Annual Report
2010-11

CSIR-Central Road Research Institute
New Delhi (India)
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It is my privilege to present the Annual Report of this Institute for the period from April 2010 to March 2011. The Institute publishes its Annual Report to provide a brief description of our year-long research activities to colleagues and scientific communities. Apart from scientific contributions the report includes information about infrastructure, intellectual property and other various aspects of scientific management and administration.

Major thrust on R&D was focused in the area of traffic and transportation planning; road safety and environment; road development planning and management; Geo-technical aspects related to road (landslide, slope stability, ground improvements etc.); construction technique and evaluation of material and mixes for Rigid and Flexible pavements; Bridge design; Evaluation and Rehabilitation and software development.

Several projects of great importance undertaken/completed by the Institute include: (i) Soil nailing techniques for facilitating construction of underpass by box pushing technique at western approach of old Yamuna Bridge; (ii) Study on suitability of synthetic fibre reinforced concrete for construction of concrete pavement in Indian conditions; (iii) Design, construction and performance evaluation of new material and mixes towards development and up-gradation of standard/specifications; (iv) Study of corrosion susceptibility of steel reinforcement protected with anti-corrosive coating/special treatment in ordinary and high performance concrete; (v) Comprehensive mobility plan for Ghaziabad city: Traffic Management Plan; (vi) Comprehensive Traffic and Transportation Study of Goa; (vii) Study of non-methane hydrocarbons in the atmospheric environment of Delhi region; (viii) Noise and vibration study along metro railway corridor at Tapan Sinha memorial hospital, Chanditala, Kolkata; (ix) Evaluation of operational efficiency of highway network using travel time reliability measures; (x) Accessibility and mobility impact on neighbourhood due to express way/highway corridor and (xi) Evaluation study on use of on-site visualization method for monitoring of safety management at construction site.

The National Highways Authority of India sponsored a major study on Road Safety Audit for Public Private Partnership on DBFO basis. Under this study the Institute was awarded twelve packages: Around 1191 km of roads in four state of India are to be audited at both development phase and construction phase.

A number of studies have been carried out for North-Eastern region. Interaction was made with North Eastern Council, Shillong; PWD, Mizoram and PWD, Assam to communicate the activities of CRRI and also understand their technological requirements.
The Institute continued with its year round activities pertaining to imparting training, conducting refresher course and knowledge dissemination etc. in the various technical areas of the Institute. Besides, sixteen special/customized training programmes on planning, design, construction and maintenance of flexible & rigid pavements on rural roads; project preparation, SBD, quality assurance and maintenance of rural roads; HDM-4 were organized for NRRDA, RCD, Patna and TANROADS, Tanzania respectively. Also, International training programme on Highway Development and Management were also organized which was attended by the participants from India, Uganda, Bangladesh, Afghanistan etc.

CSIR-CRRI contributed to human resource development in various areas by providing facilities to students for project work and training. During the year, several students from reputed academic institutions carried out their project work for B.Tech/M.Tech/M.Sc. programmes. Some of the students worked for their Ph.D/post-graduate programme.

During the period, the Institute participated in seven exhibitions in Delhi and other states. In all these exhibitions, the achievements and ongoing R&D activities of the Institute's were presented with poster and charts.

A steady number of quality publications in journals of high impact factors are the hallmark of the Institute's progress in research publication.

A large number of distinguished scientists both from India and abroad visited our Institute, delivered lectures and held discussions with different R&D groups of the Institute.

A new Research Council of CSIR-CRRI headed by Prof. D. V. Singh, Former Director was constituted for their valuable guidance.

I acknowledge the contributions made by everyone of our staff in the success achieved by the Institute during the year and look forward to their greater involvement and efforts in our collective endeavor to become a globally competitive in the road and road transport sector.

Dr. S. Gangopadhyay
Director
Objectives

The scientific & technical objectives of CARI 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 runways 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.
सीएसआईआर - केंद्रीय सड़क अनुसंधान संस्थान, नई दिल्ली

गुणवत्ता नीति

सीएसआईआर - केंद्रीय सड़क अनुसंधान संस्थान (सी एस आईआर - सी आर आर आई) सड़क व सड़क परिवहन के क्षेत्र में व्यवसायिक उत्कृष्टता का विकास करने तथा व्यवसाय के समस्त उपरोक्त विभाग तकनीकी समस्याओं का उपयुक्त समाधान प्रस्तुत करने के लिए, अनुसंधान एवं विकास कार्यक्रमों, परामर्श सेवाओं एवं मानव संसाधन विकास कार्यक्रमों को संपन्न करने हेतु कठिनाई है।

Quality Policy

The CSIR-Central Road Research Institute (CSIR-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.
Instrumentation and Monitoring of Kaliasaur Landslide on National Highway-58

As reported earlier (Annual Report 2009-10), under network project “Engineering of Structures against Natural and Other Disasters”, with SERC, two landslides namely, Patalganga and Kaliasaur had been selected for investigation and monitoring.

The work done on Kaliasaur Landslide during the last five years has been analyzed and a final report along with suggestions for long-term remedial measures for the stability of Kaliasaur landslide was submitted to Department of Science & Technology in 2010. One of the most important elements of the study was monitoring of the slope through DGPS (Differential Global Positioning System) and specially designed steel pedestals.

Monitoring results of the slope and other investigations have revealed that the landslide was still in active form. The reactivation of this slide in the months of Sept-Oct 2010 has confirmed the revelation of the prediction made on the basis of the monitoring results and other investigations. Highly fractured rocks at the crown part of the landslide have been indicated the least safety factor and maximum movement magnitude during the analysis. During recent reactivation of slide this part (crown portion) in the month of October 2010 has been the source of failure (Fig. 1a&b). Significant increase in the extension of landslide boundary (Fig. 2) i.e., 20 meters was observed within a period of 45 days. A stretch of about 93 m of National Highway-58 was blocked for almost all these 45 days. Indirect losses on account of detouring due to reactivation of this slide have been calculated using unit cost estimation method. This method is applicable whenever a unit variable is known (i.e. no. of days an area is affected) and the associated unit cost (i.e. loss per day) can be determined.
A general equation for the approach is as follows:

\[
\text{Detour cost} = (\text{Extra operating cost} + \text{Extra fuel used} \times \text{fuel price}) \times \text{number of travellers affected.}
\]

Closure of the NH-58 due to reactivation of landslide forced traveller to detour through bypass (Khedakhal-Kandai). The detour distance (Fig. 3) is approximately 28 km which is three times the distance on highway (approx. 9 km, i.e. A to B). To calculate the cost of these detours, traffic pattern, extra charges on fares as well as on vehicles fuel, along the highway were examined and used the unit cost estimation method. The total detouring cost calculated for 45 days during September-October, 2010 was Rs. 2,45,43,180 (approx). Though this figure only indicates the detouring cost excluding the cost on man hour lost, expenditure on repeated restoration and sliding for four months by BRO (this includes two dozers deputed with a dozens of labourers for four months and still continuing), table of life lost, cost of property (including a few damaged vehicles) etc. The total loss due to this landslide is being estimated.
The reactivation of Kaliasaur landslide comes as a constraint for our slope monitoring agenda. Out of 75 pedestals installed in landslide for the purpose of monitoring, only a few have been able to sustain their positions. The rest of the pedestals have got buried under the debris or carried away by it.

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

This project was also undertaken in the network project, however, some support was also provided by National Disaster Management Authority (NDMA) in assigning a study to prepare guidelines for construction of roads in cyclone prone areas and also provided administrative support to collect the relevant information from different bodies dealing with the study of such nature. Draft of the “Guidelines for Road Construction in Cyclone Prone Areas” has been prepared and submitted to NDMA.

In the Guidelines, Chapter 1&2 deals with Introduction and Destructors caused by Cyclones. A tropical cyclone is a storm system characterised by a large low pressure centre and numerous thunderstorms that produce strong winds and flooding rain. Tropical cyclones feed on heat released when moist air rises, resulting in condensation of water vapour contained in the moist air. Cyclones affect both Bay of Bengal and the Arabian Sea. The states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu and Gujarat are more vulnerable to its attack. There are three elements associated with a cyclone, which cause destruction — storm surge, strong winds/squall, inland flooding. Cyclonic storms affect human habitations and infrastructure in a multiple way. Providing road connectivity in cyclone prone areas emerges as a vital tool for undertaking rescue and rehabilitation operations. Principle mode of destruction of road embankments and pavements due to cyclonic storms would be through erosion caused due to storm surge and flooding.

Chapter 3 deals with Planning of Road Network in Cyclone Prone Areas. Effective road connectivity ensures fast deployment of men, materials and machinery to cyclone affected areas and also ensures speedy evacuation of people from vulnerable places to safer areas in the face of an impending disaster threat. Hence the need for development of a reliable road network in the vulnerable areas is very vital to ensure coordination of relief and response in the event of a cyclone. It is essential to provide road connectivity to rural habitations in cyclone prone areas, especially cyclone shelters. The aspects dealing with the subject are discussed in the Chapter.

Chapter 4 deals with Construction of Road Embankments. In this chapter, engineering requirements of compaction, material characteristics of fill to be used, broad details of construction methodology, side slope protection measures to be adopted to mitigate soil erosion, ground improvement measures to be adopted, etc have been described. Roads in cyclone prone areas are often constructed very near to sea coast and river banks. Erosion of coastline and river banks often leads to road damage.

Chapter 5 deals with ‘Sea Erosion Control Techniques & River Bank Protection’. In this Chapter, use of various geosynthetic products like geotextile tubes, geotextile bags, geotextile filters, gabions, geotextile containers, mangrove cultivation, armour system, etc has been explained.
Chapter 6 deals with points to be considered for selection of pavement types for roads to be constructed in Cyclone prone areas.

Chapter 7 deals with mitigation measures for bridge & structures to effectively withstand impact of cyclone.

Chapter 8 deals with traffic management measures to be taken while conduction evacuation exercises before the onslaught of cyclone.

**Experimental Test Track Construction with Cement Stabilisation**

As reported earlier (Annual Report 2009-10), an experimental test track section of around 60 m length (2 lanes) of road was constructed at left side of road, towards Wagha border near Amritsar along the Amritsar-Wagha border 4 lane road on National Highway. In the experimental test track construction, two sections were made, one with pavement layers as per conventional method of flexible pavement and second with cement stabilised sub grade and granular sub base layers with 2.5 per cent cement. Pavement cross-sectional thickness is given in Table 1. Performance study of this experimental road is in progress by using Bankelman Beam and Dipstic equipments before and after monsoon season. Figures 4 and 5 show the plate load test and measurement of roughness by Dipstic.

![Plate load test in progress](image)

![Measurement of roughness by Dipstic](image)

**Table 1: Pavement Thicknesses provided for Conventional and Experimental Stabilised Section**

<table>
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<tr>
<th>Pavement Layers</th>
<th>Conventional Design Section (mm)</th>
<th>Experimental Design Section, Stabilised (mm)</th>
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</thead>
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<tr>
<td>BC</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>DBM</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>WMM</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>GSB</td>
<td>250</td>
<td>300 (GSB</td>
</tr>
<tr>
<td>Sub grade</td>
<td>500</td>
<td>200 (Stabilised with 2.5 % cement)</td>
</tr>
<tr>
<td></td>
<td>(CBR = 7 %)</td>
<td>300 (Conventional soil CBR = 7 %)</td>
</tr>
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</table>
Pilot Project on Use of Jute Geotextiles in PMGSY Roads

As reported earlier under the pilot project on Use of Jute Geotextiles in PMGSY roads sponsored by Jute Manufactures Development Council (JMDC), construction of five PMGSY roads using different types of jute geotextiles has been completed in four states. Each of these PMGSY roads, comprise of several sub-sections in which jute geotextiles (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. During the period under review, second cycle of performance monitoring of these roads was completed. 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. B). Report preparation based on the performance monitoring is under progress.

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

Presently due to paucity of funds and non-availability of good construction materials, great emphasis is being laid to utilise locally, waste and marginal materials. Often these materials need to be stabilised to achieve the desired gradation and strength. There are several IRC guidelines dealing with the subject of soil stabilisation. It was found that most of them are quite old and outdated in context of present day's construction practices. The identified guidelines are:

2. IRC: 49-1973: "Recommended Practice for the Pulverisation of Black Cotton Soils for Lime Stabilization"
3. IRC: 50-1973: "Recommended Design Criterion for the use of Cement Modified Soils in Road Construction"

All these guidelines were reviewed and based on the current national and international practices; these are being modified and brought into a single document with above title. These guidelines includes, general features of stabilization, guidelines for soil/granular material stabilization, specifications and test requirements for
stabilized materials, construction procedure, quality control and limitations on the use of stabilized materials. These guidelines have been published by IRC as a special publication (IRC:SP:89-2010).

**Preparation of Guidelines on Recommended Practice for Treatment of Embankment and Hill Slopes for Erosion Control**

The impact of highway location on the environment is a major concern to the highway engineer and the public. The highways, if they are not properly located, designed, constructed or maintained, would be subjected to erosion and may at times contribute sediments to the streams. The control of soil and water is basic to protect the road structure and the conservation efforts; therefore, highway design, construction and maintenance procedures must be continuously evaluated to minimise erosion and sedimentation problems. Erosion can be controlled to a considerable degree by geometric design, particularly through aspects relating to cross section. In some respects, the control is directly associated with proper provision of drainage and fitting landscape development. Thus effect of erosion should be considered in the location and design stage. Instances are not wanting where many embankment slopes made up of different types of soils have suffered a high degree of damage due to erosion from rain and wind. Denudation of vegetation from soil slopes or the lack of vegetative cover on embankment slopes is often responsible for formation of rills and rain-cuts, eventually leading to a surificial slide or to an undermining of the edges of the road pavement structure. When vegetation

is established on the slopes, there becomes available an effective dense network of root system, penetrating to a depth of about 0.5 to 0.75 m into the slope, which serves to anchor down the soil mantle and render it resistant to erosion. The Institute has taken up the task of revising the IRC Guidelines on erosion control (IRC 56) which was formulated in 1974. Presently this task has been completed and IRC Council has approved the revised guidelines prepared by CRRI. This revised guideline highlights the techniques of establishing a vegetative cover on embankment slopes by different methods such as use of organic mulch, readymade turfs of grass, application of jute or coir nettings, etc. In the recent past, considerable research has been carried out on the ‘Use of Geosynthetics’ for erosion control. There is also an emerging area of bioengineering techniques, which can be adopted for erosion control by field engineers. These aspects have been kept in view while revising these guidelines.

**Guidelines for Stabilization of Hill-Rock Slopes**

Guidelines for stabilization of hill-rock slopes, has been taken up by the Institute to prepare a manual through IRC New Delhi. The objectives of the study are:

- Evaluation of existing different methods of rock slope investigation in form of new and modified techniques.
- Rock mass rating (RMR), Slope mass rating (SMR) and Rock mass quality (Q) etc and their inter relationship to understand rock defects and rock slope instability.
Lessons learnt from implementations of remedial measures rock slopes.

- Evaluation of different types of stabilization techniques for rock slope failure.
- Monitoring the efficacy of different types of stabilization techniques for rock slope failure.
- Preparation of guidelines for stabilisation of hill rock slope failure.

The following work has been accomplished:

- Review of existing different methods of rock slope investigation in form of new and modified techniques such as RMR, SMR and Q etc and their inter relationship to understand rock defects and rock slope instability in a better way.

- Rock Mass Rating (RMR) and Slope Mass Rating (SMR) are required to be evaluated in a joint control rock blocks of different locations of hill slope of India. Rock engineering investigation as shown in Fig. 7 for unstable rock slope area described based on different method such as Rock Mass Rating (RMR), Slope Mass Rating (SMR), and Rock Mass Quality (Q) and Rock Defect study by determining the Block Volume (Vb), Measurement of the Volumetric Joint Count (Jv) etc. It helps to characterize the rock slope and indicate the causes of slope failure in specific location.

- Rock Slope stability Analysis will be carried out to evolve a set of suitable remedial measures both for short term and long term remediation of failure of rock slope. These remedial measures would comprise improving surface and sub-surface drainage, retaining structures, reinforcement techniques, rock bolts, shotcrete, rock anchors, cable anchors, steel ribs, steel fiber reinforced shotcrete (SFRC), etc. Rock slopes in hilly terrains of India failed due to several parameters. The guidelines for stabilisation for rock slopes present concrete remediation programme for unstable rock slope stretches for implementing agencies like state PWD's and Border Road Organization (BRO) where unstable rock slopes are encountered adjacent to National and State highways in hill region states India. The preparation of guidelines for stabilisation of hill rock slope failures is in progress.

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**Rock Engineering Investigation for Rock slopes**

(Non-mineral, texture, composition + Rock mass, Change length of road)

- Keyblock theory analysis
- Rockmass characterization
- Identify Key blocks
- Quantification of Removable and prone to failure
- Magnitude, Direction and failure of rock blocks
- Relationship between RMR and Q
- Integration and interpretation of different categories of techniques for Sector wise (location specific) stability of rock slope.
- Rock fall control Measures
- Rock slope failure
- Periodic maintenance/ Instrumentation and Monitoring of Unstable hill rock slope Rock slopes.

*Fig. 7: Rock engineering investigation and remediation for hill rock slope*
Guidelines on Management of Landslides on the Indian Roads and Highways

Landslides are one of the major disasters and most widespread amongst geological hazards. Most of the landslide occurrences, especially those that have caused extensive damage to life and property, are recorded along the highways and main connecting roads of hilly terrain of the country. Thousands of kilometres of our road network pass mountainous areas prone to landslides. While old network is being serviced, new road lengths are being added to meet the demands of development. The IRC State-of-Art Report on Landslide correction techniques, Guidelines for stability of Slopes and Embankments and several papers in the IRC Journals having bearing on the subject are grossly inadequate to address the problem of landslide management in all its varied dimensions. Therefore, Guidelines for integrating landslide management with development planning are needed. By anticipating the landslides before they occur and by taking recourse to sound principles of slope engineering, and appropriate technology at an correct time landslide disasters could be averted.

National Guidelines on Management of Landslides on Roads and Highways in India will be prepared with particular reference to the background of: (a) planning, preparedness and prevention, (b) cost and time effective slope engineering, landslide correction, and road safety through early warning, and (c) rapid response and speedy reconstruction and rehabilitation. The guidelines will address the landslide management issues related to the highway sector in the overall context of national vision, strategy and action plan for management of disasters.

Guidelines would familiarize highway engineers with special areas of interest such as instrumentation and monitoring of critical slopes and landslide hot spots, landslide hazard zonation mapping and risk assessment, retrofitting of slopes and road infrastructure and design of cost-effective slope protection works fashioned to suit different geotechnical situations.

The guidelines under preparation are the part of IRC (Disaster Management committee), 11th Five Year Plan, Network project on “Engineering of Structures against Natural and other Disasters” and Collaborative proposal on “Environmental Management Plan (EMP) for Katra-Oazigund sections of proposed Udhampur-Srinagar-Baramullah Railway Link in J&K” with CSIR-NEERI, (Fig. B).

Typical Problems for Drainage System on Delhi Roads and their Remedial Measures

It has been observed that many roads despite good drainage system, fail prematurely, Fig. 9 (a and b). The reason for the same was investigated and it was found that the reason for failure can be attributed to the poor drainage capacity of the pavement.
itself. It is essential that whatever amount of water which enters into the road pavement layers due to several reasons, must come out from the pavement as early as possible. The investigations revealed that the pavement during rainy season gets choked with water due to poor permeability of the pavement layers itself. Normally, in conventional method of pavement design, a drainage layer popularly known as Granular Subbase (GSB) is provided on the entire width, to remove the water from pavement structure. Sometimes such layers do not serve its intended function.

It was therefore decided to study the drainage capacity of Granular Sub-Base Layer for all the six grades of MORTH specifications. Further, the effect of permeability was analysed by changing the gradation i.e., removing the fines and then adding fines in small increments to the MORTH specifications. The effect of fines in GSB layer was analysed for 2, 4, 6 and 8 lane roads at 2 and 3 per cent slopes. Results for Coarse Grade-1 are given in Fig. 10 and Table II. The study has been completed and some of the salient findings are as follows:

- The rate of flow and permeability (k) increases, as the fines restricted in GSB layer.
- As the lane width increases, GSB layer with higher permeability be used because the time to drain increases with the increase in lane width.
- Rate of k increases drastically if fines are not present and reduces significantly, even if 5 per cent fines are added. So, it is suggested that the existing MORTH specifications be modified from the existing limit of 3 to 10 per cent to 3 to 5 per cent for soil passing 75 micron sieve.
- The results further show that at 3 per cent internal slope, time-to-drain off water is far less as compared for time-to-drain at 2 per cent internal slope. It is therefore suggested that the slope within the pavement layers should be kept at 3 per cent for better intra-pavement drainage.
### Table II Time – to- Drain for Slope against Permeability Values for Coarse Grade-I

<table>
<thead>
<tr>
<th>Lane Type</th>
<th>K (ft/day)</th>
<th>K (centisec)</th>
<th>Time – to – drain (hrs) 2% Slope</th>
<th>Time – to – drain (hrs) 3% Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Lane (25 ft)</td>
<td>41.44</td>
<td>0.014</td>
<td>59</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0.0300</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>19.2</td>
<td>0.0066</td>
<td>80</td>
<td>63</td>
</tr>
<tr>
<td>4 Lane (49 ft)</td>
<td>41.44</td>
<td>0.014</td>
<td>96</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0.0300</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>19.2</td>
<td>0.0066</td>
<td>207</td>
<td>159</td>
</tr>
<tr>
<td>6 Lane (70 ft)</td>
<td>41.44</td>
<td>0.014</td>
<td>153</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0.0300</td>
<td>72</td>
<td>54</td>
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<td></td>
<td>19.2</td>
<td>0.0066</td>
<td>254</td>
<td>247</td>
</tr>
<tr>
<td>8 Lane (92 ft)</td>
<td>41.44</td>
<td>0.014</td>
<td>189</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0.0300</td>
<td>89</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>19.2</td>
<td>0.0066</td>
<td>408</td>
<td>301</td>
</tr>
</tbody>
</table>

### Consultancy Assignments

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

In continuation to the work reported earlier (Annual Report 2009-10), regarding the underpass construction by pushing two numbers of RCC Boxes with internal dimensions (opening) of 10.5 x 5.75 m each and one number RCC box of 9 x 4 m. The boxes were to be pushed through existing 135 years old embankment having highly unstable...
cohesionless sandy soil backfill in between retaining walls. About 200 to 250 trains pass this section daily, and any disruption to rail traffic in any case was not allowed. To accomplish box pushing for construction of underpass, a novel methodology using 'Soil Nailing' was adopted. The final design details for nails is given in Fig. 11.

