaha Vijay Kumar, B.Com

Singh Jai

Shah Ram Badan, Matric

Singh Randhir, Non Matric

Singh S.P., Controller of Store and Purchase (Retired on Jan. 31, 2009)

Verma Veena, M.A.

Laliteshwar, Steno

Store Section

Bairagi K.

Chhachhia Sumer Singh

Kukreti, C.M., HSc

Kumar Bijender

Paswan Gore Lal, Matric

Singh Jaswant

Verma,S.G., SO, Store and Purchase (Acting Co (S & P) w.e.f. Jan.28, 2010)

Security, Guest House and Canteen

Security

Mani Chinta, Matric

Prakash Om, Non Matric

Singh Dharam, **(Care Taker)**

Singh Ram, Non Matric

Guest House

Acharya Keshav Ram

Balmiki Ramsai (Joined on Nov. 3, 2009)

Bariya Rajesh

Lal Sohan, Non Matric

Narayan Chet

Prakash Braham, Non Matric

Siddiqui Fasih Ahmed (Manager)

Singh Rajbir

Singh Rajpat

Suraj

Canteen

Chand Hari

Hem Kumar

Kumari Kamlesh

Kumar Manoj

Rao Ramesh

Singh Balbir

Singh Rajinder

Thapa Prem Bahadur, Non Matric

Dr. P.L. Bongirwar
Ex. Jt. Project Director (MMRDA)
B/1102, Pataliputra CHS
Four Bungalow Signal
Andheri (W)
Mumbai – 400 053
M: 09867288464
Email: plbongirwar@rediffmail.com

Chairman

Sh. G. Sharan
Director General (Road Development)
Ministry of Shipping, Road Transport & Highways
Transport Bhawan, Sansad Marg
New Delhi – 110 001
Ph: 23718575; Fax: 23715047
Email: dgrd@nic.in

Member (Agency Representative)

Shri R. Subramanian
Engineer in Chief
Delhi PWD
MSO Building , I.P. Estate
New Delhi – 110 002

Member (External Member)

Shri N.K. Shangari
Scientist G
Central Building Research Institute
Roorkee – 247 667

Member (DG's Nominee)

Dr. H.C. Mehndiratta
Former Professor (IIT Roorkee)
50/8A, Bhagirathi Enclave
Balbir Road
Dehradun – 248 001
Ph: 0135-2671035

Member (External Member)

Dr. N. Lakshmanan
Director
Structural Engineering Research Centre
CSIR Campus, Post Office TTTI
Taramani,
PB No. 8287
Chennai – 600 113
Ph: 044-22542139; Fax: 22541508
Email: director@sercm.csir.res.in ; director@sercm.org

Member (Sister Lab)

Shri C. Kandasamy
Member (Technical)
National Highways Authority of India
Plot 5&6, Sector 10, Dwarka
New Delhi – 110 075

Member (External Member)

Lt. Gen. K.S Rao,
Director General
Border Roads
Seema Sadak Bhavan,
Ring Road, Delhi Cantt.
Delhi 110 010
Ph: 25886858; Fax: 25686857
Email: hrmonitoringcell@gmail.com

Member (External Member)

Dr. S. Gangopadhyay
Director
Central Road Research Institute
P.O. CRRI, Mathura Road
New Delhi – 110 025

Member (Director, Lab)

Dr. K.S. Reddy
Professor
Department of Civil Engineering
Indian Institute of Technology
Kharagpur – 721 302

Member (External Member)

Dr. Naresh Kumar
Head, R&D Planning Division
Council of Scientific & Industrial Research
Rafi Marg, New Delhi – 110 001
Ph: 23710453 Fax: 23710540
Email: headrdpd@csir.res.in

Management Council of CRRI,

Dr. S. Gangopadhyay **Director** CRRI New Delhi	Chairman
Sh. S. K. Bhattacharyya Director CBRI, Roorkee	Member
Dr. Kishor Kumar Scientist 'F' CRRI New Delhi	Member
Dr. Purnima Parida Scientist 'E-II' CRRI New Delhi	Member
Sh. Binod Kumar Scientist 'E-I' CRRI New Delhi	Member
Sh. Subhash Chand Scientist 'E-I' CRRI New Delhi	Member
Sh. Naresh Kumar Sharma Group III (6) CRRI New Delhi	Member
Head, RPBD & PME	Member
Sr. CoFA/CoFA/F&AO	Member
Sr. COA/COA/AO	Member Secretary