![Fig. 11: Configuration of nail design technique](image)

The project has been completed. Some of the very interesting challenges during the study were:

- To suggest and design a system to retain the collapsible sandy strata in vertical position under the dynamic loads caused by moving trains, after the demolition of the retaining wall, so that the box can be gradually pushed inside the sand, to create an underpass.

- To develop a methodology for box pushing, so that the train movement remain operational without interruption during the period of box pushing.

- During the entire period of construction, guidance was made to engineers of the railway and the contractor at site on day to day basis. Since the work of such a nature was carried out for the first time in the country, minor modifications in the design and construction methodology as per the site conditions were to be made from time to time and the same were duly checked and verified using the available software against all possible mode of failures.

In addition to the above, there were a number of site specific problems during the period of construction; such as convergence of nails at several locations, development of piping phenomenon in sand and collapsing of sand at some locations, which were overcome/tackled immediately. Figure 12 shows traffic movement through boxes.

![Fig. 12: Traffic movement through boxes](image)
Design and Execution of Soil Nail Wall System for the Stabilisation of Railway Embankment for the Construction of Underpass Using Box Pushing Under the Existing Railway Line Near Apsara Border, Dilshad Garden

The Delhi Public Works Department has proposed to construct two subways across the Shadhara-Ghaziabad road at the intersection of Apsara border. One of the underpasses was from ISBT Anand Vihar to Seemapuri and the other was proposed from Seemapuri to ISBT, Anand Vihar bus terminal. These two proposed underpasses are parallel to existing Railway over Bridge (ROB) on either side of the same ROB. The side slopes of the approaches embankments for ROB were protected and confined with 900mm diameter sheet piles. These sheet piles were constructed from the footpath top and were interconnected with girder arrangements prior to construction of underpass. The internal dimensions of each segment of precast boxes were of 9.0 x 5.75 m with the thickness of 0.90 m. The maximum outer dimensions of the boxes are 10.80 x 7.55 m with an overburden of about 2m above the box level. The estimated pushing length was found to be 50 m for each box.

About 200 to 250 trains pass this section daily. In order to create an underpass box pushing was proposed through a strata which was of consisting of silty sand/poorly graded fine sand. The work of designing a scheme for stabilisation of cohesion less soil strata so that it remains stable when cut to almost vertical profile for a height of about 7.5 to 8 m during box pushing operation, was entrusted to CRRI by M/s AFCONS Infrastructure Limited. After site visit, exploratory boring and laboratory tests, ‘Soil Nailing Technique’ was proposed for stabilisation of sandy soil. The complete design details of soil nailing and a suitable construction methodology was provided. As per the design, a series of driven nails were inserted into the ground which resulted in the stabilisation of vertical cut slope. The box pushing and gradual removal of sand of the cut slope was taken up simultaneously. The exposed nails were pushed further after subsequent pushing and removal of sand till the target end was reached. Different stages of the construction of underpass shown in Figs. 13, 14, 15, 16, 17 & 18.

Fig.13: RCC box to be pushed below the railway line (Seemapuri to Anand Vihar side)

Fig.14: RCC box to be pushed below the railway line (Anand Vihar to Seemapuri side)
Design and Execution of Soil Nail Wall System for the Stabilisation of Railway Embankment for the Trenchless Crossing of 1700mm Diameter MS Pipe below Railway Track near Old Steel Bridge of Yamuna Bazaar, Delhi

Delhi Jal Board had proposed the work to lay a water pipe line of 1700mm diameter parallel to new by-pass ring road, below railway track near old steel bridge, Yamuna Bazar, Fig. 18. A small tunnel boring machine (TBM) of diameter 1.7m having length of 3m was being used for trenchless technique at the depth of 7.5m from the rail top. The work was allocated to Larson & Toubro (L&T) Ltd., further, the work was awarded by L&T to CRRI. The alignment of the pipe line was passing through the Railway embankment near old steel bridge at Saleem Garh Fort, comprising of poorly graded sand. The pipe was pushed through sandy strata by stabilising the embankment using driven Soil Nailing Technique as was done for box pushing through the same embankment 2.5m away, Fig. 20. The work was completed manually by cutting and pushing the vertical face with the help of jack without using the heavy TBM before stipulated time, Fig. 21.
Sub-Soil Investigation for Bridge Over Agra Canal Near Meethapur, New Delhi

Delhi Govt. has constructed two lane bridge over Agra Canal in 1999-2000 and now it has to be widened into 2/6 lane bridge. As per the requirement, the work of designing of widening of existing two lane bridge and the new proposed bridge was awarded to CRRI. Work on Geotechnical investigation is in progress as shown in Figs 22 & 23.

Sub-soil Investigations for the Construction of Over Bridge on Gurgaon Canal near Meethapur, New Delhi

Delhi Govt. has constructed two lane over bridge on Gurgaon Canal in 1999-2000 near Meethapur and now it has to be widened into 2/6 lane bridge. As per the requirement, the work of sub soil investigation and designing of proposed widened portion of existing two lane bridge and the new proposed bridge was awarded to CRRI.

The purpose of the sub-soil investigation was to obtain all the relevant information relating
to the sub-soil conditions at the site so as to evaluate the safe bearing capacity of soil which would help the designer to design the suitable foundation system for 2/6 lane bridge. On the basis of Rock Quality Designation (RQD) and compressive strength of rock, the bearing capacity of the rock has been estimated as 150 t/m² at a reduced level of 198.500m towards Badarpur side and 197.00 towards Meethapur side. In view of the weathered rock quality, the actual level of foundation may vary at site at the time of actual execution of work. Work is in progress as shown in Fig. 24.

Fig. 24: Drilling work in progress

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

As reported earlier (Annual Report 2009-10), the National Highway-39 is the only connecting route between Dimapur and Kohima (the state capital of Nagaland) and having slope failure at various locations. The investigation work required geomorphological, structural and geological analysis along with the evaluation of geo-technical properties for designing suitable remedial measures to stabilize the slopes at various critical locations including km-162, 174, 179, 180, 214 and 221, which have been completed. Figures 25 & 26 show the detailed morphological and geological map of km 174. Geo-technical evaluation of slope materials was done to perform the stability analysis. Several remedial measures were suggested including the provision of a reinforced earth wall. One of the designed structures is shown in Fig 27. The complete report has been submitted to Border Roads Organisation.

Fig. 25: Morphological map at km 174

Fig. 26: Geological map of km 174

CSIR-CRRI, New Delhi
Protection of Unstable Cut Slopes along Approach Roads and Railway Lines and Stabilization of the Proposed Dumping Sites

As reported earlier (Annual Report 2009-10), the project was sponsored by M/s Konkan Railway Corporation Limited to study the protection of unstable cut slopes along the approach roads and railway lines and to stabilize the proposed dumping sites on Katra-Quazigund section of Udhampur-Srinagar-Baramulla rail link in Jammu and Kashmir. From Kashmir to Banihal section, three dumping yards were selected for the study. On Katra to Laole section (Jammu to Banihal), preliminary site visit was carried out. Figure 28 shows a typical dumping yard where railway station is proposed. Laboratory investigation of muck generated during tunnelling and stability analysis of selected dumping yards is in progress. Stability analysis of existing slopes of all three sections was carried out. Figure 29 shows proposed design section.

Experimental Test Track Construction Using Jarofix Waste Material

As reported earlier (Annual Report 2009-10), the project is sponsored by M/s Hindustan Zinc Ltd., Chanderi, Chittorgarh, Rajasthan to study the potential of Jarofix as an embankment and sub-grade material with and without stabilization. Based on laboratory characterisation and recommendation, an experimental test track section was constructed using Jarofix at 50 km from Chittorgarh. Design of embankment and sub-grade are carried out using Jarofix and mix of Jarofix:soil (50:50) material. Stability analysis of a proposed typical section under different conditions was evaluated considering the water table and seismic factor and found safe (more than 1.5). Construction of experimental test track of length 500 m is carried out using
Jarofix and mixes (50 Jarofix : 50 soil) in the embankment and sub grade layers along the left side of widened portion of a State Highway (SH 76) towards Udaipur. The construction of embankment layer and its evaluation of strength by Plate load test is shown in Figs 30 & 31. Further work is in progress.

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

As reported earlier (Annual Report 2009-10), Government of Delhi has entrusted construction of Signature bridge and its approaches at Wazirabad across river Yamuna to DTTDC. The work was carried out in water logged area, wherein fly ash was used as backfill material for embankment construction. 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 engineers at various stages of project. Some of the important stages of the study are shown in Figs 32, 33 & 34.
Design of Road Embankment in Submerged/Flood Affected Border Areas of Bhuj, Gujarat

As reported earlier, the National Buildings Construction Corporation Ltd (NBCC) is executing the work to construct ‘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 enters and recedes frequently leaving inland marshy and swampy, dotted with small to very large salt water bodies. A road construction methodology for a severely water logged stretch of about 3.5 km has been proposed. The natural ground level along this stretch is in the form of a bowl, hence even after the stagnated water dries up, this area may get waterlogged once again during monsoon. Depth of waterlogging at present varies from 1.5 to 2 m. Hence it was suggested that well graded coarse particles, obtained from stone or mororm quarry can be used as fill material in waterlogged area. This material can be back dumped into the water (by end tipping) and a working platform be created. Once the working platform rises above surrounding water level, compaction of further layers of filling material (coarse grained material from quarry) can be taken up using vibratory rollers in layers. Construction of side slope erosion control measures using rivet mattresses and geotextile layer and toe wall made of gabions can be taken up in the next stage after the stagnant water dries up. Accordingly, NBCC has now constructed road embankment in this stretch using coarse granular material as shown in Fig. 35.

Validation of Slope Protection Works of Zirakpur-Parwanoo Four Laning Project (Himalayan Expressway)

Transportation corridors in hilly regions are highly susceptible to landslides/rock falls. M/s Himalayan Expressway Ltd (Concessionaire) are executing Zirakpur-Parwanoo Road project for NHAI, which involves four laning of NH-22 (Chandigarh-Shimla Road) for 17.44 km length and new bypass of 10.14 km length in the states of Punjab, Haryana and Himachal Pradesh. Bypasses are being constructed to provide alternate routes to
existing congested road sections passing through towns, namely Pinjore, Kalka and Parwanoo. Such bypass section of this new alignment is being constructed in hilly terrain involving embankment construction of height up to about 20 m and slope cutting up to 25 m. Suitable slope protection measures are required in slope cutting sections to prevent occurrence of landslide/rockfall. The task of ‘Validation of Slope Protection Measures’ has been taken up by CRRI.

Detailed field and laboratory investigations including electrical resistivity studies to characterise slope forming material have been carried out. The slopes comprise of weathered shale/ conglomerate/ soil mix. Stability of slopes was analysed using software. The analysis showed that even though slopes are safe under normal serviceability conditions, when saturation/earthquake conditions are considered, the slopes had factor of safety less than one. Hence, passive protection measures like provision of steel rope net/cable panel, turfing with netting, ISMB fencing, etc have been suggested. Figure 36 shows slope protection work is in progress.

Feasibility Study of Jarosite Waste Materials in Construction of Embankment and Sub Grade

This feasibility study of Jarosite waste material in the construction of embankment and sub grade was sponsored by Hindustan Zinc Ltd. Chanderia, Chittorgarh, Rajasthan. Jarosite waste material samples were collected from Hindustan Zinc Ltd. (HZL) Chanderia, Chittorgarh and Debri, Udaipur, Rajasthan separately.

Laboratory investigations were carried out to utilise Jarosites in the construction of embankment and sub grade. Both Jarosites are light weight material having yellowish colour. Considering their low density, both Jarosites were mechanically stabilised in the range of 25 to 75 per cent with bottom ash and local soil to improve their geotechnical properties. Geotechnical characteristics of Jarosite and mechanically stabilised Jarosite mixes from Debri HZL, Rajasthan, India are given in Table III. It is recommended that Jarosite alone or mixed with bottom ash and local soil can be tried for the construction of experimental test track section in the pavement layers of embankment and sub grade if it is a non hazardous material.
Table III Laboratory Results of Jerosites

<table>
<thead>
<tr>
<th>Type of mix</th>
<th>MDD (kN/m²)</th>
<th>OMC (%)</th>
<th>LL (%)</th>
<th>PI (%)</th>
<th>CBR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JD</td>
<td>13.2</td>
<td>32</td>
<td>55</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>BA</td>
<td>12</td>
<td>30</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>JD1BA</td>
<td>12.7</td>
<td>25</td>
<td>NA</td>
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<td>NP</td>
</tr>
<tr>
<td>JD2BA</td>
<td>12.9</td>
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<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>JD3BA</td>
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<td>29</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>S</td>
<td>20.5</td>
<td>7</td>
<td>25</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>JD1S</td>
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<td>33</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>JD2S</td>
<td>16.7</td>
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<td>37</td>
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<td>17</td>
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<tr>
<td>JD3S</td>
<td>15</td>
<td>26</td>
<td>50</td>
<td>33</td>
<td>17</td>
</tr>
</tbody>
</table>

*JD - Jerosite Dobari, BA - Bottom ash, S - Soil, NP - Non plastic, NA - Not applicable

Feasibility Study of Super Fine Copper Slag in Land Filling and Road Construction

This feasibility study of super fine copper slag waste material in land filling and road construction is sponsored by M/s Hindalco Industries Limited, Dahej, Gujarat. Super fine copper slag is a waste material produced during extraction of copper concentrate from high copper ore by floatation and filtration processes. At present, the accumulated super fine copper slag is about 2 lac MT, while its annual production is about 1.5 lac MT per year at Hindalco Industries Limited, Dahej, Gujarat. Feasibility study of super fine copper slag in the road construction was carried out by detailed laboratory investigation. It is mixed with pond ash and granulated copper slag collected from the same plant in the range of 25 to 75 per cent. A typical geotechnical property of super fine slag is given in Table IV. It is recommended that super fine copper slag alone or mixed with pond ash and granulated copper slag can be tried for the construction of experimental test track section in the pavement layers of embankment and sub grade if it is a non hazardous material.

Table IV Laboratory Results of Super Fine Copper Slag

<table>
<thead>
<tr>
<th>Type of mix</th>
<th>MDD (kN/m²)</th>
<th>OMC (%)</th>
<th>LL (%)</th>
<th>PI (%)</th>
<th>CBR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF</td>
<td>20.12</td>
<td>17</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
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<tr>
<td>P</td>
<td>10.72</td>
<td>40</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>SF1P</td>
<td>12.7</td>
<td>32</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>SF2P</td>
<td>15.2</td>
<td>26</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
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<td>SF3P</td>
<td>18.8</td>
<td>19</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
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<td>G</td>
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<td>7</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>SF1G</td>
<td>25.3</td>
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<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>SF2G</td>
<td>24.2</td>
<td>8</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
<tr>
<td>SF3G</td>
<td>22.1</td>
<td>12</td>
<td>NA</td>
<td>NA</td>
<td>NP</td>
</tr>
</tbody>
</table>

SF - Super fine slag, P - Pond ash, G - Granulated copper slag, NP - Non plastic, NA - Not applicable
Demonstration of Field Trials for Emergency Repair of Defence Runways at Two Locations (Pune and Jaisalmer)

Under the study sponsored by Airforce, the quantities of materials in terms of aggregates, bitumen emulsions and cement have been calculated and reported to Indian Air Force. The proposed method of repair is also communicated for the repair of craters. Concept is illustrated in Fig. 37.

**Fig. 37: Methodology diagram for bomb crater repair**

**Stabilisation of Granular Sub-base (GSB) and Wet Mix Macadam Material Using Bitumen Emulsion**

Stabilization of granular layers such as Wet Mix Macadam (WMM), Granular Sub-base (GSB) using bitumen emulsion in pavement structure has been undertaken to reduce the pavement thickness. It is evident from the results that un-stabilized GSB material has lower compressive stress compared to stabilized similar materials. The mix with addition of 1 per cent cement show higher compressive stress. The stabilization of GSB mix matrix reveals that adhesion between bitumen emulsion and mineral aggregates give better performance than granular GSB. On the other hand, the addition of 1 per cent cement provides an added advantage of increasing the bearing compressive stresses (Fig. 38). A complete set-up test on the remained specimens once completed will provide a bigger picture in the usefulness of the stabilization technology in lieu of conventional pavement construction method in India.

**Fig. 38: The superimposition of applied load to failure for different GSB mixes**
Performance Evaluation of Bituminous Concrete Surfacing Laid with SBS Modified Bitumen (PMB-40) on NH-1 New Delhi

This study sponsored by M/s Hindustan Colas Limited (A unit of Hindustan Petroleum Corporation Ltd) has been taken up in January 2006. Periodic performance of VG-30 and PMB-40(SBS) modified bitumen has been monitored between Km 0 and 10 of NH-1 (Part of Outer Ring Road) in New Delhi. The particulars of test sections monitored are given in Table V. Modified bitumen was used in 40 mm thick bituminous concrete as wearing coat. Roughness, Deflection and Distress measurements were made periodically for 6 years. A view of typical test section on NH-1 is shown in Fig. 30.

Table V Particulars of Test Sections Laid on NH-1

<table>
<thead>
<tr>
<th>Test Section Number</th>
<th>Carriageway</th>
<th>Chainage (KM)</th>
<th>Binder Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Delhi-Karnal (LHS)</td>
<td>9.760-0.650</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>2A</td>
<td>Delhi-Karnal (LHS)</td>
<td>10.000-10.200</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>3A</td>
<td>Delhi-Karnal (LHS)</td>
<td>11.600-11.700</td>
<td>Neat (60/70)</td>
</tr>
<tr>
<td>4A</td>
<td>Delhi-Karnal (LHS)</td>
<td>13.000-13.200</td>
<td>Neat (60/70)</td>
</tr>
<tr>
<td>5A</td>
<td>Delhi-Karnal (LHS)</td>
<td>14.400-14.600</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>6A</td>
<td>Delhi-Karnal (LHS)</td>
<td>15.000-15.200</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>1B</td>
<td>Karnal-Delhi (RHS)</td>
<td>0.750-0.950</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>2B</td>
<td>Karnal-Delhi (RHS)</td>
<td>10.000-10.200</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>3B</td>
<td>Karnal-Delhi (RHS)</td>
<td>11.600-11.700</td>
<td>Neat (60/70)</td>
</tr>
<tr>
<td>4B</td>
<td>Karnal-Delhi (RHS)</td>
<td>13.000-13.200</td>
<td>Neat (60/70)</td>
</tr>
<tr>
<td>5B</td>
<td>Karnal-Delhi (RHS)</td>
<td>14.400-14.600</td>
<td>Modified (SBS)</td>
</tr>
<tr>
<td>6B</td>
<td>Karnal-Delhi (RHS)</td>
<td>15.000-15.200</td>
<td>Modified (SBS)</td>
</tr>
</tbody>
</table>

Fig. 30: A view of test section on NH-1
The following conclusions are drawn from this study:

(i) SBS modified bitumen used at test site of NH-1 conformed to IS: 15462 and IRC: SP: 53 specifications.

(ii) The properties of SBS modified bituminous mixes are found superior than bituminous mixes produced with VG-30 grade conventional bitumen.

(iii) SBS modified bituminous mixes have better resistance to rutting at high temperature.

(iv) The progression of development of surface distress is low on test sections laid with SBS modified bitumen as compared to test sections laid with conventional bituminous mixes.

(v) The rut depth value on SBS modified sections is low (< 8mm.) as compared to conventional bituminous mixes (> 10mm.)

(vi) SBS modified sections indicated lesser increase in roughness than conventional sections.

(vii) SBS modified bitumen performed better than conventional bitumen under overloading condition/exceptionally heavy traffic.

(viii) SBS modification leads to increase in service life of overlays in the range of 30 to 40 per cent.

Use of Fly Ash in Construction of Bituminous Road Surfacing

This study has been sponsored by M/s National Thermal Power Corporation Limited (Ash utilization Division). The test results of Stone Matrix Asphalt mix with and without plastic waste, containing 8 per cent pond ash are given in Table VI.

Table VI Test Results of SMA Mix at Various Binder Contents

<table>
<thead>
<tr>
<th>Property</th>
<th>9% Pond Ash with 0.47% Plastic Waste</th>
<th>9% Pond Ash without Plastic Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Bulk Specific Gravity of Total Aggregates, Gmb</td>
<td>2.701</td>
<td>2.701</td>
</tr>
<tr>
<td>Percent Aggregate in Total Mixture, Ps</td>
<td>94.78</td>
<td>94.34</td>
</tr>
<tr>
<td>Percent Coarse Aggregate in Total Mixture, Pca</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>Voids in Coarse Aggregate, VCADRC</td>
<td>43.7</td>
<td>43.7</td>
</tr>
<tr>
<td>Bulk Specific Gravity of Compacted Mixture, Gmb</td>
<td>2.360</td>
<td>2.360</td>
</tr>
<tr>
<td>Percent Air Voids, Va</td>
<td>4.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Percent Voids in Mineral Aggregates, VMA</td>
<td>17.2</td>
<td>17.3</td>
</tr>
<tr>
<td>Voids Coarse Aggregate in Mixture, VCA mix</td>
<td>37.6</td>
<td>37.4</td>
</tr>
<tr>
<td>Draindown, %</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Indirect Tensile Strength at 25°C, kg/cm²</td>
<td>8.8</td>
<td>10.8</td>
</tr>
</tbody>
</table>
The conclusions of the study are as under:

1. Fly ash can be used as fine aggregate and filler for bituminous road construction.

2. Fly ash can be used up to 5 per cent as part of mineral aggregate for semi-dense and dense bituminous concrete. However, usage of fly ash may be in the range of 8 to 10 per cent for cold mixed microsurfacing (CMM) and stone matrix asphalt (SMA).