In-house Projects taken up during the year 2009-10		
S.No.	Title of Projects	Project Leaders
1	Study of Thermal Effects for the Design of Rigid Pavements Through Instrumentation of Concrete Pavements at CRRI, New Delhi	Mrs. Lakshmy P.
2	Seismic Response Study of Earth Embankment	Dr.Soraj Prakash
3	Evaluation of Elastic Properties of Concrete using Vibration Analysis	Dr. R.K. Garg
4	Development of a correlation between corrosion rate of steel in concrete measured by Galvapulse (NDT) Equipment and Gravimetric Method	Dr. VVLK Rao
5	Development of Critical Infrastructure Information System in GIS Environment for Maintenance of Bridges on NH and State Highways	Sh.Rajeev Goel
6	Behavior of Shear Deficient RC Beams Strengthened by Externally Embedded Reinforcement	Sh. S.K. Sharma
7	Upgradation of R&D and Testing Facilities in the Area of Bridge & Structural Engineering	Dr. Lakshmy P Dr. R.K.Garg
8	Distress Diagnostic, Performance Evaluation and Bridge Management System for Concrete Bridges: Phase II- Development of one Prototype of the Visual Inspection Unit	Dr. R.K. Garg
9	Detailed Performance Evaluation of Micro-Surfacing on Various Delhi Roads	Dr.Sangita
10	Development and Application of Polymer Modified Binder with Improved Compatibility	Ms. Ambika Bhel
11	Development of an advance technology to produce and lay down the asphalt mixtures at lower temperatures and to lower down the plant emissions occurring during hot mix asphalt process	Ms. Ambika Bhel
12	Performance Evaluation of Test Section laid with Stone Matrix Asphalt (SMA) Surfacing under NOMC Area	Sh.C.Kamraj
13	Development of a Suitable Methodology in Terms of Repair Treatment of Defence Runway in Emergency	Dr. N.K.S.Pundhir
14	Upgradation of R&D and Testing Facilities in the Area of Pavement Engineering	Dr. Sunil Bose Ms. Ambika Behl
15	Development of Methodology for Commissioning and Site Acceptance Test (SAT) of Heavy Vehicle Simulator (HVS) Type of APTF	Sh. M.N.Nagabhushana
16	Studies on Landslide Correction Techniques in India (Revised)	Sh. Deepak Mukherjee
17	Guidelines for Prevention of Landslides in Hill Road Construction	Dr. Pankaj Gupta
18	Economic Evaluation of Geosynthetic Reinforced Wall with Different Backfill	Sh. P.S.Prasad
19	Typical Problems for Drainage System on Delhi Roads and Remedial Measures	Farhat Azad
20	Upgradation of R&D and Testing Facilities in the Area of Geo-Technical Engineering	Sh. Sudhir Mathur/ Dr. Vasant Havangi
21	Improvement of Engineering of Construction and Demolition (C&D) Waste for Road Construction	Sh. J.Ganesh

On Going Projects

S.No.	Title of Projects	Project Leaders
22	Preparation of Guidelines for Stabilisation of Hill Rocks Slopes	Sh. R.K.Panigrahi
23	Development of non Destructive Equipment for Determination of Dry Density of Compacted Soils	Dr. Vasant Havanagi
24	Dissemination of Information, Research Liaison & Training	Sh. T.K.Amla
25	Development of Nuclear Gauge for Measurement of Bitumen Content of Bituminous Mixtures (A Collaborative in-House Project Proposal with ECIL, Hyderabad)	Sh. PPrasanna Kumar
26	Upgradation of Road Geometrics and Road Condition Evaluation System	Sh. Y.C. Tiwari
27	Study on Skid Resistance of Different Types of Surfacing at Different Test Speeds under Different Traffic and Environmental Conditions	Sh. Sudesh Kumar
28	Rationalisation of Overlay Design of Flexible Pavements using Benkelman Beam and Falling weight Deflectometer	Sh. R. K. Srivastava
29	Design, Construction and Performance Evaluation of New Materials and Mixes Towards Development and Upgradation of Standards/Specification	Sh. Sanjay Deori
30	Development of National Document Guidelines on use of Weigh-In-Motion System in India for Axle load Monitoring	Sh. Pradeep Kumar
31	Development and Design of Thin Stone Matrix Asphalt (TSMA) mixtures as Preventive Maintenance Treatments for Flexible and Feasibility of its Application on Rigid Pavements	Dr. P. K. Jain
32	Modern Practices in Bituminous Road Construction	Dr.P.K.Jain
33	R&D Management	Dr. Rekha Sharma
34	Development of Research Compendium	Sh. Alied Saxena
35	Evaluation of Operation Efficiency of Highway Network using Travel Time Reliability Measures	Dr. Ravi Shekhar
36	Application of Geographical Information System (GIS) in Traffic Congestion Management	Sh. A.Mohan Rao
37	Accessibility and Mobility Impact on Neighborhoods Due to Expressways/High Speed Corridor	Dr. Mukti Advani
38	Modeling of Driving Cycle for Road Network Development Plan in Urban and Suburban Area Applying GPS – A Case Study on NCR	Dr. Ravinder Kumar
39	Development of Cold Mixed Patching Materials for Instant Repair of Potholes	Dr. N.K.S.Pundhir
40	Impact of Vibration and Noise on Driver Fatigue and Psychomotor Abilities	Dr. Neelima Chakravorty
41	Upgradation of R&D and Testing Facilities in the Area of Traffic Engineering & Safety	Dr. Surender Mohan Dr. Neelima Chakrabarty
42	Assessment of Drivers Driving Characteristics using Advanced Driving Simulator	Dr. Neelima Chakraverty
43	Development of Database and Standard for Evaluation of Photometric Properties of Traffic Control Devices	Dr.Surender Mohan