3. Optimized mixes with fly ash as filler in place of lime require about 0.2 per cent lesser bitumen content, which amounts to 4 to 5 per cent savings in bitumen consumption.

4. Optimized SDBC or BC mixes with fly ash or lime-fly ash as filler indicate slightly less stability of mix, which get enhanced by adding waste plastic (8 per cent by weight of optimum bitumen content of 0.4 to 0.5 per cent by weight of mix depending upon type of specification).

5. Use of fly ash as filler in SDBC, BC and SMA mix enhances resistance to moisture sensitivity of mix as evident from higher value of indirect tensile strength ratio and retained Marshall stability, after conditioning Marshall specimen in water.

6. Cold Mixed SDBC containing 5 per cent fly ash indicates acceptable values of stability and volumetric properties.


Modern Practices in Bituminous Road Construction


Engineering Suitable Overlay Fabric to Serve as a Cheaper Substitute of Bitumen Mastic

The study was sponsored by Institute of Jute Technology, Kolkata. The scope of the
study is limited to the use of jute geo-fabric in bituminous pavements for prevention of reflection cracking. The objectives of the study is the characterization and evaluation of Jute Fabric on various pavement performance related parameters to identify suitable overlay fabric for prevention of reflection cracking. The material testing and mix design part is over. The fatigue testing of the bitumen impregnated jute geo-fabric is in progress. Beam fatigue testing of plain beam samples, with VG-30 bitumen impregnated jute, with PMB-40 impregnated jute and also with VG-10 impregnated jute has been completed.

Development of Thin Stone Matrix Asphalt for Preventive Maintenance of Flexible Pavement

The study has been completed. Following conclusions are drawn from the study.

(i) Thin SMA with special PMB can be used for preventive maintenance of urban roads.

(ii) Thickness of treatment can be restricted to 15 to 20mm in single operation.

(iii) Treatments are cost effective as well as environment friendly.

(iv) Mixes can be prepared and laid at 20°C lower temperature.

Field Performance Study on Cold Mixed Structural Layers of Flexible Pavement

This study has been carried out to develop cold mix technology for bituminous macadam and semi dense bituminous concrete in desert, high rainfall and snow bound area. The test sections were laid in 2007 and 2008 in Rajasthan (Fig. 40), Mizoram and J&K. The performance monitoring of test sections indicates acceptable performance for 3 years. The conclusions of the study are given below:

Fig. 40: Laying of SDBC with emulsion on Dantara – Khajowale Road (Rajasthan)
Periodic Performance Evaluation of Dankuni–Palsit Paragarh Road Section of NH-2

Under the study sponsored by M/s Novaphalt Construction Private Ltd., HDPE modified bitumen is used in BC and DBM layers. Periodic performance (6 monthly) has been monitored for 5 years. Measurements included roughness, deflection and distress. The following conclusions are drawn from the study.

(i) Performance of HDPE modified bitumen under heavy traffic condition is observed much better between Dankuni and Palsit as compared to Palsit-Paragarh.

(ii) Performance of Durgapur bound carriageway is found better than Kolkatta bound carriageway as traffic stresses are more.

(iii) The roughness of all the 16 test sections is in the range of 1800 to 2200 mm/km after service of 5 years, indicating effectiveness of HDPE modified bitumen under heavy traffic in moderate temperature climate.

(iv) Blending of HDPE at site is acceptable procedure for required performance of surface.

Consultancy Assignments

Advice for Use of Micro Surfacing Technology on National Highway NH-10 (Punjabi Bagh to Mundka)

This study has been sponsored by Public Works Department, Govt. of Delhi for appropriate advice regarding suitability of micro surfacing specification to minimize damage. The present bituminous road surface is likely to damage by falling water from Metro Track. The site was inspected and advice was given to treat affected surface by Type I slurry sealing and Type II micro surfacing in conformity of IRC: SP: 83-2008 guidelines.

Guidance for Evaluation of Roads under PMGSY Constructed with Cold Mix Technology in North East

The study has been sponsored by M/s Bit Chem Asphalt Technologies Ltd, Guwahati with the
objective to guide technical staff of Bit Chem and IIT Guwahati team for performance evaluation of various roads. Demonstration was done at various roads viz Bezera-Mandakata Road, Bongshar-Ramboi Road, Nalbari-Ghagrpara Road, and Road from NH-52 to Rajkhowa Para. All these roads were constructed by cold mix technology and are performing very well.

**Construction of Bituminous Overlays Using Plastic Waste Modified Mixes**

The project was sponsored by Public Works Department (Government of Delhi). Various roads viz. road nos 75B, 72, 72 Extension, 71 were laid with waste plastic modified mixes. CRRI conducted design of mix and quality control besides guidance in implementation of technology viz. incorporation of waste plastic at HMP and its specification. Roads are performing satisfactory.

**Laboratory Evaluation and Field Performance of Commercially available Slurry Seal**

The study has been sponsored by Star Seal India, New Delhi. After laboratory evaluation, the field trials were carried out on Moolchand-Nehru Place Road. The performance of slurry seal surface on Moolchand-Nehru Place Road and Safdarjung Airport is found satisfactory after 10 months (Fig. 41).

**Recycling of Bituminous Overlays on Road Nos 111, 112, 113 near Mayur Vihar and Dharamshilla Hospital, New Delhi**

The execution of recycling of bituminous overlay was carried out by M/s Wirtgen India. The milled materials collected from site are sieved to determine the grading of the

*Fig. 41: Satisfactory performance of slurry seal after 10 months on Moolchand - Nehru Place road*
aggregate in existing materials. The grading results are compared to the recommended grading according to MORT&H and the missing fractions are added to material for a specific required blend, say 35:65 per cent fresh: milled respectively. Lime was added to the mix to enhance resistance to moisture susceptibility.

**Advisory Consultancy for Laying of Bitumen Mastic at Mandi House Round About New Delhi**

At the instance of New Delhi Municipal Corporation, site was inspected and specifications of Bitumen Mastic for improvement of round about were suggested.

**Advisory Consultancy for Guiding in Laying Bitumen Mastic at Barakhamba Road-Tolstoy Marg Crossing**

This project is sponsored by New Delhi Municipal Corporation, New Delhi. Site was inspected jointly by CRRI and New Delhi Municipal Corporation officials. Necessary advice was rendered to New Delhi Municipal Corporation for improvement of round about using Bitumen Mastic.
PROJECT TEAM MEMBERS OF RIGID PAVEMENTS DIVISION
A Study on Dry Lean Concrete Containing Portland Pozzolana Cement

The current practices of the construction of cement concrete road for highways in India require a layer of Dry Lean Concrete (DLC) as a base course over which concrete slab rests.

DLC is generally manufactured with OPC as per IRC: SP-49: 1998 specifications. IRC specification IRC: SP-49: 1998 also advocates the use of other cements such as Portland Pozzolana cement (PPC), Portland slag cement in the manufacture of DLC. The specification requires 10 MPa compressive strength of DLC at 7-day.

The minimum Portland cement content of 150 kg/m³ is prescribed for DLC. In case of Portland Pozzolana cement, the IRC specification says nothing about minimum amount of Portland Pozzolana cement (PPC) for DLC. Therefore, this study intends to investigate experimentally the amount of PPC, concrete mix proportions i.e. aggregates to cement ratio, moisture content, and curing period for the DLC to be manufactured with PPC so that the requirements of IRC specifications in term of strength development could be met.

The primary objectives of the study are to conduct experimental studies to establish the following:

a. To determine optimum quantity of Portland pozzolana cement (PPC) to be used in dry lean concrete meeting the strength requirements of IRC SP 49:1998.

b. To determine optimum water content for achieving maximum dry density of dry lean concrete containing Portland pozzolana cement with a maximum aggregate-to-cement ratio.

c. To determine optimum curing period for dry lean concrete meeting the strength requirements of IRC SP 49 containing PPC.

To achieve the above said objectives, PPC was tested for normal consistency, setting times, strength, specific gravity etc. for a comparison with OPC. Optimum moisture content for several trial mixes were determined by using Vee Bee Consistometer, Modified Proctor Test, and Vibrating Jack Hammer meant for no slump concrete mixes (Figs 42 & 43).

Fig. 42: Vee Bee Consistometer
Study on Suitability of Synthetics Fiber Reinforced Concrete for Construction of Concrete Pavements in Indian Conditions

To assess the suitability of synthetics fiber reinforced concrete for construction of concrete pavements in Indian conditions, two types of synthetic fibers (polyester and polypropylene), in three dosages i.e., 0.1, 0.2 & 0.3 per cent of cement were used. Additionally polypropylene fibrillated fiber was also used for the study. In total, 976 concrete specimens (10 x 10 x 50 cm beams, 15 cm cubes, 15 x 30 cm cylinders, 7.5 x 7.5 x 30 cm beams and 50 x 50 x 10 cm slabs) from 36 concrete mixes have been studied. The fresh state properties of concrete such as slump, bleeding, settlement and hardened state properties i.e. flexural strength, compressive strength, abrasion resistance & shrinkage etc. have been studied for fiber reinforced concrete as well as controlled concrete mixes (Figs 44, 45 & 46).

The procedure to prepare dry lean concrete specimens for testing was followed in accordance with ASTM C1435, “Practice for Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer”. Specimens were de-molded after approximately 24 hours of preparation of test specimens. After de-molding, the specimens were put in water curing tank immediately.

The study concluded that dry lean concrete containing PPC meeting IRC: SP-49 strength requirement for the use in base course of concrete pavements can be manufactured at an aggregate to cement ratio between 9.7 to 11 at a moisture content of 6.5.
The production of ash (flyash + bottom ash) from thermal power station is approximately 120 million ton per year, out of total ash produced, the flyash content is only 10 to 15 per cent and rest 85 to 90 per cent is bottom ash having coarse particle and less reactivity. Being the high reactivity value, fly ash has been used by researchers as a part replacement of cement, but very little work has been done for utilization on bottom ash. Attempt has been made to utilize bottom ash as a replacement of fine aggregate.

Bottom ash from various thermal power stations has been collected. Characterization and lime reactivity of the bottom ash has been determined. The L.R. value is 4 to 16 per cent and the carbon content is 2 to 5 per cent. Sample with 0, 10, 20, 30, 40, 50, 60 and 70 per cent replacement of fine aggregate by bottom ash has been prepared for the comparative study of strength development, durability and other engineering properties of concrete. Further work is in progress.

Consultancy Assignments

Evaluation of Suitability of Oil Well Drill Cuttings for Road Making

As reported earlier, Oil & Natural Gas Corporation Limited has sponsored the study to evaluate the feasibility of using drill cuttings, generated during the process of drilling oil and gas wells in road making and also to estimate heavy/toxic metals in cutting leachates. Drill cutting samples were collected from various depths of oil wells at Dahej, Gujarat. At site, on visual inspection, drill cuttings appeared to be aggregates of
different sizes coated with mud. But when dried, these cuttings crumbled under light finger pressure and resembled soil particles. Therefore, characterization of drill cuttings was done similar to soils. Based on Unified Soil Classification System, these drill cuttings were classified as sandy soils (100 per cent passing through 4.75 mm mesh) associated with clay of low plasticity ILL, < 50 & PI, 12 to 17 per cent, (Fig. 47). Results of proctor compaction test revealed high density of drill cuttings. CBR test indicates that these cuttings have high load bearing capacity. Unconfined compressive strength is also very good. Heavy metals leached out from drill cuttings are within permissible limits. Oil well drill cuttings are having all desired engineering characteristics to be exploited as a potential material for preparation of stable and strong sub-grade for roads (Table VII). Amount of heavy/toxic metals is negligible and therefore can be safely used in road construction (Table VIII).

![Graph](image)

**Fig. 47: Grain size distribution of drill cutting specimens**

<table>
<thead>
<tr>
<th>Engineering Properties</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid limit, %</td>
<td>29.1</td>
<td>39.4</td>
<td>40.0</td>
<td>40.4</td>
<td>34.8</td>
<td>33.4</td>
</tr>
<tr>
<td>Plastic limit, %</td>
<td>17.0</td>
<td>22.6</td>
<td>26.2</td>
<td>26.2</td>
<td>19.0</td>
<td>17.6</td>
</tr>
<tr>
<td>Plasticity Index, %</td>
<td>12.1</td>
<td>16.8</td>
<td>13.8</td>
<td>14.2</td>
<td>16.8</td>
<td>15.8</td>
</tr>
<tr>
<td>Maximum dry density, g/cc</td>
<td>1.97</td>
<td>1.86</td>
<td>1.92</td>
<td>1.88</td>
<td>1.98</td>
<td>2.10</td>
</tr>
<tr>
<td>Optimum moisture content, %</td>
<td>13.65</td>
<td>15.74</td>
<td>13.36</td>
<td>14.93</td>
<td>13.96</td>
<td>11.10</td>
</tr>
<tr>
<td>California bearing ratio, %</td>
<td>16.0</td>
<td>12.7</td>
<td>30.0</td>
<td>11.7</td>
<td>25.7</td>
<td>28.4</td>
</tr>
<tr>
<td>Moisture absorption, %</td>
<td>4.9</td>
<td>4.4</td>
<td>1.7</td>
<td>8.6</td>
<td>6.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Unconfined compressive strength, kg/cm²</td>
<td>32.50</td>
<td>47.32</td>
<td>35.00</td>
<td>40.50</td>
<td>35.17</td>
<td>48.67</td>
</tr>
</tbody>
</table>
Proof Checking and Review of Rigid Pavement Design for NH-69 (Nagpur to Betul)

The study was sponsored by Indian Technocrat Limited (ITL), New Delhi with the objective to review the design of rigid pavement to be constructed for the widening of existing road of 2-lane to 4-lane (from km 137 to 213) from Nagpur to Betul on NH-69 (Fig. 48). The construction of the proposed road is based on PPP mode. Therefore, some governing features of the rigid pavement design such as design period, thickness of DLC layer etc. have also been taken as per Clause 5.4.2 of IRC: SP: 84-2009. The originally proposed slab thickness of the rigid pavement by the consultant was 320 mm which was reduced to 300 mm after review of the design (Fig. 49). The review of design has resulted in a huge saving of materials which is worth i.e about Rs. Five Crore.

![Image of road and road signs]

**Fig. 48: A view of existing road**

**Fig. 49: A typical cross-section of the designed concrete road**

<table>
<thead>
<tr>
<th>Metals</th>
<th>Heavy/toxic metals, mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Barium</td>
<td>90</td>
</tr>
<tr>
<td>Chromium(III &amp; VI)</td>
<td>40</td>
</tr>
<tr>
<td>Lead</td>
<td>0</td>
</tr>
<tr>
<td>Nickel</td>
<td>0</td>
</tr>
<tr>
<td>Copper</td>
<td>160</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0</td>
</tr>
<tr>
<td>Zinc</td>
<td>0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>60</td>
</tr>
<tr>
<td>Strontium</td>
<td>0</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0</td>
</tr>
<tr>
<td>Selenium</td>
<td>0</td>
</tr>
<tr>
<td>Manganese</td>
<td>10</td>
</tr>
<tr>
<td>Mercury</td>
<td>0</td>
</tr>
</tbody>
</table>
Design and Construction of Cement Concrete Pavement i.e. Concrete Overlay on the Existing Bituminous Surface on Internal Lanes of NDMC Colonies at Motibagh and Sarojini Nagar Areas

This study was sponsored by New Delhi Municipal Corporation with the objectives to design cement concrete overlay on the existing bituminous roads as well as on unpaved portion and to provide concrete mix design containing fly ash for PQC and lean concrete.

The suggested ultra thin white topping designed for 20 years consisted of 100 mm thick lean concrete leveling layer and 100 mm thick PQC of M-40. The suggested PQC panel size is 1.2m X 1.2 m. Figure 50 shows a view of finished ultra thin white topping concrete at Motibagh.

Fig. 50: A view of finished ultrathin white topping concrete pavement at Motibagh

Design of Concrete Pavement for Dhansa Road from Najafgarh Town to Dhansa Border, Delhi

The objective of the project was to design the concrete pavement for the proposed road on the basis of field data.

Municipal Corporation of Delhi is improving and strengthening the Dhansa road from Najafgarh town to Dhansa border. The existing four lane divided bituminous road connecting Jindar in Haryana to Delhi at Dhansa border is 10 km in length (Fig. 51 & 52).

MCD requested the Institute to design the concrete pavement for the proposed road on the basis of field data.

The suggested design for the Jointed Plain Concrete Pavement included 270 mm thick Pavement Quality Concrete, 125 micron thick Polythene Sheet as separation layer between PQC and DLC, 100 mm thick Dry Lean Concrete layer to be provided over existing bituminous pavement. The structural design of concrete pavement for the proposed road was submitted to the sponsor.

Fig. 51: A view of Najafgarh – Dhansa road

Fig. 52: Distressed top surface of the road
Design of Rigid Pavement for T-Junction at Sector-62, Village Khoda & Sector-57, Noida (U.P.)

At the request of Project Manager Maintenance Civil, Noida (U.P.), the study has been taken up with the objective to design a cement concrete pavement for the state highway to avoid water logging during rainy season. The existing road is bituminous, which gets damaged every year due to water logging during rainy season.

Noida Development Authority has decided to construct cement concrete pavement for the proposed road. The road is approximately 1 km in length and 7 m wide on both side of the median. Due to high volume of traffic, the road is to be further widened by 3 m on both sides. Presently it is a bituminous road which needs immediate overlay. Design parameters like traffic census, crust thickness etc were found out. Soil properties were also determined in the laboratory. Based on the prevailing Single axle and tandem axles and expected traffic growth, the design of cement concrete road has been provided. A view of the existing road at Noida (UP) is given in Fig. 53 and cross section of the concrete overlay is shown in Fig. 54.

Fig. 53: A view of the existing road at Noida (UP)

Improvement and Strengthening of Bijwasan Road, Jathikaramore to NH-8

This assignment was taken up at the request of Municipal Corporation of Delhi. The scope of the work involves laying in position ready mixed concrete (RMC) for R.C.C storm water drain, providing and laying sealing compound for expansion joints, reinforcement for R.C.C. drain work using cold twisted bars and transverse contraction/construction joints. The testing of materials, mix design, strength and other engineering properties were determined and measures for quality improvement were suggested. Figure 55 shows the construction of RCC storm water drain.

Fig. 54: Cross section of concrete overlay

Fig. 55: Construction of R.C.C storm water drain in progress

Design of Concrete Overlay on Gheza Road at Bhangel Village, Noida, U.P.

At the request of Noida Authority, the Institute undertook the design of concrete overlay on Gheza road in the reach of Bhangel village, Noida.
The existing concrete pavement has developed distresses such as cracks, raveling of concrete exposing the coarse aggregate, loss of sealant etc. (Fig. 56). In order to avoid further damage, Noida Authority decided to overlay the existing pavement with concrete overlay.

Based on the site condition, traffic data & soil parameters were studied for the design of concrete overlay. The designed thickness of the concrete overlay was 100 mm over the existing distressed concrete pavement.

Quality Control of the Construction of Cement Concrete Road from EDM to Ghazipur Fruits and Grain Market Entrance (Road No. 56-A), Delhi

Public Works Department, Delhi requested the Institute to ensure the construction of the road by performing random quality control checks/testing and provide professional advice and guidance regarding quality of works/construction aspects of the concrete pavement. Fig. 57 shows the quality control inspection of the tie bars.

Cement Concrete Road in the Campus of CSIR-HRDC, Ghaziabad

A cement concrete road was constructed in the campus of CSIR-HRDC, Ghaziabad. The Engineering Service Division, CSIR requested
Development of National Document /Guidelines on Use of Weigh-in-Motion System in India for Axle Load Monitoring

The main objective of this study is to prepare State-of-Art Report on Weigh-in-Motion Technology and to develop National Document / Guideline on the Use of Weigh-in-Motion (WIM) System for Axle Load Monitoring. The methodology adopted incorporates literature review / survey of various Weigh-in-Motion technologies available worldwide and their operational practices. Field visits were also made to some of the places where Weigh-in-Motion systems is installed in India and abroad. Figure 60 shows a typical view of Piezo Sensor based Weigh-in-Motion system.

This study will facilitate in developing National guideline on the use of WIM System for axle load monitoring on Indian Highways. Enforcement authorities would be able to use the appropriate WIM system towards controlling overloading on Indian Highways which would economize on road maintenance and rehabilitation costs, minimize road accident costs, and bring about improved road safety. The literature and field work related to the study has been completed and the document/report is under preparation.

Design, Construction and Performance Evaluation of New Materials and Mixes toward Development and Upgradation of Standards/Specifications

This study includes new materials and mixes viz. Stone Matrix Asphalt (SMA), Microsurfacing and Hot Asphalt Mixes using waste plastic, which have been laid on actual sites, for performance monitoring, towards development and upgradation of Standards/Specifications. The broad objectives of the study are given as under:

(i) Laboratory characterization of materials/mixes and design of stone matrix asphalt (SMA), microsurfacing and hot asphalt mixes using waste plastic.

(ii) Construction Supervision and quality checking during execution of road sections laid with stone matrix asphalt (SMA), microsurfacings and waste plastic modified hot mix asphalt.

(iii) Time-series periodic performance monitoring of road sections laid with SMA, microsurfacings and waste plastic modified hot mix asphalt.