S. No.	Title of Projects	Project Leaders
44	Adequacy of Signal Timing for Pedestrians	Dr. Nishi Mittal
45	Creation of R&D Resource Base Facilities Available at CRRI	Sh. Naresh Kumar Sharma
46	Micro Environmental Exposure to Carbon Monoxide from Motor Vehicle Exhaust	Ms. Anuradha Shukla
47	Environment Risk Assessment and Safety Consideration in Transportation of Hazardous Materials by Road	Dr. Niraj Sharma
48	Modification of Bitumen & its Emission Characteristics	Dr. Sippy Kalra Chauhan
49	Validation of the Relationship Between Time Mean Speed and Space Mean Speed	Mrs. S. Padma
50	Study of Mass & Number Concentration Profile of Particular Matter at Selected Corridors in Delhi.	Ms. Anuradha Shukla
51	Assessment of Tropospheric Ozone in Relation to its Precursors / Meteorological Parameters.	Ms. Anuradha Shukla
52	Road Noise Modelling for Delhi	Sh. Nasim Akhtar
53	Assessment of Human (Driver) Responses to Vibration	Sh. Nasim Akhtar
54	Study of Benzene and VOCs (Volatile Organic Compound) in Delhi	Ms. Rina Singh
55	Entry Headway Characteristics at Signalized Intersection	Mrs. S. Padma
56	Carbon Footprint of Passenger Transportation : Metro Vis-a-Viz Road	Dr. Kirti Bhandari
57	Upgradation of R&D and Testing Facilities in the Area of Transportation & Environmental Engineering	Dr. Anuradha Shukla/ Sh. Nasim Akhtar
58	Variability in Vehicle Fuel Consumption under Controlled Conditions	Sh. P.V. Pradeep Kumar
59	To Investigate the Effect of Road Traffic on Indoor Air Quality within Metro Stations	Dr.Kirti Bhandari
60	A Study on Dry Lean Concrete Containing Portland Pozzolana Cement	Dr. Rakesh Kumar
61	Effect of Bottom Ash/Pond Ash as Replacement of Fine Aggregate in Concrete	Sh. J.B.Sen Gupta

Completed Projects

In-house Projects Completed during 2009-10		
S.No.	Title	Project Leaders
1	Seismic Resistant Design of Bridges: Performance of Concrete Bridges under Seismic Forces	Dr. R.K. Garg
2	Scope of the Use of Marble Slurry Dust (MSD) in High Performance Concrete Formulations	Dr Renu Mathur
3	Study of Strength of Concrete vis-a-vis Grades of Cement in Market	Dr Renu Mathur
4	Influence of Driver Characteristics on Fuel Consumption of Vehicles	Sh. P.V. Pradeep Kumar
5	Simplification of Design Live Loads on Highway Bridges	Sh. J.K. Goyal
6	Stabilisation of Black Cotton Soil with Pond Ash and Cement	Sh. Alok Ranjan
7	Laboratory Study to Determine the Suitability of Fly Ash and Marble Dust as Mineral Filler in Micro Surfacing Mix	Sh. Satish Pandey
8	Understanding Road Rage and Potential Mitigation Measures	Dr. Neelima Chakravorty
9	Feasibility Study for Conducting Surveys for Installation of WIM (Weight-in-Motion) at 13 Locations of Entry Points in Delhi	Dr. Niraj Sharma
10	Detailed Analysis of Slopes through Finite Element Method	Dr. Sukumar Saha

MEMBERS OF ADMINISTRATION

Personnel and Vigilance Section

Director Office

Administration

Security

Establishment - I

Establishment - II

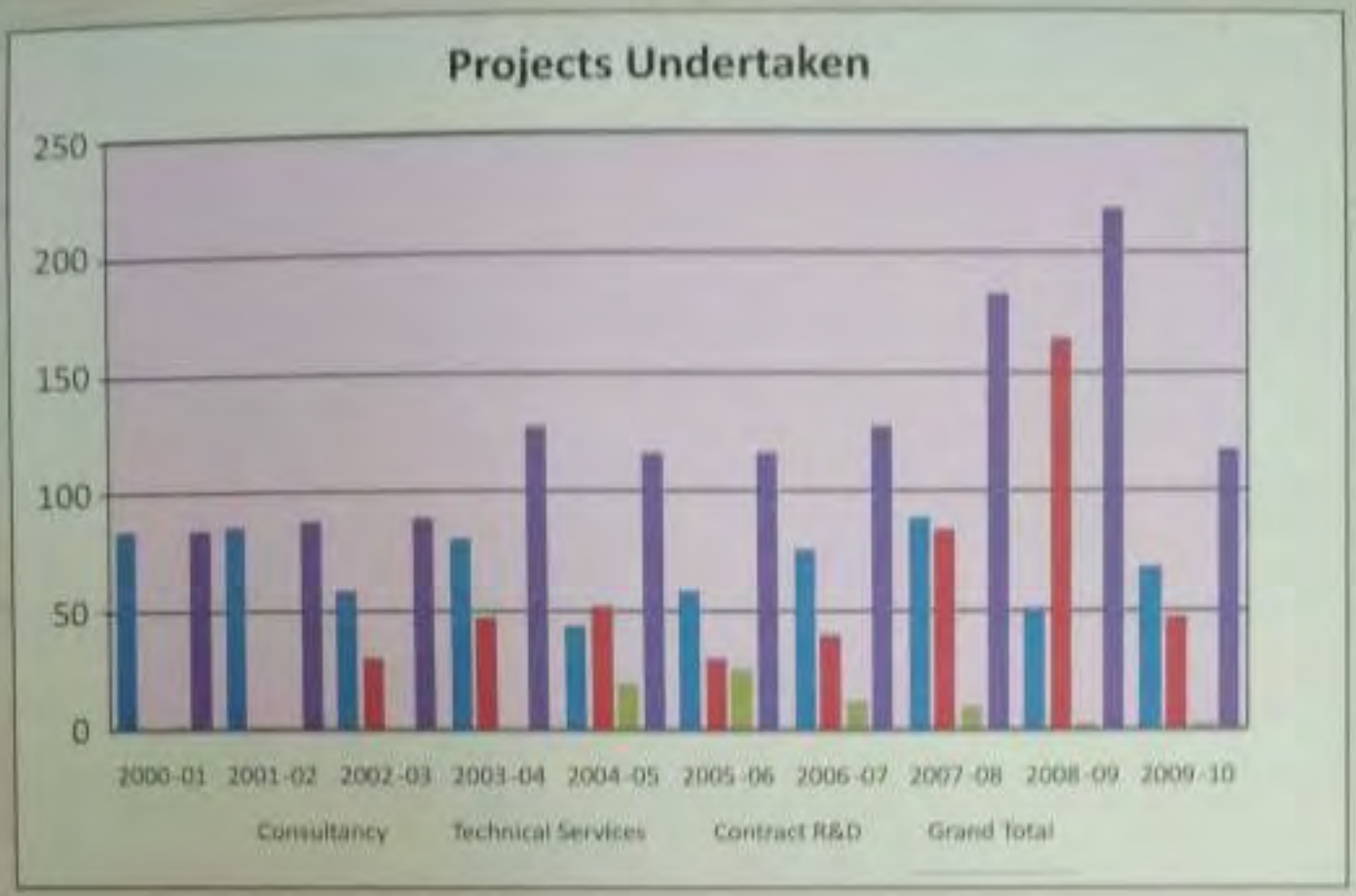
MEMBERS OF FINANCE &ACCOUNTS SECTION

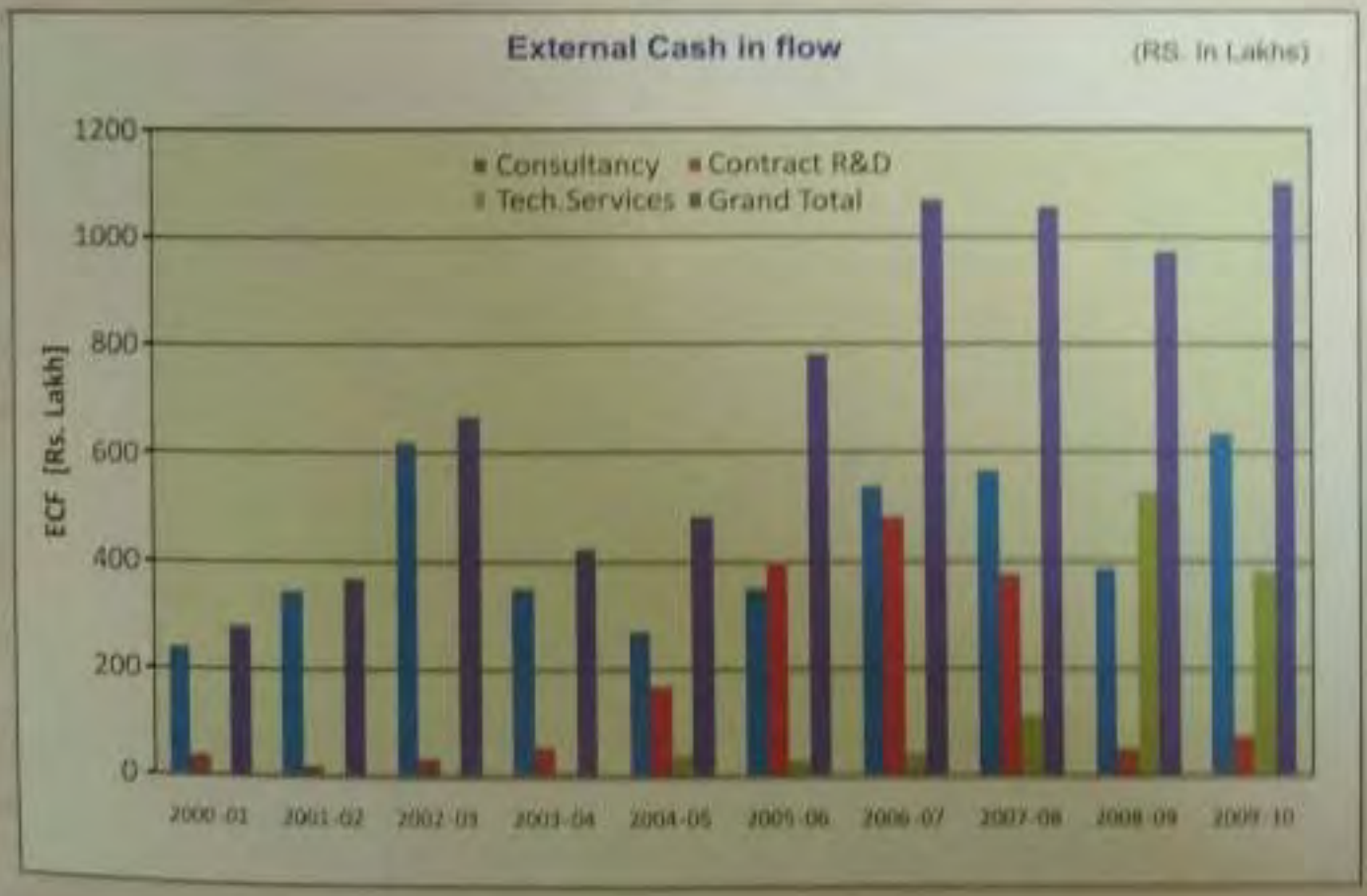
MEMBERS OF PURCHASE & STORE SECTION

MEMBERS OF CIVIL AND ELECTRICAL TEAM

MEMBERS OF GUEST HOUSE AND CANTEEN TEAM

MEMBERS OF HORTICULTURE


Projects Undertaken
250
200
150
100
50
0
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
Consultancy
Technical Services
Contract R&D
Grand Total


External Cash in flow
(RS. In Lakhs)
ECF [Rs. Lakh]
1200
1000
800
600
400
200
0
Consultancy
Contract R&D
Tech.Services
Grand Total
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10

केन्द्रीय सड़क अनुसंधान संस्थान
CENTRAL ROAD RESEARCH INSTITUTE
(An ISO Institution)
New Delhi -110 025
Website: www.crridom.gov.in