In addition to the above, study will also be extended to other upcoming/new materials such
as Warm Asphalt, Foam Bitumen etc. whenever and wherever feasible.

40mm thick Stone Matrix Asphalt (SMA) mix was designed in the laboratory using 60/70 Penetration Grade Paving Bitumen. The sources of constituent materials, 20mm and 10mm nominal sized aggregates were obtained from Narnaupur quarry and Stone Dust from Charkhi Dadri Quarry. 60/70 Penetration Grade Paving Bitumen was supplied by construction agency from M/s Mathura Refinery. The Cellulose Fibre (Topcel) as additive was supplied by M/s Organico Chemicals Industries, Mumbai. The Marshall method using 50 blows was used for design of SMA Mix.

Different roads identified for preventive maintenance treatments, in the jurisdiction of New Delhi Municipal Council (NDMC), for laying 40mm thick Stone Matrix Asphalt (SMA) with Topcel on existing bituminous pavement surface as wearing course, are given as under:

<table>
<thead>
<tr>
<th>Name of the Road</th>
<th>Date of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panachheen Road</td>
<td>Oct. 2009</td>
</tr>
<tr>
<td>Shanker Road</td>
<td>Oct. 2009</td>
</tr>
<tr>
<td>Lodhi Road (India Habitat Centre to Aurobindo Marg)</td>
<td>Nov 2009</td>
</tr>
<tr>
<td>PM Chowk Roundabout</td>
<td>Nov. 2008</td>
</tr>
<tr>
<td>Zakir Hussain Marg</td>
<td>May 2007</td>
</tr>
</tbody>
</table>

40mm thick Hot Mix Asphalt (HMA) / Bituminous Concrete (BC) hot mix was designed in the laboratory using 60/70 Penetration Grade Paving Bitumen. The sources of constituent materials, 20mm and 10mm nominal sized aggregates and Stone Dust were obtained from Dadri Quarry near Delhi. 60/70 Penetration Grade Paving Bitumen was supplied by construction agency from M/s Mathura Refinery. The locally available waste plastic was used as additive in the Bituminous Concrete (BC) mix. The Marshall method using 75 blows was used for design of HMA mix.

40mm Bituminous Concrete (BC) with waste plastic (as wearing course) was laid over 50 mm thick Dense Bituminous Macadam (DBM) on the roads Sarita Vihar T-Point to Okhla Barrage and SA Road to Maa Anandamayee Marg (Kalka Temple to ESI Hospital) in the jurisdiction of Municipal Corporation of Delhi (MCD).

Type-III Microsurfacing (layer thickness of 6 to 8mm) was designed using Polymer Modified Bitumen emulsion. The constituent materials used in the mix included mineral aggregates passing 9.5mm sieve, SBR latex modified bitumen emulsion, ordinary portland cement as the filler, potable water free from harmful salts / contaminants and having pH value in the range of 6 to 7, and chemical additive of acidic in nature. The constituent materials sourced were (i) quartzite aggregates available in the surroundings of Delhi, and (ii) SBR latex modified bitumen emulsion produced near Delhi at the local emulsion plant of M/s Elsanex SA, Spain. The emulsion was modified by 2 to 3 per cent polymer latex solids with a residual asphalt content of 65.0 per cent and viscosity of 29 seconds (Saybolt Furol at 25°C). The composition of mix designed was 13.0 per cent emulsion, 1.0 per cent Portland cement as filler, 13.0 per cent water and 0.5 per cent chemical additive.

Microsurfacing was laid over Dense Bituminous Macadam (DBM) or Semi Dense Bituminous Concrete (SDBC) for preventive maintenance treatments on the roads in the jurisdiction of New Delhi Municipal Council (NDMC), as given under:

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Microsurfacing Test Sections

<table>
<thead>
<tr>
<th>Name of the Road</th>
<th>Composition</th>
<th>Date of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akbar Road</td>
<td>Microsurfacing (Type-III) over 25 mm SDBC</td>
<td>May 2010</td>
</tr>
<tr>
<td>Krishna Menon Marg</td>
<td>Microsurfacing (Type-III) over DBM</td>
<td>Oct. 2009</td>
</tr>
<tr>
<td>Satya Marg</td>
<td>Microsurfacing (Type-III) over DBM</td>
<td>Nov 2009</td>
</tr>
<tr>
<td>Chandra Gupta Marg</td>
<td>Microsurfacing (Type-III) over DBM</td>
<td>Nov 2009</td>
</tr>
</tbody>
</table>

The first series of Performance observation on various road sections laid with Stone Matrix Asphalt (SMA), Hot Mix Asphalt mixes using Waste Plastic and Microsurfacing were undertaken during November – December, 2010.

The performance observations being undertaken over the road sections include the following:

a. Assessment of Pavement Surface Distress by visual observation
b. Measurement of Pavement surface roughness by using Roughometer-II
c. Deflection measurements by using Benkelman Beam method
d. Traffic volume survey, 24 hours round the clock

Further work with regard to processing of analysis of 1st series of performance data is in progress.

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

In continuation of the earlier report (Annual Report 2009-10), the activity on “Identification of Test Sections”, based on Sections Matrix (Table IX) formulated under Road Module, has been completed. A total of 61 road sections have been identified for collecting time-series performance data (three series at an interval of one year). Shown in Fig. 61 are the road sections identified in different states of the country.

<table>
<thead>
<tr>
<th>Description</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Type Classification</td>
<td>Flexible Pavement (Bituminous)</td>
</tr>
<tr>
<td>Number of Lanes</td>
<td>Rigid Pavement (Concrete)</td>
</tr>
<tr>
<td>Traffic Category (Commercial Vehicles Per Day)</td>
<td>Two (Two Ways; Hilly Sections)</td>
</tr>
<tr>
<td>Rolling (11 to 25)</td>
<td>Three (One way)</td>
</tr>
<tr>
<td>Hilly (26 to 60)</td>
<td>High (&gt; 4500)</td>
</tr>
<tr>
<td>Terrain Classification (Per cent cross country slope)</td>
<td>Low (&lt; 1500)</td>
</tr>
<tr>
<td>Good (&lt; 5%)*</td>
<td>Fair (5 – 15%)*</td>
</tr>
<tr>
<td>Good (&lt; 1%)**</td>
<td>Poor (&gt; 15%)*</td>
</tr>
<tr>
<td>Pavement Condition (in terms of total surface distress)</td>
<td>Semi Arid (300 to 800)</td>
</tr>
<tr>
<td>Sub Humid (800 to 1600)</td>
<td>Sub-tropical-Hot (-5 to 45)</td>
</tr>
<tr>
<td>Moisture Classifications (Annual Precipitation, mm)</td>
<td>Tropical (20 to 35)</td>
</tr>
<tr>
<td>Sub-tropical-Cool (-10 to 30)</td>
<td></td>
</tr>
<tr>
<td>Temperature Classification (Air Temp, °C)</td>
<td></td>
</tr>
</tbody>
</table>

*Flexible Pavement  **Rigid Pavement
Performance observations being undertaken for these sections include the following:

a. Pavement's Structural Details - Pavement Type and crust composition (Once)

b. Pavement's Structural Condition – Deflection measurements by Bankelman Beam Method and Falling Weight Deflectometer (Periodic)

c. Pavement's Functional Condition – Pavement roughness measurements (Periodic)

d. Pavement Surface Distress – Types, extent and severity of distress / defects (Periodic)

e. Pavement Construction and Maintenance History (Once)

f. Vehicle Information Details (Once)

g. Axle Load Spectrum and Classified Traffic Volume Data for 48 hours round the clock (Periodic)

h. Road Inventory Details and Road Geometrics (Once)

i. Environmental Conditions (Periodic)

1st series of performance observations on the road sections identified in different states is in completion stage. Shown in Figs 62, 63 & 64 are various activities/observations being conducted on the selected road sections.

Fig. 61: Location of road sections identified and some typical views
with the aim to determine its structural capacity so as to evolve suitable corrective/remedial measures needed to improve its current condition and to correct the deficiencies (distress/defects) being encountered on the road. This assignment, involving evaluation of project road in three different sections viz. from km. 0 to 3; 3 to 10; and 10 to 38, was taken up for determining the likely causes of failure/damage and to recommend suitable rehabilitation/remedial measures.

The project road named Kosi-Nandgaon-Barsana-Govardhan road (MDR) is popularly known as KNBG road and is 38 kms long. The road has a carriageway width ranging from 5.5 to 7.0 m with earthen shoulders on both sides. Due to the higher traffic volume and heavy axle loads, pavement surface has developed extensive cracking and other modes of distress including settlement/undulation, making the road condition poor and bumpy with uneven surface, poor profile and poor riding quality. In addition, it was also observed that a Nala flows and water is accumulated in deep cuts along the road. The poor condition of road is responsible for higher road user cost and low travel speed leading to unsafe and uncomfortable ride/journey.

The scope of work included the following:

- Visual assessment of pavement surface condition for the entire length of road.
- Laboratory evaluation of materials retrieved through test pits (5 Nos) in order to assess the subgrade strength and quality of constituent materials.
Traffic volume counts on the project road at two strategic locations for 24 hours round the clock.

• Axle load survey at one location for 24 hours round the clock to compute Vehicle Damage Factor (VDF).

• Benkelman beam deflection studies on 30 to 40 per cent of road length, covering all types of surface condition, as per IRC: 81-1997.

A variety of activities/tasks were carried out under the field investigations with a view to assess the structural and functional conditions of existing pavement, so that the suitable recommendations on remedial/corrective measures for improving the present condition of road can be suggested. The different types of data/results collected/observed/measured, both in the field and in the laboratory, with regard to this project road have been processed/analyzed/computed.

Following salient observations have been made from the synthesized data/results:

(i) The distress levels on the project road vary from fair to worst. In general, predominant distress types on the pavement surface are large sized and wide pot holes, deep settlement and extensive patching. Though the cracked area had been patched at many locations (between km. 3 to 10) but most of the patched surface has started deteriorating again.

(ii) The higher values of mean characteristic deflections obtained clearly indicate that the road in question is structurally unsound/weak and has inadequate capacity to be able to resist the stresses due to current and projected traffic loading. It may, therefore, be inferred that the project road is in dire need of rehabilitation/strengthening in terms of structural overlay which is absolutely essential to improve its condition and ensure long term performance.

(iii) The wheel loads of vehicles were measured with the aid of static wheel weigh pads. On an overall basis, the average weighted VDF is 6.10 for UP direction (i.e. Kosi to Nandgaon/Rajasthan border), whereas, it is 13.60 in DN direction (i.e. from Nandgaon/Rajasthan border to Kosi). These results clearly indicate that higher axle loads and overloading are being carried by large number of commercial vehicles plying on the project road, especially in DN direction (i.e. from Rajasthan border to Kosi). The higher value of VDF (which is 13.60), amongst the two values obtained in UP and DN directions, has been considered for rehabilitation design of road section from km 0 to 10.

(iv) As regards the VDF for road section from km. 10 to 37 (i.e. from Nandgaon to Barsana/Govardhan), a value of 3.5, as per IRC: 81-1997, has been assumed since this road section is found to be subjected to lightly loaded traffic only and not many heavily loaded vehicles, as it is passing through many villages and no major activities are taking place.
The relative compaction of subgrade layer varies from 89.3 to 91.1 per cent. The soil type varies from ML to CL-ML with low CBR values ranging from 3 to 3.5 per cent. The quality of aggregates used in WBM layers appears to be good. Gradation of BM though is falling in MORTH specifications, but it is outside the grading envelope in one case each on 13.2 and 4.75 mm sieves. The binder content in the mix is found to be much lower in the two cases than normally suggested value of 3.3 to 3.5 per cent. The physical properties of aggregates used for production of BM mixes are satisfactory though they are found to be having more flaky and elongated material than permissible. Gradation of SDBC though is falling in MORTH specifications but it is outside the grading envelope in one sample each on 13.2, 4.75 and 1.18 mm sieves.

The binder content in SDBC mixes is found to be much lower than normally suggested value of minimum 5 per cent. The physical properties of aggregates used during the production of SDBC mixes are satisfactory.

The cumulative numbers of standard axles (in millions standard axles) on the project road for a design life of 10 years, has been computed and are given in Table X.

The assessment of structural adequacy of a pavement is determined by using characteristic deflection values and the projected traffic loading in terms of cumulative number of standard axles. By using the data on mean characteristic deflections (1.16 mm for sections from km 3 to 10 and 1.54 mm for sections from km 10 to 37) and traffic loading of 52.88 ms and 9.31 ms respectively, the overlay thickness for road section from km 0 to 10 and km 10 to 37, have been worked out for 10 years design life as per IRC: 81-997.

As regards the road section from km 0 to 3, this specific road section is nearly untrafficable at present for all practical purposes with bituminous surfacing having got completely washed away/stripped off. In addition, large sized, deep and wide pot holes, loss of surfacing materials, unevenness, deep settlement/undulation/deformation, all have developed throughout the length and width of this complete road section. It may also be noted that the top level of road is below the built up area which causes ponding/accumulation of water on the pavement surface. Keeping above in view, it is recommended that cement concrete overlay may

### Table X Cumulative Number of Standard Axles for a Design Life of 10 Years

<table>
<thead>
<tr>
<th>Chainage (Kms)</th>
<th>Traffic (CVPD)</th>
<th>VDF</th>
<th>Cumulative Number of Standard Axles (million standard axles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10</td>
<td>1004</td>
<td>13.60</td>
<td>52.88</td>
</tr>
<tr>
<td>10 to 37</td>
<td>688</td>
<td>3.5</td>
<td>9.31</td>
</tr>
</tbody>
</table>
be provided as permanent solution for this road section, so as to bring an end to this perpetual problem. The details of rehabilitation design of cement concrete overlay, recommended for road section from km. 0 to 3, are also given in Table XI. In addition to the concrete overlay, alternate rehabilitation designs involving bituminous overlay have also been given in Table.

As emphasized earlier, the current condition of pavement surface for two sections viz. km. 0 to 3; and km. 10 to 37; is extremely poor with bituminous surface having got completely washed away/striped off in majority of these road sections. Also, large sized potholes, and deep settlement/deformation have occurred frequently on the road sections making WBM layers fully/partly exposed and eroded which causes bumpy and undulated ride. Due to large undulation and deformation, there is large amount of loss of surfacing material from the pavement leading to very poor levels of the road.

In view of the above considerations, it is thought appropriate to provide 150 mm thick layer of Granular subbase (GSB) in road sections from km. 0 to 3 and km. 10 to 37, which would primarily act as the drainage layer which is presently missing in the existing pavement structure. In addition, it is further advised to provide 250 mm thick (125 mm x 2) Wet Mix Macadam (WMM) in road section from km. 0 to 3 which would facilitate and ensure proper levels and Camber/Cross fall of the road section before the bituminous overlay is provided.

### Table XI Recommended Rehabilitation Design for the Project Road

<table>
<thead>
<tr>
<th>Chainage (Kms)</th>
<th>CSA in 10 years design life (million standard axles)</th>
<th>Mean characteristic deflection (Dc) (mm)</th>
<th>Overlay thickness in terms of BM (based on mean Dc) (mm)</th>
<th>Recommended Rehabilitation Design (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alt- I</td>
<td>Alt- II</td>
</tr>
<tr>
<td>0 - 3</td>
<td>52.88</td>
<td>ND</td>
<td>100 DLC 290 PDC</td>
<td>150 GSB + 250 WMM</td>
</tr>
<tr>
<td>3 - 10</td>
<td>52.88</td>
<td>1.16</td>
<td>130</td>
<td>50 DBM + 40 BC + 75 BM + 40 SDBC</td>
</tr>
<tr>
<td>10 - 37</td>
<td>9.31</td>
<td>1.54</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ND: Not Done*
As regards the road section from km. 10 to 37, it is advised that 100 to 150 mm thick WMM may be provided, depending on the site requirements, to achieve proper levels and Camber / Cross fall. This is felt absolutely essential to ensure long term performance of the rehabilitation measures being recommended for the two road sections. It is pertinent to note that GSB and WMM layers being recommended, prior to the laying of bituminous overlays, are mainly from the considerations of (i) adequate drainage, and (ii) adequate levels / camber / cross fall / surface finish etc. though these layers would also contribute partly to the structural strength of pavement, to some extent. It is pertinent to mention at this stage that the existing bituminous surfacing/ layers will be completely ripped off/ milled out prior to the execution of Granular sub base, which would ensure adequate bonding between the layers.

In addition to the provision of cement concrete overlay recommended in road section from km. 0 to 3, it is strongly suggested to provide the same Cement Concrete overlay on different road sections lying in the village areas, stating from one end of a village boundary to the another end. Along with this, side drains along such stretches may also be provided. This would ensure all time long term performance of project road in built up areas also which otherwise is a common and serious problem encountered on roads in habitated areas like villages etc.

Investigation to Determine the Likely Causes of Pre-mature Distress in Road Section from Km. 72.600 to 105 (Excluding Khatauli Bypass) on NH-58 and Needed Remedial Measures

This assignment was taken up at the request of Project Manager, M/s Gayatri Projects Limited (GPL), Mediparam with an aim to investigate and determine the likely causes for development of pre-mature distress viz. cracking, settlement / deformation and rutting etc. on Meerut – Muzaffarnagar road section from Km 72.600 to 105.000 on NH-58, and suggest the needed remedial measures. The road section is a four lane dual carriageway (two lanes on each carriageway), with each carriageway having a width of 7.5 metre.

Field investigations undertaken included the following:

(i) Assessment of pavement surface condition (km. wise) on visual basis for the entire length of affected road section (for each of the two carriageways) to find out the extent and severity of various distress types developed on the road section

(ii) Laboratory evaluation of road materials retrieved through the test pits in order to find out the subgrade strength and quality of different materials used (five test pits were dug open)

(iii) Traffic volume survey at one strategic location, representing the road section, for 24 hours round the clock (Manual classified counts)
(iv) Axle load survey, using static wheel weigh scales, at the same traffic location, for 24 hours round the clock (covering commercial vehicles only, on random sampling basis) to compute the extent of axle loading being carried by the trucks and determination of Vehicle damage factors (VDFs).

(v) Benkelman Beam deflection studies on the entire road section (11 points per km, on each of the two carriageways)

(vi) Measurement of pavement surface roughness on two carriageways for the entire length of road section (lane wise, per km)

Pavement surface condition, which was done by visual inspection, for Muzaffarnagar bound carriageway (LCW) was observed to be generally good. On an overall basis, no significant distress was noticed, except for 4 or 5 kilometres which had developed moderate level of cracking.

Meerut bound carriageway (RCW), on the other hand, was found to be distressed for considerable length mainly along the inner lane of this carriageway. Distress on Meerut bound carriageway was observed in the form of alligator/crocodile cracking mostly occurring along the inner lane but quite often along the outer lane as well. Shown in Figs. 65 & 66 are the extensive and severe cracking developed along and across the outer and inner lanes of Meerut bound carriageway and patch works done on the distressed area.

The numbers of commercial vehicles per day are found to be 4212 and 3185 for Meerut bound and Muzaffarnagar bound carriageways respectively.

Fig. 65: Extensive and severe alligator cracking on Meerut bound carriageway

Fig. 66: Widely cracked area on Meerut bound carriageway

A large number of commercial vehicles, randomly selected for weighing under this study, were found to be excessively overloaded, especially on Meerut bound carriageway. On Muzaffarnagar bound carriageway, a good number of trucks were found to be either empty or partly/full loaded. The results obtained show that there are large variations in VDFs on the two carriageways. Projected traffic loading in terms of cumulative number of standard axles has been arrived at
for future design lives of 5, 10 and 15 years for assessing the rehabilitation/strengthening requirements, if any. The traffic loading in terms of cumulative number of standard axles has been worked out, separately for each of the two carriageways, for three different scenarios of design lives viz. 5, 10 and 15 years, assuming an annual growth rate of commercial vehicles as 7.5 per cent. The weighted Vehicle Damage Factors (VDFs), as found from the actual axle load survey done, are 17 for Meerut bound carriageway (RCW) and 8 for Muzaffarnagar bound carriageway (LCW).

Roughness measurements were undertaken with a view to assess the riding quality of road section, which gets affected mainly by the condition of pavement surface. Pavement surface roughness, in both carriageways of the entire road section, was measured lane wise, on each wheel paths by using Roughometer-II.

A total of five test pits, three on Meerut bound carriageway and two on Muzaffarnagar bound carriageway, measuring 1 x 1 m in size, were also dug open up to the subgrade level, at selected / representative locations. The total thickness including thickness of each constituent layers was also measured at several locations in each of the test pits and average value was computed. The samples of bituminous materials (mixes), granular materials and sub grade soil were also collected from all the test pits for detailed evaluation in CRRI laboratory.

Based on the general appraisal of pavement surface condition, a total of 21 cores were retrieved from bituminous layers (BM, DBM and BC), from the representative locations spread over different lanes in each of the two carriageways.

The values of characteristic deflections, obtained for Meerut bound and Muzaffarnagar bound carriageways, are clearly indicating that a good number of road sections in Meerut bound carriageway, in particular, are structurally inadequate. Therefore, the pavement of Meerut bound carriageway is in dire need of rehabilitation/strengthening in terms of structural overlay so as to augment its structural capacity which would subsequently improve upon the present condition and in turn the overall performance. Pavement of Muzaffarnagar bound carriageway has adequate capacity for the present day traffic volume and loads but would, however, require strengthening only at a later stage and not in the present time.

The overlay thicknesses, as worked out for four segmented road sections vary from 50 mm DBM+50 mm BC to 75 mm DBM+50 mm BC for a design life of 5 years for Meerut bound carriageway. Similarly, overlay thicknesses worked out for Muzaffarnagar bound carriageway for four segmented road sections are in the range of NIL to 50 mm BC for 5 years design life and from NIL to 50 mm DBM+50 mm BC for 10 years design life. No overlay can be recommended for 10 and 15 years design life on Meerut bound carriageway and for 15 years design life on Muzaffarnagar bound carriageway since the projected traffic loading in all these three cases go beyond 100 msa for which overlay design charts are not available in IRC: 81-1997.
Based on the field and laboratory investigations and data results obtained, the major key findings emerged can be summarized as given under:

1. The magnitude of distress is high on pavement of Meerut bound carriageway as compared to pavement of Muzaffarnagar bound carriageway mainly due to its use by increasing number of commercial vehicles carrying heavy axle loads. It is observed that pavement surface condition on many sections of Meerut bound Carriageway varies from fair to poor. On the other hand, pavement surface condition on some sections of Muzaffarnagar bound carriageway varies from good to fair. The amount of total surface distress, in the range of 25 to 60 percent on Meerut bound Carriageway, has occurred on kilometres 76 to 77, 77-78, 78-79, 80-81, 85 to 86, 90 to 91, 91 to 92, 102 to 103, 103-104 and 104 to 105. The predominant types of surface distress developed on the road section are cracking and rutting/settlement.

2. It has been observed that significant length of road section on LCW has roughness values in the range of 2000 to 2500 mm/km while it is in the range of 2000 to 3000 mm/km on RCW. Therefore, the roughness is within the acceptable limits (Level-2) in both the carriageways, as specified in the Concession Agreement and the pavement may be considered to be functionally adequate at the present time except for few kms (4 to 5 kms) on Meerut bound carriageway which would need immediate resurfacing with 40 mm BC.

3. The trends of deflection data, obtained through Benkelman Beam deflection studies, clearly indicate that the deflections are much higher on Meerut bound carriageway as compared to Muzaffarnagar bound carriageway, implying thereby that the pavement is structurally inadequate on Meerut bound carriageway and would be unable to cater to anticipated heavier axle loading in future. It is also clear that the existing pavement structures, in both the carriageways, are deficient (in the remaining design life) with regard to their structural adequacy in comparison to the projected traffic loading than they were designed for.

4. Based on the characteristic deflection data and cumulative number of standard axles computed for the two carriageways, it becomes very clear that the existing roads are structurally inadequate and would not be able to cope up with the projected traffic loads. Consequently, the road sections are in dire need of immediate rehabilitation/strengthening to augment their structural adequacy so as to improve their load carrying capacity.

5. It appears that the road section (particularly on Meerut bound carriageway) has inadequate structural strength for the existing pavement commensurate to the projected traffic loading. As a
matter of fact, the distress has occurred on this carriageway mainly because of unanticipated / higher traffic volume and heavier axle loading caused by commercial vehicles than the pavement has been designed for.

6. Very high VDFs (17 & 8) have been found on Meerut bound and Muzaffarnagar bound carriageways indicating excessive overloading. VDFs, as per the prevailing traffic loads, are much higher than the VDFs suggested in IRC Guidelines and / or adopted for the road section during design stage. It is primarily due to the excessive loads that the pavement layers have got over-stressed, resulting into the development of pre-mature distress, especially on Meerut bound carriageway.

7. It was also found that the binder film or the coating of bitumen with aggregates was not satisfactory making the mix vulnerable to stripping in the presence of water.

8. It was observed during the test pitting that cracks are not deep seated in lower pavement layers and these were confined only upto BC layer.

Some of the probable causes for development of pre-mature distress on the road section may be summarized, as given below:

1. The shape and binder absorption characteristics of aggregates used during the execution of bituminous works may have impacted on the fatigue and deformation characteristics of bituminous mixes.

2. It appears that the pavement layers have got over-stressed, primarily due to these being subjected to excessive stresses / strains (due to higher traffic volume and excessive axle loads), especially due to repetitive loads on wheel paths (mainly within the inner lane of Meerut bound carriageway).

3. Use of uncrushed gravel (shingles / river pebbles) in bituminous mixes appears to be one of the contributing factors in development of pre-mature distress on the road section since such aggregates have got poor / inadequate binder-aggregate coating ability.

4. The quality of bituminous binder (CRMB-60) in wearing course also has influence on the performance of road section. Premature ageing / hardening is also one of the potential reasons for development of pre-mature distress on the road section, as is clearly demonstrated by the results of bituminous binder. CRMB-60 used for production of BC mixes appears to be brittle since it has very low penetration value and also its elastic recovery value is less than the minimum specified requirement.

5. Excessive traffic volume and axle loads (i.e. high vehicle damage factors) than considered during the pavement design stage are largely responsible for the distresses developed.
Recommendations, based on the investigations undertaken, are given as under:

1. It is advised that no further seal coat and/or slurry seal should be done at this stage on the distressed area of road section since it may not yield any useful results.

2. It is further advised that no BC layer be removed since even the distressed BC layer would only add to the structural strength of existing pavement (which seems to be structurally inadequate commensurate to the projected traffic loading) and would thus contribute in resisting bearing the stresses and strains which are excessive on the road section due to higher traffic volume and heavier axle loading.

3. A number of road sections on Meerut bound carriageway are distressed due to inadequate structural strength of the existing pavement. Thus, some of the sections would need immediate resurfacing while the rest of sections would need strengthening/rehabilitation in the immediate future.

4. Open and wide cracks, at isolated locations, shall be sealed with rubberized bitumen (preferably Polymer Modified Bitumen) immediately after their occurrence on the pavement surface.

5. Settled and depressed area shall be filled for profile corrections by dense bituminous mix, wherever required.

6. As regards the rectification of distresses (i.e. mainly alligator cracks), developed on the road section, it is suggested that crack prevention course in the form of Stress Absorbing Membrane Interlayer (SAMI), as per Clause 522 of MORTH Specifications, may be provided over the affected road sections. For ensuring desirable performance, two coats of SAMI on Meerut bound carriageway have been recommended for majority of the sections due to the extensive cracking and inadequate structural capacity of the pavement. Two / one coat of SAMI, on few sections, on Muzaffarnagar bound carriageway (as the case may be), has also been recommended.

7. SAMI would arrest the cracking and minimize / retard further deterioration of road section which would in a way lead to augmentation of the ability of existing pavement to some extent to enable it to resist heavy stresses being witnessed on this road section and minimize progressive deterioration. This would ensure not only the improved pavement performance but also the safe and comfortable traffic operations.

8. Stress Absorbing Membrane (SAM), which is elastomeric bitumen rubber membrane, is laid over the cracked surface, together with a cover of aggregate chips, in order to extend the life of pavement before major treatment is carried out. SAM can be laid either in single coat or in double coat depending on the type, severity and magnitude of cracking. It is recommended that SAM may be provided in double coat on the cracked surface of road section.
in question, SAM in double coat may be expected to last for about one to one and a half years and thus re-appearance of cracks may not probably get exhibited until such time.

9. In view of poor binder absorption characteristics of aggregates available in the vicinity of project road, it is advised that anti-stripping agent may be used in both DBM and BC mixes. It may also be considered to use polymer modified bitumen even in DBM mixes (as against the conventional 60/70 bitumen), which is though slightly costlier and not a common practice in India, but it is expected to provide durable, long lasting and improved performance of the road section. If this is not found appropriate / acceptable, then the source of aggregates will need to be changed at least for the BC layer and aggregates finally selected should be cubical having adequate binder coating ability.

10. Resurfacing with 50 mm BC is recommended for some sections on immediate basis. However, rehabilitation in terms of structural overlay will be required for the remaining sections after about 1 to 1.5 years on Meerut bound carriageway to sustain projected traffic loading, over a design life of 5 years. Based on the characteristic deflections data and projected traffic loading, the overlay thickness and suggested treatments, as recommended, may be provided.

11. Since it is not possible to recommend structural overlay on Meerut bound carriageway beyond a design life of 5 years (in view of restrictions of projected traffic loading being > 100 msa until this period), it is advised that another series of detailed structural evaluation of the road section may be got done after about 4 years. Similarly, functional evaluation of road section may be done once every year to find out the resurfacing needs.

Evaluation of Master Plan Roads (60 m & 45 m ROWs) in Dwarka and Needed Remedial and Improvement Measures

The assignment was taken up at the request of Delhi Development Authority (DDA) to carry out detailed evaluation of Master Plan roads (60 & 45 m ROWs) in Dwarka and subsequently recommend the remedial and improvement measures in terms of specific maintenance treatments required to be applied.

The scope of work included the following:

- Structural evaluation of roads by Benkelman Beam deflection method (Covering 50 per cent length of project roads by taking 11 points/km in each carriageway),
- Visual assessment of pavement surface condition for the entire length of all the project roads, to assess the extent and severity of various types of surface distress,
- Pavement Roughness measurements, lane wise, by using Roughometer II on the entire length of all the project roads,
- Traffic volume counts on six roads, 24 hours round the clock.
Axle load survey, covering only trucks and buses, on random sampling basis, at one location for about 12 hours during the night hours.

Test pits observations covering a total of six pits (three pits on 60 m ROW roads and three pits on 45 m ROW roads).

Laboratory evaluation of sub grade soil to determine its engineering / physical properties and strength (CBR).

The typical surface condition in terms of various types of surface distress / defects observed at few selected locations on various project roads are illustrated in Figs 67 & 68.

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

(i) Average roughness of project roads varies from 2200 to 3570 mm/km. This indicates that the surface condition of project roads is in average and poor condition and there is a need to provide strengthening and / or resurfacing / renewal layer to improve upon their condition.

(ii) The total surface distress varies from 5 to 40 per cent. This indicates that the surface condition of project roads is in fair to poor condition and there is a need to provide strengthening and / or resurfacing / renewal layer to improve upon their condition. Commercial Vehicles Per Day on these project roads vary from 136 to 2463

(iii) Vehicle Damage Factors of 9.29 and 5.54 on Road No.201 for Najafgarh Road to Delhi and Delhi to Najafgarh Road carriageways respectively indicate that the commercial vehicles carry more loads on the Najafgarh Road to Delhi carriageway.

The following recommendations were made:

1. The requirements for rehabilitation (structural overlay) and resurfacing for various project roads have been worked out separately for two different design periods i.e. 5 years and 10 years. Overlay required, based on 10 years design life is recommended, wherever required.

2. It is further recommended that for those roads which are not in need of any overlay
requirements either for 5 years design life and/or for 10 years design life, a 40 mm thick Bituminous Concrete (BC) layer may be provided as resurfacing layer/ renewal coat now and at the end of 5 years from functional (serviceability) requirements point of view to ensure better rideability to the road users.

The needed field work viz. traffic volume survey at two different locations adjacent to the proposed project road and laboratory evaluation of subgrade soil (four samples) collected along/near the proposed project road, has been completed. The design parameters considered/assumed are as follows:

a. Design Traffic Volume = 500 Commercial Vehicles Per Day
b. Subgrade CBR = 5 per cent
c. Design Life = 5 years (Stage I); and 15 years (Stage II)
d. Annual growth rate of commercial vehicles = 7.5 per cent

e. Vehicle Damage Factor (VDF) = 3.5
f. Design Traffic computed in terms of Cumulative Number of Standard Axles

(i) Stage I: For 5 years design life = 3 msa
(ii) Stage II: For 15 years design life = 10 msa

Interim recommendations on the design of flexible pavement have been formulated for the project road. The thickness of flexible pavement and its composition, above the subgrade layer of 500 mm thick, for full design life of 15 years, as per IRC:37-2001, comes out to be as follows:

40 mm thick Bituminous Concrete (BC) as wearing surface
+ 70 mm thick Dense Bituminous Macadam (DBM) as bituminous base (binder course)
+ 250 mm thick Wet Mix Macadam (WMM) as Granular Base

Design of Pavement for 30 m Right of Way Roads in Sectors 29 & 30 (part) at Rohini, Delhi

This study was undertaken at the instance of Delhi Development Authority (DDA) with the objective to design a flexible pavement for 30m Right of Way Roads in Sectors 29 & 30 at Rohini. The proposed road is 2940 metre long and would cover an area of about 1,76,400 square metre. This road is proposed to be developed as a six lane divided carriageway.

The scope of work included the following:

1. Inspection to the project area and proposed construction sites.
2. Traffic assessment/surveys on some existing roads around the project sites/area, depending on the influencing area (1 or 2 locations; 24 hours round the clock).
3. Test pitting on similar roads in the adjoining area (1 or 2 nos.), if required.
4. Verification of results of subgrade soil provided by DDA by undertaking only very limited tests.
5. Design of flexible pavement based on the data/results obtained from (1) and (2), by using IRC: 37-2001.
+300 mm thick as Granular Sub Base of CBR not less than 30 per cent.

Since the project road falls in the undeveloped/semi developed/green field area, it may be expected that initially the road would not be subjected to heavy traffic. The growth of traffic would be at a very slow rate and the road would be able to receive heavy vehicles only when the project area starts developing and/or gets fully developed in course of time. Therefore, it would take reasonable time after construction before the proposed road receives significant amount of heavy traffic.

Keeping in view the above considerations/limitations, it is suggested that the total pavement design arrived at for full 15 years design life, as given above, may be implemented in two stages viz. pavement design for 5 years design life initially (as Stage I) and rehabilitation design at the end of 5 years to cater to the projected design traffic for remaining 10 years design life for augmentation of structural capacity of the existing pavement (as Stage II).

The designs of flexible pavement for these two stages are recommended below:

a) **Stage I: Design of Flexible Pavement for 5 Years Design Life**

25 mm thick Semi Dense Bituminous Concrete (SDBC) as wearing surface

+50 mm thick Bituminous Macadam (BM) as bituminous base (binder course)

+250 mm thick Wet Mix Macadam as Granular Base

b) **Stage II: Design of Flexible Pavement for the Remaining / Next 10 Years Design Life (To be Implemented at the End of Initial 5 years i.e. After Completion of Stage I Design Life)**

40 mm thick Bituminous Concrete as wearing course

+50 mm thick Dense Bituminous Macadam

The following may also be noted:

1. There is only a difference of 70 mm in thickness of Granular Subbase between the design traffic of 5 years design life (3 msa) and design traffic of 15 years design life (10 msa). It is recommended that the full thickness of Granular Subbase (i.e. 300 mm) may only be provided initially even if the road is to be developed in stages, since it can’t be done at a later stage.

2. 25 mm thick SDBC is recommended in place of 20 mm thick Premix Carpet (PC) for 5 years design life (as indicated in IRC: 37-2001) since (a) it performs better and has longer service life, and (b) the road is not expected to have much heavy traffic during Stage I life and thus the PC surfacing will be subjected to severe ageing and weathering and would deteriorate much faster than SDBC.

3. If layer equivalencies are to be applied than the remaining crust to be provided
Applications of Rhinophalt 
Preservative and its Performance 
Evaluation on Three Toll Roads 
(Trial Stretches) in Rajasthan and 
Gujarat States

The project on applications of Rhinophalt preservative on roads was taken up at the request of M/s IL & FS Transportation Network Limited, Ahmedabad with the objective to undertake performance evaluation of Rhinophalt Preservative used on three toll roads in Rajasthan and Gujarat States viz. (a) Gomti–Beawar, (b) Ahmedabad–Mehsana and (c) Vadodara–Halol.

This preservative protects the surface from weathering and oxidation and following application, effectively halts the deterioration of bituminous surface. Rhinophalt is a revolutionary process that significantly extends the life of asphalt and macadam. With repeat applications at every five to seven years, Rhinophalt is a sustainable and extremely cost-effective process. By giving asphalt a longer life, it reduces traffic disruption, aggregate waste and extraction, and most significantly it reduces the whole life cost in road maintenance. Rhinophalt is suitable for all asphalt surfaces including roads and carriageways, airport runways and taxiways, car parks, platforms, docks and ports.

The study is planned to be implemented in three different phases, as described below:

Phase-I: Pre-Application Investigations
Phase-II: Post-Application Investigations
Phase-III: Periodic Performance Monitoring/ Evaluation

(at the end of 5 years design life) for 
full 15 years design life comes to 50 
mm DBM. Therefore, it is recommended 
that 50 mm DBM may be provided at 
the end of 5 years design life with 40 
mm thick BC as the surfacing since 25 
mm thick SD BC provided initially would 
also have completed its useful life by 
that time.

4. It is desirable / preferable to adopt 
stage construction practices in case 
of new roads (that too in urban areas) 
since it is extremely difficult many a 
times to assess accurately / reliably 
the current traffic and/or anticipated 
traffic during the whole design life 
due to uncertainties involved and 
possible changes in the road network, 
land use of the area served, probable 
growth of traffic, and different kinds of 
developmental activities which would 
take place in the project area in the 
long range (say 15 years or more).

5. In case Stage-I design is finally adopted, 
it is recommended that existing pavement 
may be evaluated after completion of 5 
years design life to assess / know the 
exact requirement of structural overlay 
for the remaining design life since the 
traffic would have got stabilized by that 
time.

6. The 60/70 penetration grade paving 
bitumen or Viscosity Grade–30 (VG- 
30) bitumen, as per IS: 73-2008, is 
recommended for construction of BM, 
DBM, SDBC and BC.
During the first phase, monitoring of construction quality during the application of Rhinophalt preservative treatments on trial stretches has been done. Figures 69 & 70 show the preparation and application of Rhinophalt Preservative on toll road.

In addition to the monitoring of construction quality with regard to application of Rhinophalt preservative treatment on trial stretches, pre and post application investigations were also undertaken to study the effectiveness of Rhinophalt preservative on three toll roads. Figure 71 shows the Benkelman Beam deflection measurements being taken on a road section before the application of Rhinophalt.

Performance studies are planned to be undertaken on three stretches for a period of three years include the following:

1) Assessment of pavement surface condition by visual inspection
2) Benkelman beam deflection measurements
3) Pavement surface roughness measurements
4) Traffic volume and axle load surveys
5) Test pit observations
6) Skid resistance
7) Laboratory evaluation of cores retrieved from bituminous layers

The first series of performance observations is planned to be taken during May / June 2011.
The product being applied under this study is already in use in different countries and is now proposed to be evaluated for Indian condition. If found suitable, it would assist in increasing the life of pavements and ensure improved performance on long term basis.

Performance Study on the Use of Fly Ash in Construction of Bituminous Road Surfacing

As reported earlier (Annual Report 2009-10), this project was taken up primarily to evaluate performance of road sections constructed with different types of bituminous surfacing by using fly ash as mineral filler vis-a-vis bituminous surfacing constructed in a conventional way. Detailed investigations were undertaken for the assessment of condition of existing pavements.

Based on the data / results obtained from investigations, renewal/resurfacing treatments in terms of 40 mm thick Bituminous Overlay was recommended to improve the current condition of project roads / links from their functional point of view and to provide comfortable ride to the users. Proposed specifications on various sections of different project roads, which are to be constructed using lime and fly ash as the mineral filler, were also recommended.

Based on the recommendations made by CRRI, bituminous works using flyash are being done on existing project roads within the NTPC, Badarpur plant campus. Development of periodic pavement performance data (such as deflection, roughness, surface distress, traffic volume etc.) at six months interval for a period of 3 years is planned to be taken for evaluating the feasibility / effectiveness of use of fly ash in construction of bituminous road surfacing.

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

As reported earlier (Annual Report 2009-10), this assignment, sponsored by Airports Authority of India, was taken up primarily to evaluate airfield pavement at Jaipur airport towards determining and ascertaining the likely causes of distress and subsequently suggest the remedial measures for improving the condition of runway. This airfield pavement is also planned to be upgraded in future in order to receive heavier types of aircrafts for its future operation.

Investigations were undertaken and the surface of runway pavement was closely examined for evidence of distress / deterioration etc. through visual survey. The surface condition of runway, in general, was observed to be rough/hungry with porous texture and the was found to be very wet with signs of mud-pumping at certain locations (Figs 72 & 73).

![Fig. 72: Dosing of water on the runway surface](image-url)
Further examination of the pavement also revealed that a significant amount of water has got entrapped within the pavement layers, which has entered into the bituminous layers from the top surface (which is porous) and through the side shoulders. It has consequently resulted in undulation, ravelling and rutting etc. at various locations. The pavement had been repaired with bituminous mixes by doing patches of varying sizes.

A total of four test pits, each 1.25 x 1.25m in size, on or near the edge of pavement were cut open, one on the sound condition of pavement and three on the problematic areas of runway. The construction materials from different component layers including subgrade were collected from these pits for laboratory evaluation. Based on the general appraisal of pavement surface condition, cores of 100 mm and 150 mm diameter from bituminous layers were retrieved from the representative locations spread over the entire length and breadth of the runway (flexible portion).

During the period of investigations undertaken and subsequent discussions held with AAI officials, it emerged very clearly that stagnation of water within the pavement layer and poor drainability of the pavement layers has caused persistent problems which is resulting into the rapid deterioration of runway. The close examination of runway was also showing similar signs, like moisture being noticed on the surface of runway even during the dry season. It was found that good amount of water has got entrapped within the bituminous layers and was seeping out from the edges of runway (Figs. 74 & 75). It was also observed that most of the water was entrapped within the bituminous layer and very little had percolated down to the base and subgrade level.

Fig. 73: Dosing of water & mud-pumping on the runway surface

Fig. 74: Water seeping out from runway in test pit

Fig. 75: Entrapped water on the main runway
A detailed examination of the cores and laboratory results obtained has indicated that the voids were high in bituminous layers (12 to 18 per cent as against 3 to 6 per cent) and the degree of compaction was generally inadequate (69 to 99 per cent as against 97 per cent). The binder content in BC layer was of the order of 4 to 5 per cent as against 5 to 6 per cent. The stripping was of the order of 30 to 50 per cent as against the upper limit of 5 per cent. At some locations, the cores from bituminous layers could not be recovered fully as it had broken during the process of coring due to loose bonding. The data clearly indicates that the existing bituminous layers are porous and more pervious which allow infiltration of water leading to saturation of pavement layers, thereby weakening the pavement structure as a whole. It has resulted in accelerated deterioration of the runway.

In order to assess the infiltration of water through the surface of runway and the rate of exit of water through the pavement layers, software available at CRRI called "DRIP" was used. DRIP (Drainage Requirement in Pavements) was used to check the severity of problem. It was found that the time to drain i.e., 't' for the given condition is about 1588 hrs, which comes out to be almost 2 months, thereby confirming the status of runway in Poor Quality of Drainage.

The pavement surface condition, in general, was found to be fair to good. Percentage distress in problematic areas varied from 15 to 80 per cent. Oozing of water on the surface was also seen at many locations occurring throughout the length, mostly along the left hand side towards 27 END and at few places along the right hand side. The total surface distress observed on left and right sides was found to be as high as 80 per cent.

It was also observed that camber was disturbed throughout the runway due to frequent maintenance and rehabilitation works undertaken from time to time for repair of distressed pavement. As the top surface of runway had already stripped off, the surface has become porous and in the absence of proper camber, rainwater tends to percolate through the pavement surface, allowing the passage of surface water into the pavement structure. Most of the free water has entered into the pavement through joints, cracks, and pores in the surface of pavement.

The main observations are as follows:

- The primary source of free water to the pavement structure is infiltrated water.
- Permeability requirements for lateral flow are very high because the hydraulic gradient is very low and the area of flow is small.
- Proper filters need to be included if the drainage system is to function properly for a longer period of time.

On the basis of field and laboratory investigations, it can be concluded that the following three factors have contributed to the distress related problems on the runway.

- Poor drainage condition
- Stripping of binder
- Inadequate quality control measures

In order to drain off the water from runway, the following two remedial measures have been suggested as Option I and Option II.
Option I: Provision of Edge Drains

It is recommended that all along the shoulder of runway, 30 cm wide and 80 cm deep trenches be made which may be filled in with granular material (filter) conforming to the specifications given in Table XII. It is also recommended that the filter material be encapsulated with a Geotextile conforming to the specifications indicated in Table XIII.

Geo-textiles of half the strength given above may be used in trenches because of lower stress which would be imposed on them. K of fabric $\geq 10$ k (of the soil to be drained).

OPTION II: Provision of Geo-Composite Panel Drain

Geo-Composite Panel Drain is a cost effective subsoil drainage system which comprises of high density polyethylene core encapsulated in a filter Geotextile that provides high strength and faster response due to its unique ribbed panel design. It is supplied in rolls and is simple and easy to install in trench excavations. The cores are supplied in rolls, generally 40 mm wide and 450mm deep. It can be placed in trenches with a minimum cover of 100 mm. These cores can sustain a loading of more than 150 KPa.

Besides above, the following remedial measures have also been recommended for rehabilitation of runway pavement.

As per PCN reported by AAI, the runway is structurally adequate for the aircrafts presently plying on it. Keeping in view the distress condition of runway, poor surface and subsurface drainage condition, absence of side drainage, inadequate binder content and compaction of bituminous

<table>
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<tr>
<th>Table XII Grading of Filter Material</th>
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<tr>
<td>IS Sieve designations (mm)</td>
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<tr>
<td>75.0</td>
</tr>
<tr>
<td>26.5</td>
</tr>
<tr>
<td>4.75</td>
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<tr>
<td>0.425</td>
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<tr>
<td>0.075</td>
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Note: The material passing 425 micron (0.425 mm) sieve according to IS: 2720 (Part 5) shall have liquid limit and plasticity index not more than 25 per cent and 6 per cent respectively.

<table>
<thead>
<tr>
<th>Table XIII Strength Requirements of Drainage Textile</th>
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<tbody>
<tr>
<td>Property</td>
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<td></td>
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<tr>
<td>Grab Strength</td>
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<td>Puncture Strength</td>
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<td>Burst Strength</td>
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layers, high porosity and air voids etc., it can be concluded that the runway would deteriorate very rapidly, if corrective measures are not taken timely and urgently. The runway, therefore, requires strengthening/rehabilitation measures on immediate basis. It is, therefore, suggested that 50 mm thick BC over 75 mm DBM may be provided after providing the subsurface drainage. It would arrest further deterioration and would also improve the structural and functional ability of runway. It is further recommended that PMB-40 may be used in BC mixes instead of VG-30 bitumen.

Quality Checking/ Audit / Surveillance of a large number of Road Projects involving Full Construction, Strengthening, Resurfacing, Widening and Improvement / Upgradation Works in National Capital Region (NCR)

CRRI is significantly contributing to the societal benefits by providing technical knowhow and expertise during the quality control of road works which is facilitating value addition to the road construction quality and hence provision of good quality roads to the public at large thus leading to reduced maintenance costs and road user costs etc. The Institute is actively engaged/occupied on conducting third party quality checking for a number of important road projects, being executed in NCR by various road departments/authorities such as New Delhi Municipal Council (NDMC), Delhi PWD, DDA, Municipal Corporation of Delhi (MCD), Ghaziabad Development Authority (GDA) and New Okhla Industrial Development Authority (NODA) etc.

New Infrastructural R & D facilities Developed / Procured

The following State-of-Art Equipments/Facilities have been created at the Institute:

a) Automated Road Survey System

The Automated Road Survey System (ARSS) is a vehicle mounted system and is based on the latest survey techniques, utilizing laser, global positioning system and video image processing tools etc. The survey vehicle will be used for automated collection of road condition related data for National Highways. The inventory data will include road asset inventory within the ROW, measurement of gradient (rise and fall), horizontal curvature, pavement surface roughness and GPS coordinates (X, Y, Z) viz. longitude, latitude & altitude etc.

Based on the information collected through ARSS and using the map data, a user friendly GIS based interactive system will be developed. Key features of the Automated Road Survey System are:

a. High survey speed up to 100 km/hr
b. Longitudinal profiling (International Roughness Index)
c. Transverse profiling (rut depth) using Rut Scan Technology
d. Pavement texture in terms of Mean Profile Depth (MPD)
e. Pavement texture in terms of Sensor Measured Texture Depth (SMTD)
f. Slope, cross-fall and radius of curvature
g. GPS coordinates (X, Y, Z) viz. longitude, latitude & altitude, using Real Time DGPS

h. Video imaging for
   - Roadside furniture / Road Asset

i. 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

j. It is Windows XP based

A view of Automated Road Survey System, recently procured by CARRI from Australian Road Research Board (ARRB), is shown in Fig.76.

b) Roughometer-III

Roughometer-III is a high speed device used for measurement of pavement surface roughness. It is portable type equipment and consists of small accelerometer (sensor) device installed at the rear axle of survey vehicle, a distance measuring instrument, interface module and a controller. The 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 unit of International Roughness Index (IRI).

Fig. 76: Automated road survey system
PROJECT TEAM MEMBERS OF BRIDGES AND STRUCTURE DIVISION
Evaluation of Kalisindh Bridge for Increase in Axle Load of Freight Wagons on the Routes of West Central Railway (WCR)

Western Central Railway, Jabalpur has sponsored a R&D project to study the effects of increased axle loading (CC + B + 2) of freight wagons on Kalisindh Bridge (under slung steel girders) on the iron ore routes of Bina-Kota section of WCR. The aim of the project is to evaluate the effect of increased axle loading on primary members of the bridge under static and dynamic loads, determination of fatigue load effect on steel bridges based on cyclic loading and laboratory test on steel bridge element, thermal stresses and stresses in bearing etc. through instrumentation of the rail, superstructure, bearings and the piers/abutments.

The study thus involved, theoretical analysis of bridge, planning of the instrumentation scheme, extensive site work covering the installation of sensors and instruments and related activities at the sites, continuous monitoring of sensors/instruments data during passage of test trains and prevailing trains after installation, and studies related to the behaviour and performance of the bridge based on the field data. So far, the Institute has accomplished the field study in three parts and findings arising out of two visits have been reported to the WCR.

The study has successfully implemented a “conditioning monitoring system” comprising of several state-of-the-art techniques. The methodology adopted for the measurement of various performance parameters such as axle load spectrum, tractive and braking force in coupler, rail and bearing shows very encouraging results on repetitive basis (Fig. 77). The final measurement also confirms that the stresses, deflection and displacements of the bridge superstructure components remain within the allowable limits, under CC + B + 2 (enhanced proposed loading by Indian Railways) loading conditions (Fig. 78). The laboratory study for fatigue on a bridge component also exhibits satisfactory results (Fig. 79). Thus, such kind of study enhances the confidence of stake holders and allow the bridge owner to operate and functionalize the maintenance regime in more scientific manner.

![Fig. 77: Measurements of dynamic tilt on pier and tractive efforts though instrumenting the coupler](image-url)
Study of Corrosion Susceptibility of Steel Reinforcement Protected with Anti-corrosive Coatings / Special Treatments in Ordinary and High Performance Concretes

The scope and objective of the project sponsored by MORTH is to evaluate the corrosion susceptibility of coated reinforcements embedded in ordinary concrete against high performance concrete made with un-coated reinforcement.

The scope of the project shall be limited to evaluation of fusion bonded epoxy coated reinforcement (FBECR), hot dip galvanized (HDG) bars, cold applied zinc (Zingal) coating and thermo mechanically treated (TMT) bars, embedded in the ordinary concrete with a 28 day compressive strength of 35 and 40 MPa, and the high performance concrete (HPC), of similar strength ranges, embedded with un-coated reinforcement bar. An RCPT value of 800 coulombs and 1200 coulombs shall be chosen as requirement for HPC. The HPC shall be made with the combinations of (i) GGBFS + Silica fume, (ii) Fly ash + Silica fume, (iii) GGBFS + Fly ash + Silica fume.

The inception report and the state-of-art report were prepared and submitted to the Ministry. The steel moulds for casting the test concrete specimens were designed and fabricated.

Study of Thermal Effects for the Design of Rigid Pavements through Instrumentation

The objective of this completed study was to study the thermal effects in concrete pavements of three different thickness (300, 250 and 75mm) using instrumentation and monitoring.
The stress induced due to temperature gradient is an important parameter in the design of concrete pavements and as per the IRC: 58-2002, the variation in temperature across the thickness of concrete pavement slab is assumed as linear. However, it is a well-known fact that temperature distribution across the depth of slab is non-linear in rigid pavement and the method adopted for design is only an approximation. In our country, very limited field data is available to validate the temperature gradient used for design. Therefore, the concrete pavement of three different thicknesses, constructed in the Institute premises, has been instrumented and monitored for two years.

The study had been divided into two phases, phase-1 comprises of installation of sensors (Vibrating wire strain gauges and temperature sensors) to monitor several structural parameters (strain, thermal gradient, curling of slab, etc.) for a period of one year and phase-2 comprises of long-term monitoring of performance parameters and analysis of results. For the instrumentation work, three sections have been constructed with depth of concrete pavement 300, 250, and 75 mm designated as section-1, 2, and 3 respectively. The section-1 and section-2 was constructed with conventional concrete M-35 (43 grade cement (425Kg/m³) near guest house, CRRI. The section-3 was concreted with high performance fiber reinforced concrete ultra-thin white topping using M-35 concrete (43 grade cement (425Kg/m³), fly ash 10 per cent and fiber (recron) polyester 0.1 per cent at approach road to DRRI office.

Monitoring of parameters included the thermal gradient, strain and curling of slabs due to temperature. The following observations were made during routine monitoring:

1. **Monitoring of Temperature Variation:**

   **Section-1: (300mm)**

   During winter, the slabs remain in positive temperature differential between 10.30 am to 8.00 pm and in negative temperature differential between 8.00 pm to 10.30 am. The positive and negative temperature differential observed was minimum during winter. The condition of zero temperature differential occurred at 9.00 am and 7.30 pm. Maximum value of positive and negative temperature differentials were observed during summer and the maximum positive temperature differential was 6.7°C during May 2006 and average maximum negative temperature differential was -3.41°C during June 2005 (Fig. 80).

   ![Fig.80: Routine diurnal temperature variation (Jan-05) 300mm thick slab at section-1](image)

   **Section-2: (250mm)**

   It was observed that the slab remains in positive temperature differential during most
of the day time from around 10.00 am to 9.00 pm and in negative temperature differential from 9.00 pm to 10.00 am. The maximum positive temperature differential was 7.38°C and maximum negative temperature differential was -2.98°C during May 2006.

Section-3: (75mm)

The maximum positive temperature differential was 4.23°C in July 2006 and maximum negative temperature differential was -2.30°C during June 2005.

Monitoring of Strain:

Strain variation is more at the surface of the concrete as compared to the variation at various depths of slab. It is least at the bottom which shows that shrinkage at the surface layer is more as compared to lower layers. The magnitude of the strain decreases with increase in depth of concrete slab.

The maximum strain during hardening of concrete was observed at all depths after nearly 12 hours after placement of concrete. The strain value at top and bottom of concrete slab was observed as +50 (tensile) and +6 micro strain respectively and the corresponding value of stresses are 14.75Kg/cm² and 1.77Kg/cm².

Top surface of slab remains under tensile stress between 8.30 am and 9.30 pm and for rest of the period it is under compressive stress. The bottom of the concrete slab mostly remains under compression. It comes under tension for a short period in early morning. Figure 81 shows diurnal strain variation in 300 mm thick slab.

**Behaviour of Shear Deficient Beams Strengthened by Externally Embedded Reinforcement**

The objective of this on-going research project is to (i) study the performance of the rectangular RC beam specimen strengthened using near surface mounted (NSM) reinforcement, (ii) to study the enhancement in the shear capacity of the beam strengthened using the NSM technique and (iii) the field application of NSM technique for strengthening of the bridge component.

Under the project, rectangular reinforced concrete beams of size 150x250x2000 mm were cast in the laboratory with different deficiency in shear capacity. The concrete beams were strengthened by using near surface mounted (NSM) reinforcement such as steel strips and carbon FRP strips at an inclination of about 45 degree to the longitudinal axis of the beam. The strips were embedded after carving out grooves on both the vertical faces of the beam in shear region. The minimum groove width of the groove was kept 3 times the thickness of the strip and depth about 1.5 times the depth of the strip. The specimens were instrumented for
strain and deflection measurements during the testing. The specimens were tested under three-point loading which was applied through hydraulic jack. The development of the cracks and failure mode was monitored. The typical failure mode of shear deficient beam and the rehabilitated beam are shown in Figs. 82 and 83 respectively. The failure mode of the beam that does not have shear stirrups was due to the development of the critical diagonal shear crack in a classical way whereas, in the case of shear strengthened beam the existing critical diagonal crack neither developed nor opened up and the failure occurred due to “debonding” of NSM strip under the load point. The strain variations in the longitudinal steel reinforcement, NSM diagonal strips recorded during the testing is shown in Fig. 84. The magnitude of the recorded strain in the CFRP strips was about 8 per cent of the effective strain (ratio of the strain in the strip to the effective strain of strip, 800/ (0.85x2900/210000)) of CFRP strips (C210), revealing that the strip did not fracture. However, the reduction in the strain magnitude indicates that the failure mode is due to the debonding of the strips. The shear capacity of the beam with diagonal NSM strips is about 96 per cent that of the specimen having shear stirrups (V_s - V_c + V_u ).
Consultancy Assignments

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

As reported earlier, Engineering Department, West Central Railway, Jabalpur approached CRRI for the evaluation of bridges on the route of West Central Railway due to increase in axle load of freight wagons. The MoU was signed for the health monitoring of four bridges.

During this year, the second Interim Report was submitted to the clients. Subsequently the third and final round of field monitoring was completed in February 2011. Figure B5 shows the position of centrally loaded engine on the Instrumented span of length 22.86m span of the eight span fish valley type steel bridge.

![Fig. B5: A view of Ganjal bridge at WC railway during field monitoring](image)

Figure B6 shows the strain and Fig. B7 shows the displacement on the Flange of the Plate Girder at the Mid Span (Us) during the passage of the test train at a speed of 60 kmph.

![Fig. B6: Strain on the top range of the plate girder at the mid span (Us) due to test train at the speed of 60 kmph](image)

![Fig. B7: Vertical deflection at the mid span of the plate girder (Us) due to test train at 60 kmph](image)

The recorded data is being analyzed and will be compared with the theoretical results to evaluate the performance of the bridge under increased axle loads.

Evaluation and Monitoring of Rohari Steel Bridge in Katni-Maikpur Section of Jabalpur Division for Increased Axle Load of Freight Wagons

West Central Railway, Jabalpur approached the Institute for evaluation and monitoring of
33.45m long single span steel through truss type Rohari bridge, with the aim to evaluate the effect of increased axle loading on primary members of the bridge under static and dynamic loads, determination of fatigue load effect on steel bridges based on cyclic loading and laboratory test on steel bridge element, thermal stresses and stresses in bearing etc. through instrumentation of the rail, superstructure and bearings. Typical views of Rohari bridge are shown in Fig. 88 (a & b).

The rail is instrumented with electrical strain gauges for determining prevailing wheel loads and longitudinal forces in rails under various loading conditions. In critical members of bridge superstructure, strain intelliducers, electrical strain gauges, dial gauges, accelerometers, temperature sensors were installed. Strains were measured in rocker bearing and load cell installed across roller bearing to know the longitudinal force being transferred to bearing by the moving train. Level plates and tilt plates were installed on top of abutments to monitor the settlements and tilting of abutments. To monitor the stresses in the abutment during the various load cases, strain intelliducers are installed on the surface of the abutment in vertical direction below the rails. To estimate the total longitudinal force applied during starting of train and application of brakes by the engine, strain intelliducers were pasted around the periphery of CBC coupler and the strains were recorded during various load cases. Figure 89 shows the views of some of the installed sensors in the bridge. Railway has arranged a special test train for the testing of the bridge. The bridge was subjected to various load cases of this test train as well as prevailing trains as per RDSO recommendations and continuous data was recorded using data acquisition systems for further analysis.

Steel sample of the bridge was tested under fatigue loading in the laboratory. Analytical studies have also been carried out under various railway loadings using RM-2006 software.
Fig. 89: A view of some installed gauges

a) Strain Intelliducers in truss

b) LVDT for vertical deflection

c) Accelerometers for dynamic characteristics

d) Electrical strain gauges in rail

e) Electrical strain gauge in rocker bearing

f) Strain Intelliducers in engine coupler
The observations are as follow:

- The measured peak vertical deflection at mid-span of bridge due to passage of test train is 12.5mm which is lower than the permissible values.

- Measured dynamic characteristics of the bridge are found to be comparable with the theoretical ones. This indicates the acceptance of theoretical model.

- The measured maximum stresses in critical members of this bridge due to passage of test trains at different speeds are lower than the corresponding theoretically computed axial stresses.

- Coefficient of Dynamic Amplification (CDA) has been computed for critical members of the superstructure for test train running up to 58 kmph. CDA values are found to be different for various members for all the speeds of test train considered.

- Theoretical analysis results show that maximum stresses in superstructure are due to HML loading of railway. Under HML loading, the total maximum tensile stress of 92 MPa and total maximum compressive stress of 126 MPa is computed. Under test train running at 60 kmph case, the total maximum tensile stress of 55 MPa and total maximum compressive stress of 76 MPa is found.

- Measured maximum compressive and tensile stresses were found to be 50 and 30 MPa respectively under test train running at 58 kmph. These values got changed to 40 and 70 MPa respectively when full service brakes were applied on entire formation of test train.

- The measured local peak dynamic stress in critical members of this bridge due to passage of some of the goods train/passenger train are lower than the corresponding theoretically computed axial stress for all the loadings. The maximum measured tensile & compressive and tensile stresses due to passage of passenger/goods train is 34 MPa and 45 MPa.

- Based on the measured peak dynamic strain around the coupler cross-section of test train, the longitudinal force in coupler at the time of starting of goods train is estimated as 3.9 to 11.2 tons while at the time of braking as 20.9 to 29.1 tons.

- Based on the measured longitudinal strain on rails during starting/braking of test train, it is found that the maximum force of 9.2 tons is transmitted to each rail during starting of test train from roller end with brake binding of wagons.

- From the train records obtained from rail-sheaf circuit, the number of axles and corresponding axle loads passing over the bridge can be assessed using the computed calibration factor. From the strain records, it is observed that wagons/bogie weighing not more than 80 tons are passing over the bridge.
Rehabilitation of Sultanpuri Bridge at RD 21260m on Supplementary Drain, Delhi

The Sultanpuri bridge on Supplementary Drain at RD 21260 m is located in Delhi, connecting residential areas Sultanpuri on one and Mangolpuri on the other end. The bridge has four simply supported spans with 2-lane carriageway width and footpath on either side of the carriageway. The general view of the bridge is shown in Fig. 90.

At the instance of Govt. of NCT, Delhi, the Institute undertook the consultancy work to (i) carry out the visual inspection of superstructure and pier caps of four spans of the bridge, (ii) determine the in-situ concrete strength of superstructure and substructure (deck slab, longitudinal girders, diaphragms, pier and pier cap) through non-destructive tests, (iii) evaluate the concrete compressive strength after extracting few cores, (iv) visual inspection of bearings of each span and (v) to suggest suitable rehabilitation measures for the pier caps and other bridge components.

The pier caps of all the three piers (U/s and D/S pier) have developed vertical cracks in the central axis region of the pier cap. The crack width is in the range of 3 to 50 mm along the depth. Fig. 91 shows the location of cracks.

Fig. 91: Vertical crack in pier cap

Fig. 90: General view of the bridge
The detailed investigations conducted to know the in-situ concrete strength of different components through non-destructive testing is shown in Fig. 92. In addition to that the concrete cover to the top reinforcement of the pier was also measured with the help of Profometer as shown in Fig. 93.

Neoprene/elastomeric bearings over each support have been either torn off or bulged excessively i.e., distorted in shape. Expansion joints are chocked and not functioning properly. Based on the investigation, rehabilitation measures have been suggested for the repair of pier caps and other components. The existing elastomeric bearings need to be replaced with new elastomeric bearings of the same dimensions. The expansion joints are also needs repair or to be replaced with strip seal type expansion joints.

**Repair and Rehabilitation of Old ITO Bridge over River Yamuna (Delhi) - 3rd Party Random Quality Check and Inspection**

The old ITO Bridge known as barrage-cum-bridge built in the late sixties has 27 simply supported spans with twin carriageways caters to the east-west traffic across the river Yamuna. The two carriageways are of width 7.5 m each and are separated by a 1.2 m wide median and have 2.5 m wide footpath on either side. Presently this bridge is used for plying of west-east traffic only and a new bridge is used for east-west traffic. Fig. 94 shows the general view of the bridge.

The study reveals that the quality of in-situ concrete is good and conforming to the compressive strength corresponding to mix proportion 1:1.5:3 used for the construction of the bridge. However, the concrete spalling and honeycombing were observed at some locations. The concrete cover to the main top reinforcement in the pier caps is also more than the required and some deficiency in reinforcement detailing.
Repair and rehabilitation of this old bridge is in progress in two phases and the 3rd party quality control of the work has been entrusted to the Institute by Public Works Department. The work pertaining to Phase-I has been completed and the report has been submitted to the client.

In Phase-I, the repair activities were rescheduled due to the Common Wealth Games (CWG) that were held in the month of October, 2010. The quality of repair has been checked through random visual inspection at site from time to time at different stages and through laboratory tests at CRRI as and when required. The existing expansion joints have been replaced with the new strip seal type expansion joints. A typical view of dismantled existing joint replaced with new joint assembly is shown in Fig. 95 (a, b & c).

Both the carriageways have been overlaid with 25 mm thick mastic without dismantling the existing one. The existing crash barriers, railings, water spouts, kerbs and median have also been replaced with new one as shown in Fig. 96.
The material used during the construction have also been tested randomly in laboratory such as determination of cube compressive strength of the supplied cubes, flattening test on GI pipes used in the crash barriers, tensile strength of MS channels, square bars. Figure 97 shows the flattening test on GI pipe. Apart from this, the neoprene rubber seal has also been tested for ultimate tensile strength and percentage elongation Fig. 98.
Non-Destructive Testing of Multistories Building in MBSQ, Maharani Bagh, New Delhi

In continuation at the work reported earlier (Annual Report 2009-10), non-destructive testing of columns, beams and shear walls of the MS building at 20 locations using rebound hammer (Fig. 99), ultrasonic pulse velocity and carbonation tests were carried out. Besides, three cores were extracted from shear walls to assess the compressive strength of concrete (Fig. 100).

The rebound hammer test results indicated that there is a variation in the strength of concrete in different structural elements. The columns and beams at the porch exhibited higher compressive strength than those of other structural members in higher floors. The compressive strength of columns in the porch area are in the range of 28 to 32 MPa, and that of beams in the porch area on the side of Lift 1 side are in the range of 23 to 27 MPa. The rest of the structural members exhibited a compressive strength in the range of 16.5 to 22.0 MPa. The ultrasonic pulse velocity of concrete is found to be more than 3.5 km/sec at many test locations thereby indicating that the quality of concrete is good. The concrete columns at porch exhibited higher UPV (above 4.0 km/sec). The quality of concrete at 5 locations was found to be medium (UPV between 3.0 to 3.5 km/sec) and that at two locations it was found to be doubtful (UPV was less than 3.0 km/sec). The results of the test done randomly for determine carbonation of concrete in the structural elements indicates that the depth of carbonation varies from 60 to 80 mm. The average equivalent cube compressive strength of concrete in the shear wall at ground floor level is 36.6 MPa.

Assessment of Load Carrying Capacity of Bailey Bridge, Koteshwara Hydroelectric Project, Uttarakhand

Bailey bridge (of 4.25m carriageway and about 200 feet single span) was erected in the upstream of Koteswara dam over river Bhagirathi which was suitable for IRC Class 30-R loading. Between year 2009 and 2010, this bridge was dismantled from upstream of the
Koteshwar Dam and erected but finally shifted to the downstream of the dam with reduced span, before the outlet of the diversion tunnel. Present span of the bridge is about 58m. After the erection of the bridge at its present location, the vehicles were not allowed to ply over this bridge due to some doubts about the present load carrying capacity of the bridge (Fig. 101).

At the instance of THDC India Ltd., field visit was carried out to get the necessary details of the bridge for performing the structural analysis as the design and drawings of the bridge were not available.

Testing of the steel samples of the bridge was done in CRRI laboratory. Percentage elongation and tensile strength of all the test specimens meet the requirement of Fe-415 grade steel.

Hence, in the analysis, steel of 415 MPa grade has been considered. The bridge was then modeled (Fig. 102) and analysed using RM 2000 software. In IRC Class 30R loading, there can be two types of vehicle namely tracked vehicle of 30 tons weight and wheeled vehicle of 38 tons weight. Maximum bending...
moment was obtained due to movement of wheeled vehicle instead of tracked vehicle. Analysis was carried out for self weight and symmetric as well as asymmetric placement of IRC Class 30-R wheeled vehicle loading across the width of the bridge, considering impact factor due to its movement. Deflections of the bridge under full live load condition are given in Table XIV.

During the load testing, load was placed over the bridge in various increments (Fig. 103). Load was applied over the bridge by simulate the IRC Class 30R wheeled vehicle itself. The CG of the load was kept at the mid-span of the bridge. Since the asymmetric loading has severe effect than symmetric load, therefore loading was placed asymmetrically on the downstream side.

The measured deflections of the bridge at mid-span after applying temperature corrections, under various stages of the applied loading are comparable to the theoretical deflection values. The instantaneous and creep percentage recovery on unloading of full load are within permissible limits. Based on the load testing results, theoretical analysis and discussions on results, it can be concluded that the superstructure meets the requirements of acceptance criteria of load test.

**Strengthening Measures for Kalimati Road Bridge, Jamshedpur**

The Kalimati Bridge was built in 1967 as a Road Over Bridge across Kalimati road, Jamshedpur. It is a 4-span RCC T-girder bridge built with a skew angle of 30° in plan. The superstructure consists of 7 numbers of longitudinal girders and diaphragm walls in each span. The total

![Fig. 103: A view showing loading over the bridge](image)

### Table XIV Deflections of the Bridge under Full Live Load

<table>
<thead>
<tr>
<th>Load placement</th>
<th>Deflection measuring locations</th>
<th>Theoretical deflection ((\sigma_{\text{theory}})) under IRC Class 30-R loading (mm)</th>
<th>Instantaneous deflection ((\sigma_{\text{inst}})) under load test (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetric loading for maximum bending moment of IRC Class 30R wheeled vehicle</td>
<td>½ L (left bank)</td>
<td>19.60</td>
<td>22.00</td>
</tr>
<tr>
<td></td>
<td>½ L</td>
<td>30.69</td>
<td>45.68</td>
</tr>
<tr>
<td></td>
<td>¾ L (right bank)</td>
<td>20.10</td>
<td>17.00</td>
</tr>
</tbody>
</table>

---

*Scanned by CamScanner*
length of skew span bridge is about 50m arranged in a four span configuration of 7.6, 17.4, 17.4 and 7.6m length (approx) resting on five supports through steel plate bearing. The longer bridge portion over the roadway is a two span continuous unit with overhangs on either side to create half joints (articulation). The end spans are suspended units supported at the articulations and on the multileg portals which serve as open abutments.

In October 2009, M/s Tata Steel Ltd., Tatanagar noticed damages (Fig. 104) to the soffit of longitudinal girders of the bridge (i.e. portion of the bridge over carriageway from Railway end to Sakchi end), due to passage of over height vehicle underneath the bridge.

During the field visit, T-girders and diaphragm walls of the bridge in the area near to the central column supports were found to be...
damaged. Mild steel reinforcement bars were found to be exposed and bent at several locations. At several locations, cracks in the various members were also noticed.

All the T-girders, diaphragm walls and columns were found to be guinited. The bearing plates were noticed to be covered with guiniting material and thus were ineffective for the intended use. Accumulation of water over the bridge deck was also observed. Due to this accumulation of the water, seepage from the articulation joints was observed. Vegetation growth over the footpath portion of the bridge was also observed.

Non-destructive investigations (i.e. Schmidt Rebound Hammer test, Ultrasonic Pulse Velocity test, Core test, Rebar Locator test and Carbonation test) were carried out at the spans of the bridge.

Schmidt hammer test results show the compressive strength of concrete at the testing locations is in the range of 47.83 to 57.19 MPa, 44.11 to 62.12 MPa and 32.48 to 61.87 MPa for girders, diaphragm walls and columns respectively. The characteristics compressive strength of concrete at test locations is estimated is in the range of 29.41 to 39.99 MPa and 32.20 to 54.69 MPa for Girders and Diaphragm walls respectively. This wide range of variation may be due to the presence of guiniting layer over the concrete surface.

UPV test results indicate that quality of concrete is 'Medium' to 'Good' in columns, 'Doubtful' to 'Good' in girders and 'Doubtful' in diaphragm walls. Doubtful quality of concrete may be due to debending of guiniting layer from concrete. UPV tests have been conducted mostly on the guinited surface as it was not possible to peel-off the layer of guiniting. At some locations, the guiniting layers and the parental concrete substrate lacks in bonding. The interfacial bond of guiniting layer and the concrete substrate is lacking in all the diaphragm walls.

Depth of carbonation at tested locations of girder varies from 6 to 37mm. As the thickness of guiniting layer varies from 28 to 55mm, so carbonation has not reached up to the steel reinforcement. Core test result indicates that estimated cube strength of concrete in girders is 25.80 MPa. Thickness of guinited layer is also measured which is found to be varying from 28 to 55mm. Cracks observed in the various members were found to be in guinited portion only. They have not penetrated into the concrete so far.

Thus, it was concluded that no major damage to the bridge has occurred due to the collision of the vehicle with the bridge deck. The damage portion is repairable. The scheme for repair of the damaged portion of the bridge was suggested.
PROJECT TEAM MEMBERS OF INSTRUMENTATION DIVISION
Development of GIS Based National Highway Management System

As reported earlier (Annual Report 2009-10), study on “Development of GIS Based National Highway Management System” for effective and efficient management of primary road network of the country has been sponsored by Ministry of Shipping, Road Transport & Highways. Under this project, an advanced Network Survey Vehicle (NSV) has been procured from ARRB, Australia for generation of data base on road conditions and inventory of road for National Highway network in the country (about 50,000 km).

During the year, collection of primary road condition and road inventory data through NSV utilizing laser, global positioning system and video image processing tools etc. on National Highways was continued. The inventory data collected through advanced data processing & reporting software include measurement of gradient (Rise & Fall), Horizontal Curvature, Pavement Surface Condition (distress), Roughness and GPS Co-ordinates (X, Y, Z) viz. longitude, latitude & altitude etc.

Upgradation of Road Geometrics and Road Condition Evaluation System

Work on upgradation of Road Geometrics and Road Condition Evaluation System is in progress. Procurement of equipments (Navigation System, Roughness measuring device) for measurement of road geometrics is under progress. For upgradation of road condition evaluation equipment, pavement view camera (2 Nos.) and asset view camera (2 Nos.) and distance measuring device have been procured. Testing and installation of Road Condition Evaluation Equipment in Tata Sumo Vehicle is in progress.

Calibration of Automatic Road Unevenness Recorder (ARUR)

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 (Fig.105). 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.

Fig.105: Calibration of ARUR in progress.

Repair & Maintenance Work:

During the year, operation, repair & maintenance of various types of R & D equipments as well as infrastructure equipments including EPABX system, Audio / Video systems, UPS systems, stabilizers, power supplies and other equipments up to component level has been carried out.
PROJECT TEAM MEMBERS OF TRAFFIC ENGINEERING AND ROAD SAFETY DIVISION
Assessment of Drivers Driving Characteristics Using Advance Driving Simulator

To evaluate various good / bad driving practices of drivers under various (simulated) driving conditions e.g. city roads and highways under various level of difficulties and their risk taking practices and obedience/violation of traffic rules as per Indian road vehicle act, a study has been carried out. The first step taken in increasing data base by using car driving simulator, including more parameters for evaluation and screening of drivers; provide centralized access to allow improve management of tests and scheduling and introduce security measures to prevent subjectivity, randomization of tests.

The main objective of this project is to make road users more safe, aware and proactive in response to other drivers on the road and prevent minor incidents caused by careless driving through assessing and screening out driver’s risk taking drivers.

For fulfilling such objective a car driving simulator was installed in the Institute. A training programme was organized in the Driver Testing Laboratory by the Engineers of Zen Tech Pvt. Ltd. which was attended by eleven scientists. Drivers of different educational background and economic status were tested for three different courses (i.e., basic, intermediate and advanced).

Hundred drivers from high responsibility group and private car owners were administered skill tests on simulator. The data collected so far highlights that during simulated driving condition 37 per cent drivers had shown risk taking attitude as they frequently crashed their vehicle with any type of static (tree, pavement etc.) or moving objects (vehicles), 27 per cent drivers did wrong lane driving, 16 per cent drivers gave wrong side indicator while changing lanes, 60 per cent drivers overtook from wrong side, 63 per cent drivers violated speed limit and 15 per cent drivers did not obey the traffic signals and road signs.

Consultancy Assignments

Road Safety Audit for Public Private Partnership Projects on DBFO Basis (NHAI)

National Highways Authority of India has sponsored the project for carrying Road Safety Audit in different parts of India. CRRI was awarded 12 packages: Around 1191 kms of roads in four states of India are to be audited as given below:

- Punjab (129 kms) (Package no : 7 & 9)
- Uttar Pradesh (399 kms) (Package no: 10, 11 &12)
- Uttarakhand (119 kms) (Package no: 13, &14)
- Andhra Pradesh (544 kms) (Package no: 32, 33,34,35 &36)

The project duration is of three years. These packages are to be audited at both Development Phase and Construction Phase of the project.
The scope of the work during:

(i) Development Period:

- Provide submission of inception Report which includes methodology and implementation plan during the development and entire construction period.
- Collect traffic data as per IRC standard, for 2 years relevant period from primary or secondary sources.
- Collect data of all fatal crashes and other road accidents for pending two years and enter into Road Information System (RIS) of NHAI.
- Collect from feasibility report/Detailed Project Report (Secondary Source) base line data as per Data Dictionary of RIS.
- Do analysis of fatal and grievously injured accidents as “Crash Analysis” and relate road accidents with traffic volume to show trend as per traffic volume count.
- Collect design details from the Concessionaire including horizontal and vertical alignments; sightlines; layouts of intersections; interchanges; road cross-section; bridges and culverts; side drains; provision for parked vehicles, slow moving vehicles (tractors, bullock carts, bicycles) and pedestrians; bus bays; truck lay-bys; toll plaza; other traffic central device, crash barriers and other incidental or consequential information;
- Review the design details provided by the Concessionaire and forward the safety drawings with its recommendations of safety related measures which will include Black Spot Analysis.
- Receive comments from Concessionaire, Independent Engineer and NHAI and furnish revised recommendations of safety measures duly examining the above comments and submit safety report which will inter alia include cost of carrying out such measures as per contract clause.
- Enter all Reports of Para 4 & 8 in RIS.
- Provide monthly reports on all activities which were planned, actually executed and planned next month.

(ii) Construction Period:

- Study the safety report of the development period and provide a gap report vis-à-vis what was given in final safety report and safety report which was finally implemented;
- Inspect the project highway once in a calendar quarter to assess the adequacy of safety measures and before COD.
Carry out 7 days classified traffic volume counting as per IRC Standards after 6 months from commencement of work (to be called time series value # 1, followed by every 6 months as time services count # 2, 3 ... and enter it in RIS.

Toll related data to be collected from Toll Plaza (Secondary Source) every month inter alia will include traffic volumes, classification of traffic volumes as per axle loads, revenue collected (total and type of vehicles), entering this data in RIS and relating with accident data.

Speed and Delay Study, Bridge Inventory and Assessing Pavement Condition and Corridor Efficiency Parameters, Study Asset Updation and Inspection.

Collect data on fatal and other accidents from Police Stations and other secondary sources, do crash analysis. Enter accident data in RIS.

Submit a safety report on additional road safety measures, if any.

Receive comments from Concessionaire, Independent Engineer and NHAI and furnish revised recommendations of safety measures duly examining the above comments and submit safety reports with financial implications as per Contract clauses of concession Agreement.

Conduct work zone safety audit

Provide monthly reports on all activities which were planned, actually executed and planned next month.

Contract Agreement was signed for 12 packages at NHAI.

During the period under review, following work was carried out

- workshop cum training program was conducted for four (4) packages viz 7, 9, 13 & 14 for the states of Punjab and Uttrakhand.

- The field training was imparted to the respective PDs of these packages in the month of January.

- Site visits to these packages were undertaken to have the field appreciation of these packages.

- Inception reports of ten packages covering approach and methodology to be followed for the assigned job were prepared and sent to NHAI & concerned PDs. Remaining two Inception reports will be sent in April, 2011.
Workshop for five (5) packages in Andhra Pradesh at Hyderabad was conducted.

Field appreciation and field training to the PDs of UP packages has been conducted.

Further work is in progress.

**Development of Road Safety Strategy and Generating Awareness on Traffic and Road Safety – Package VII (Phase-II)**

This consultancy project was sponsored by ICRA Management Consulting Services Limited. As the accidents on this high-speed facility are quite high and this is the first access-controlled urban highway in Delhi, the road safety audit of it was a challenging task. The objectives and scope of the project study are as:

- To review of the Road Safety Audit studies undertaken by PRRDB for the test sections and conduct of RSA conforming to IRC ‘Manual on RSA – 2010’.
- To study road user behaviour on project roads.
- To study enforcement & evacuation mechanism as prevalent on road corridors.
- To identify an exhaustive list of stakeholders expected to bear the direct and indirect impacts of road safety measures (or lack of it).
- To review of safety status of select stretches during construction stage.

To develop a safety awareness generation plan with an object to:

a. Instigate a sense among communities that traffic safety is a community concern.

b. Educate policy makers as well as common people regarding the road safety as a major tool to prevent accident & action to be taken in the incident of accident.

c. Initiate community policing in the selected areas to ensure obedience to traffic laws by local road users.

d. Indoctrinate the residents along the road, the sense of ownership of the road signs & other safety measures installed and explain that these are meant for their safety.

e. Provide capacity building training to target population.

f. Strengthening of local Non Governmental Organizations (NGO) and Community base organizations (CBO) and their linkage through capacity building training, so that they in-turn can provide training to other road users/personnel.

- Delivery of an Awareness Generation Plan

First survey of RSA from Chandigarh - Mohali road stretch was conducted jointly by the team which included CRRI, ICRA and IMAC professionals who visited to the preselected locations. The specific safety issues covered during audit are:
(i) Road Safety Audit of the facilities related to the motorized/non-motorized users; the cross-sectional design elements which included roadways, shoulders, medians, clear zones, drainage, plantation etc.; safety issues concerning to the service roads e.g. junctions, road widths, roadside fixed objects, shoulders drainage etc.; road side hazards e.g. trees; exit/entry points of the selected road stretches; road safety audit of the road signs, road markings and lighting system; road safety audit of the availability of subways; road safety audit of the non engineering issues, pedestrian facilities and safety provisions for NMT users.

(a) Behavioural survey of motorized and non motorized road users, pedestrians including persons with disabilities and enforcement people i.e. traffic police personnel, for estimating the following problems faced by them:

a. Problems faced by the pedestrians while crossings
b. Availability of traffic signals/road signs
c. Maintenance and usability of road signs/signals
d. Maintenance of different road safety equipments
e. Availability and usability of road safety equipments
f. Any hurdles faced by the traffic police personnel during patrolling

Inception report has been submitted and study is in progress.

High Security Registration Plate System

M/s Tonnjes Eastern Security Technologies Pvt. Ltd has started the process of manufacturing High Security Registration Plate (HSRP) for motor vehicles. This is second firm to which approval has been granted by this Institute and has started fixation of HSRP in the state of Sikkim. As per latest guidelines of MORTH the process of Conformity of production (COP) of HSRP has been restored. The work pertaining to COP of HSRP was carried out at work place at Kala-Amb, Himachal Pradesh and also at embossing station at Gangtok (State of Sikkim). A team of scientist visited both the places and collected the samples of HSRP. The necessary tests were carried out. The test regarding resistance to corrosion for which HSRP samples were tested under the action saline for two cycles of 22h in salt fog chamber. On the basis of satisfactory results of various tests, COP was awarded to manufacturer of HSRP.

Design of Rotary at Englishia Intersection

At the instance of UP, PWD, a study has been carried out with the objectives to design the rotary on Old G.T. Road at the Englishia Line Intersection, to design the access points around the intersection and to suggest measures to relieve congestion.
The physical survey plan supplied by UPPWD for the study section has been critically examined to ascertain the appropriateness of the intersection details on the ground including location of utilities and structures. Classified Turning Volume Count was conducted for 14 hour period (from 07:00 a.m. to 09:00 p.m.) at Englishia intersection. Further, 24-hour classified mid-block traffic volume count survey near Varanasi Cantonment railway station was also conducted to understand the pattern of traffic volume during the night hours on the G.T. road (Figs 106 & 107). The traffic data was analyzed for effecting geometric improvements to the Englishia intersection. Based on the observed traffic flows, the intersection design has been recommended keeping in mind the available RoW. Following recommendations were provided.

**Provision of Rotary at Englishia Intersection**

As the maximum traffic interaction is between Mughal Sarai and BHU bound approaches, a roundabout of 15 m radius coupled with dividers and channelising islands of appropriate dimensions has been proposed to guide the traffic. This design is prepared keeping in mind the higher percentage of traffic plying between Mughal Sarai and BHU bound approaches suiting to the geometry of the intersecting legs and thereby achieve longer weaving length for the
desired intersecting approaches. The design is self-regulating without any external control and would be capable of handling the projected peak traffic in the immediate short term which is expected to sustain for the next 4 to 5 years. This design also facilitates easy movement of straight traffic between Allahabad and Mughal Sarai bound approach arms through properly delineated lane markings and at the same time, appropriate weaving length has been provided for the right turning traffic from BHU approach arm to the Mughal Sarai approach arm. Further, the left turning traffic from BHU to Allahabad direction is physically segregated by providing 5.5 m exclusive lane and thereby the traffic bound to/from the Nehru Market has also been merged with the left bound traffic emanating from BHU approach.

**Provision of Pedestrian Facilities:** Contiguous foot path all around the vicinity of the intersection and pedestrian zebra crossing is earmarked at appropriate locations.

**Provision of Parking Facilities:** Parking lots have been recommended to be earmarked on both sides of the BHU approach arms catering to the parking of auto rickshaws and cycle rickshaws. To facilitate the rail commuters emerging from Varanasi Cantonment railway station, exclusive parking area has been allocated for auto rickshaws.

**Provision of Service Road:** It is included on approach of railway station only due to non-availability of RDW on other approaches.

**Estimation of Future Traffic and Sustainability of Improvement Plan**

The maximum peak hour traffic handled presently at this intersection is of the order of 5398 PCUs. Since the left turning traffic from BHU approach to the Allahabad has been segregated coupled with provision of two lanes for the left turning from Mughal Sarai approach to BHU approach, the peak hour traffic estimated to negotiate at this intersection is about 3741 PCUs only at present. Assuming 7 per cent growth rate in traffic in the next 4 years, the projected traffic volume which will be handled at this intersection is estimated to be 4903 PCUs by the end of 2014 and it is expected that the short term design conceived in this study would be sustainable till that period of time. Further, it may be noted that it will be useful to consider extending the flyover presently being constructed beyond Cantonment Railway Station up to Kamlapati Girls Inter College.

**Comprehensive Mobility Plan for Ghaziabad City: Traffic Management Plan (Phase - I)**

This study has been carried out with the objectives to work out a traffic/transport system management plan which can help in easing the existing traffic problems in Ghaziabad and also to optimize the use of existing infrastructure.

Various traffic studies like intersection volume counts, pedestrian volume counts, mid-block counts, speed and delay surveys, parking studies, and road safety audit were carried out to assess the existing traffic problems on the selected road corridors and its vicinity.

**Classified Traffic Volume Surveys**

Classified Traffic Volume surveys were carried out at selected 12 intersections to assess

CSIR-CRRI, New Delhi

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out the turning movements and intersection volumes. Intersections surveys were conducted on normal working days of the week spanning for 14-hour time period starting from 07:00 am to 21:00 hrs. These intersections and mid block sections considered in this study are distributed spatially over the entire city of Ghaziabad falling along the four major corridors namely, NH-91, NH-58, NH-24 and Master Plan Link road. The twelve intersections included for traffic studies include GDA / Old Bus Stand Intersection, Hapur Chungi Intersection, Chandrasekhar Azad Statue Intersection, U.P.Gate Intersection, Lal Kuan Intersection, Choudhary More Intersection, Mahamaya Stadium Intersection, Nandgram Intersection, Gookna Intersection, Mohan Nagar Intersection, Karehda Intersection and Aradhana Cinema Intersection. Further, 24-hour mid block classified traffic counts were carried out at four locations on the study area road network namely, NH-24 (Near U.P. Gate Intersection), on NH-91 (Near Choudhary More Intersection) and at two locations on NH-58 (In front of Cinema Theatre near Hyundai Showroom and Mahamaya Stadium). A typical illustration of the traffic scene (Fig. 108) coupled with observed turning movements and traffic composition at GDA intersection is shown in Fig. 109.

Fig. 108: Chaotic traffic scene at GDA intersection.

Fig. 109: Hourly variation of traffic volume and composition at GDA intersection.

A summary of the observed traffic at the specified intersections and mid block locations along the corridor is presented in Table XV and Table XVI. Maximum quantum of traffic is handled at
### Table XV

Summary of the Traffic Flows on Selected Intersections in the City of Ghaziabad (14-hour period)

<table>
<thead>
<tr>
<th>Name of the Intersection</th>
<th>Weekday</th>
<th>Total PCUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDA / Octroi (Roundabout)</td>
<td>104369</td>
<td>104369</td>
</tr>
<tr>
<td>Mohan Nagar Intersection</td>
<td>104554</td>
<td>104554</td>
</tr>
<tr>
<td>Mahamaya Stadium Intersection</td>
<td>104251</td>
<td>104251</td>
</tr>
<tr>
<td>U.P. Gate Intersection</td>
<td>104497</td>
<td>104497</td>
</tr>
<tr>
<td>Kalkatna Intersection</td>
<td>104698</td>
<td>104698</td>
</tr>
<tr>
<td>Nizamulqulam Intersection</td>
<td>104764</td>
<td>104764</td>
</tr>
<tr>
<td>Gonda Road Intersection</td>
<td>104412</td>
<td>104412</td>
</tr>
<tr>
<td>Chaubari Road</td>
<td>104541</td>
<td>104541</td>
</tr>
<tr>
<td>CDA (near Azad Smarak Chowk)</td>
<td>104406</td>
<td>104406</td>
</tr>
<tr>
<td>Kendriya_Vihar Intersection</td>
<td>91190</td>
<td>91190</td>
</tr>
<tr>
<td>Lal Kuan Intersection</td>
<td>76548</td>
<td>76548</td>
</tr>
<tr>
<td>Sadar Bazaar_ East Road</td>
<td>91138</td>
<td>91138</td>
</tr>
</tbody>
</table>

### Table XVI

Summary of the Traffic Flows on Selected Arterial Roads in the City of Ghaziabad (24-hour period)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Mil Block Section</th>
<th>Passenger Vehicles</th>
<th>Goods Vehicles</th>
<th>Non-Motorized</th>
<th>Total Traffic</th>
<th>Total PCUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U.P. Gate (Near U.P. Gate)</td>
<td>38664</td>
<td>10364</td>
<td>1384</td>
<td>1754</td>
<td>47940</td>
</tr>
<tr>
<td>2</td>
<td>NH-24 (near Hyundai Showroom)</td>
<td>22186</td>
<td>7986</td>
<td>724</td>
<td>2571</td>
<td>37620</td>
</tr>
<tr>
<td>3</td>
<td>NH-91 (near Vasant Kunj)</td>
<td>17950</td>
<td>6863</td>
<td>822</td>
<td>1546</td>
<td>25361</td>
</tr>
<tr>
<td>4</td>
<td>NH-58 (near Mahamaya Stadium)</td>
<td>1547</td>
<td>5163</td>
<td>758</td>
<td>1952</td>
<td>82646</td>
</tr>
</tbody>
</table>

GDA Intersection followed by Mohan Nagar intersection, Mahamaya Stadium Intersection and U.P. Gate intersection respectively which illustrates that the traffic interaction between Ghaziabad and the rest of NCR including Delhi contributes for the maximum traffic loads observed on these road sections. Further, a close look at the traffic volume handled at different intersections falling along this corridor clearly warrants for the augmentation of the carriageway widths as the observed volume (14-hour) is well in excess of 1,00,000 vehicles at most of the intersections. In the case of 24-hour mid block traffic volume counts, maximum traffic was handled on NH-24 followed by NH-58 (Near Hyundai Showroom) and NH-91 (Near Choudhary More) which demonstrates the fact that the NH-24 obviously also accounts for the sub-urban traffic commuting between Ghaziabad and Delhi which is in addition to the inter city traffic.

The proportion of two wheeler traffic dominates on the intersections located within the city whereas the share of car traffic dominates at the intersections located at the fringes of the city.
The share of non-motorized traffic especially cyclist traffic is higher (10 to 15 per cent) on those intersections (like GDA Intersection, Goknag intersection, Nandgram intersection, Choudhary More, Azad Chandrasekhar Azad Statue Intersection and Mahamaya intersection) which are located within the city of Ghaziabad (or near Shahdara) as compared to those intersections (like U.P. Gate intersection) located on the fringes of the city. This analogy is true in the case of mid block road sections which can be ascertained from the Table. This supports the argument that traffic movements possessing the longer trip length bound to Delhi and rest of NCR are mostly met through motorized two wheelers and cars whereas the cycles and other forms of NMT including cycle rickshaws contribute to local commuting needs of the road users in the vicinity of Ghaziabad.

Assuming 7 per cent growth rate in traffic in the next 10 years, the projected traffic volume that would be handled at the above intersections and the arterial roads of the city has been estimated for the horizon years of 2015 and 2020. The corridor improvement proposals integrating with the geometric design improvements for the identified intersections have been conceived taking into consideration of the e-projected horizon year flows at the respective corridors and intersections.

**Pedestrian Counts at Major Intersections**

Pedestrian counts were carried out at selected intersections in the study area where sizable quantum of pedestrian movement is witnessed in the vicinity of the intersections during the peak hours to assess the adequacy of the sidewalk requirements and the need for providing pedestrian crossing facilities including pedestrian signals and Foot Over Bridge or Subways. The peak hour pedestrian and vehicular volumes are very high such that the hazard index is much higher than the critical value recommended by IRC and thereby analyzing the need for the provision of appropriate pedestrian crossing facility based on the PV² (i.e. Pedestrian * Traffic Volume) for the above intersections. PV² Index values calculated for different locations indicated that pedestrian crossing facilities like FOB or pedestrian subways are warranted at most of the locations including the FOB at Mohan Nagar intersection, GDA / Bus Stand Intersection, Choudhary More and near Collector Office whereas staircase connecting Lal Kuan with NH-24 has been recommended as the PV² Index is very high signifying the immediate need for the provision of the above stated facilities at the above locations.

**Parking Studies at Selected Locations**

Parking studies were carried out at selected locations to assess the present parking problems at busy areas and thus examine its impact in terms of reduced speeds or congestion on those corridors. Amongst the parked vehicles, quantum of two wheelers is the maximum at most of the locations except near Hyundai Showroom wherein the number of parked goods vehicles is the maximum. A close look at the parking duration studies carried out at the locations namely GDA Off street parking lot and on street parking near Hyundai showroom showed that between 60 to 80 per cent of all vehicle types are parked for less than 2 hours. Based on the results of the study, it is recommended
to augment parking facilities in the vicinity of the commercial areas in the city by designating specified locations along the above road stretches through the creation of paid on street parking facilities.

**Speed and Delay Studies**

Speed and delay survey was conducted on the study area network by using Moving Car Observed (i.e. Probe Vehicles) method on normal working days covering both morning and evening peak periods. The survey was conducted to quantify delays and speeds of vehicles on the study area road network. The summary of details are given in Table XVII.

Based on the detailed analysis of the speed and delay data collected on the five major road corridors namely, NH-24, NH-91, NH-58, Master Plan Link Road and Dr. Ambedkar road passing through the city of Ghaziabad, it was inferred that more than 50 per cent of the delays is encountered at the junctions thereby clearly warranting the case for improvement of the study area road network geometrics at junctions and in addition capacity augmentation measures.

**Recommendations**

Traffic Management Plan (TMP) conceived in this study encompasses developing corridor improvement plans for the National Highways namely, NH-24, NH-58, NH-91 and Master Plan Link road. This also includes evolving improvement proposals for the major intersections falling on these corridors and thereby achieve better linkages between these corridors so as to improve the mobility. On the basis of set of traffic surveys conducted on the identified road network of the city, short and long range traffic improvement and capacity augmentation plans have been recommended.

**Table XVII**

**Summary of Speed and Delay Surveys**

<table>
<thead>
<tr>
<th>Name of corridor</th>
<th>Direction</th>
<th>Total Distance (in Kms)</th>
<th>Total Travel Time (in min.)</th>
<th>Running Speed (Kmph)</th>
<th>Total Delay (in sec.)</th>
<th>Delay % of Travel Time</th>
<th>Avg. Delay (in sec.)</th>
<th>Avg. Journey Speed (Kmph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lai Kuan to CISF</td>
<td>Up</td>
<td>7.8</td>
<td>13.0</td>
<td>38.7</td>
<td>51.5</td>
<td>6.6</td>
<td>6.6</td>
<td>38.1</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>7.8</td>
<td>13.0</td>
<td>38.7</td>
<td>13.8</td>
<td>1.9</td>
<td>1.8</td>
<td>38.9</td>
</tr>
<tr>
<td>Azad Chowk-Hapur Chungh-Chandpuram</td>
<td>Up</td>
<td>7.8</td>
<td>12.5</td>
<td>40.9</td>
<td>63.0</td>
<td>8.4</td>
<td>8.1</td>
<td>37.4</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>7.8</td>
<td>12.5</td>
<td>40.9</td>
<td>50.8</td>
<td>8.8</td>
<td>8.5</td>
<td>37.6</td>
</tr>
<tr>
<td>Mohan Nagar Chowk to Lakhuan Chowk</td>
<td>Down</td>
<td>10</td>
<td>26.2</td>
<td>25.3</td>
<td>26.7</td>
<td>15.8</td>
<td>26.7</td>
<td>21.3</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>10</td>
<td>26.5</td>
<td>25.6</td>
<td>180.2</td>
<td>11.3</td>
<td>11.0</td>
<td>22.7</td>
</tr>
<tr>
<td>Chaudhary More to Gokhna Jn.</td>
<td>Up</td>
<td>3.1</td>
<td>8.1</td>
<td>23.9</td>
<td>17.0</td>
<td>3.5</td>
<td>5.5</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>3.1</td>
<td>8.4</td>
<td>22.5</td>
<td>10.6</td>
<td>2.1</td>
<td>3.4</td>
<td>22.0</td>
</tr>
<tr>
<td>Meerut Chowk to Hapur Bypass</td>
<td>Up</td>
<td>4.1</td>
<td>8.2</td>
<td>34.0</td>
<td>42.0</td>
<td>8.8</td>
<td>10.2</td>
<td>31.0</td>
</tr>
<tr>
<td></td>
<td>Down</td>
<td>4.1</td>
<td>8.2</td>
<td>34.0</td>
<td>42.0</td>
<td>8.8</td>
<td>10.2</td>
<td>31.0</td>
</tr>
</tbody>
</table>
Based on the critical analysis of the peak hour traffic flows at the above identified road sections and intersections coupled with examination of the existing base map (in terms of available RDW), the improvement plans have been conceived by providing the appropriate geometric features. Care was exercised while redesigning the study area road network by providing requisite geometric design elements as per IRC: SP-41 and IRC: 65 without resorting to any major land acquisition. In the case of minor intersections falling along the corridors, the similar strategy was adopted as well without detailing of the intersection elements. In addition to the development of the above corridors, CRRI was requested as part of the present study to explore the possibility of integrating the proposed six lane road link emerging from NH-24 Bypass with NH-58 at Mahamaya Stadium Intersection. The detailed improvement plans (A4 size AUTOCAD drawings) has been developed for the above mentioned road corridors.

Further, considering the present status of the road signage system, it was felt prudent to evaluate the present status and road signage system has been recommended for each directions of travel separately in the report. During the course of the road signage audit, it was noted that the chainage details of the road corridors was hardly available for any of the road corridors and therefore the reference and identification of the location has been done based on the land marks available in the site in all the road corridors.

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

As reported earlier (Annual Report 2009-10), Lucknow Development Authority (LDA) has sponsored the study to prepare Comprehensive Traffic and Transportation Plan for Lucknow. This study has been taken in two phases viz. Phase I: a 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. This study was conducted for Phase I of the study, with the objective of preparation of traffic system management plan for selected major corridors of Lucknow to address the immediate problems of traffic.

As part of the study, following activities were carried out. (i) Field studies and data collection. (ii) Data analyses and interpretation (iii) Preparation of Traffic Management Plans and Infrastructure improvement plans for each of the selected intersections, parking areas and Corridors and (iv) Evolving and suggesting policy guidelines for enhancement of safety and efficiency of traffic in the city.

Intersection Study

Keeping in view of the traffic problems, strategic importance and location of following intersection, were selected for study. (1) Mitaivala, (2) Palakarpuram, (3) Polytchnic, (4) Husseria, (5) Ram Ram Bank, (6) Engineering College and (7) Bainsakund. Keeping in view the problems at these intersections detailed studies were carried out in order to quantify and assess the characteristics of traffic site conditions and appreciate the improvement needs. As part of the study, various field surveys were carried out at the selected intersections viz. Classified Turning Movement Survey, Pedestrian Survey, Topographic Survey etc. Field traffic survey data were analysed in
order to appreciate traffic characteristics at
the intersections. The detail of intersection characteristics, traffic characteristics and
proposed traffic management plan and geometric design for a typical intersection
(Polytechnic Intersection) are presented. The
intersection is catering to a total traffic volume
of about 127000 vehicles daily (12 hours) on a
normal working day at ground level. Variation of
hourly traffic volume is shown in Fig. 110.

Traffic flow diagrams for the typical peak
hour (morning) are shown in Fig. 111 along with
composition of traffic terms of number of vehicles.

Based on the traffic flow characteristics, pedestrian needs and site conditions and
limitations, traffic management plans were
worked out for each intersection Details
of various features of proposed traffic
management and intersection design are
shown in Fig. 112.

![Graph showing hourly variation of classified traffic volume at polytechnic intersection]

![Diagram showing morning peak hour traffic flow diagram and composition at polytechnic intersection]
Parking Study

Keeping in view the problems of intensive parking demand in different parts of the city, eight parking areas/locations were identified for detailed parking study and parking management planning viz: (i) Alambagh (Chandnagar) (ii) Hazaratganj (iii) Kpoorthla (iv) Chowk Chauraha area (v) Patrakapuram (vi) Bhooth Nath Market Area (vii) Sachivalaya Area (viii) Aminabagh area and (ix) Gole Market (Mahanagar). Various field surveys were carried out in order to quantify and assess the characteristics of parking, site conditions and appreciate the improvement needs. Details of parking study of a typical location Bhootnath Market Area are presented in Fig. 113. As can be seen, for the purpose of conducting detailed survey of typical location, the whole area has been divided into small parking blocks. The detail of each parking block is shown in Table XVIII.
Table XVIII
Details of Parking Blocks at Bhoot Nath

<table>
<thead>
<tr>
<th>Block No.</th>
<th>Name of Block and Details</th>
<th>Parking Type</th>
<th>Type of Parked Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Satkar Restaurant to Under Ground Parking</td>
<td>On-Street</td>
<td>All</td>
</tr>
<tr>
<td>2</td>
<td>Block 1.O.B. to Satkar Restaurant</td>
<td>On-Street</td>
<td>All except Vikram</td>
</tr>
<tr>
<td>3</td>
<td>M C I. Parking Opp Bhoot Nath-1</td>
<td>Off-Street</td>
<td>All except Auto Rickshaw and Vikram</td>
</tr>
<tr>
<td>4</td>
<td>M C I. Parking Opp Bhoot Nath-2</td>
<td>Off-Street</td>
<td>All</td>
</tr>
<tr>
<td>5</td>
<td>Hariom Complex Parking</td>
<td>Off-Street</td>
<td>All</td>
</tr>
<tr>
<td>6</td>
<td>Dr.Vijay Prakash to Sabaji Market</td>
<td>On-Street</td>
<td>All</td>
</tr>
<tr>
<td>7</td>
<td>M C I. Parking Bhoot Nath opposite Vinraj</td>
<td>Off-Street</td>
<td>All</td>
</tr>
<tr>
<td>8</td>
<td>Dr.Vijay Prakash to Sabaji Market (Opposite side)</td>
<td>On-Street</td>
<td>All</td>
</tr>
<tr>
<td>9</td>
<td>Parking Lot at Aryan Restaurants</td>
<td>Off-Street</td>
<td>All except Vikram</td>
</tr>
<tr>
<td>10</td>
<td>Main Road to Hariom Complex</td>
<td>On-Street</td>
<td>All except Auto Rickshaw</td>
</tr>
<tr>
<td>11</td>
<td>Gandhi Ashram Khadi Bhawan Parking Lot</td>
<td>Off-Street</td>
<td>All except Auto Rickshaw and Vikram</td>
</tr>
</tbody>
</table>

**Parking characteristics**

The variation of half hourly classified parking demand in the area is shown in Fig 114. The parking demand in the area is observed as about 500 ECS (1000 vehicle) of which about 450 ECS is due to 670 motorised vehicles and about 50 ECS is due to 336 non motorized vehicles. Two wheelers (360) dominate the total motorized parking vehicle and cycles (260) dominate the non-motorised parked vehicles in the area.
Keeping in view the parking demand, parking characteristics and availability of parking spaces and other site conditions, following conclusions/recommendations have been made for effective parking management:

- Underground parking being provided opposite Bhoot Nath Temple will address the requirement of extra parking spaces in the area.

- It is estimated that about 300 ECS of extra parking space would be sufficient to address the demand for parking in the area in future.

- It is proposed to manage the parking facility so created by state of art technology and employing Intelligent Parking Management System and discourage on-street parking by strict enforcement.

- It is also recommended to encourage use of public transport and explore other measures to curtail the increase in parking demand.

- It is further recommended to improve infrastructure for pedestrians and non-motorised vehicles for efficient use of parking and other transport infrastructure.

**Corridor Management Study**

Efficiency of transport system of a city depends upon the performance of its road network particularly major arterial and arterial corridors. In order to improve the performance of transport operation of a city or area it is important to consider the improvement of arterial corridors of the area or city rather than local improvements. Keeping this in view the whole road network of Lucknow was studied and ten corridors comprising of arterial network of the city were considered for detailed study. For the purpose of detailed surveys each corridor was divided into a number of small links based on the overall length of the corridor, homogeneity of traffic and physical parameters and indicators. In order to assess the performance parameters of each corridor and to prepare traffic management plan and infrastructure improvement plans following field surveys were carried out viz. (a) Traffic Volume Survey, (b) Occupancy Survey, (c) Pedestrian Survey, (d) Non-Motorised Transport Survey, (e) Speed and Delay Survey, (f) Inventory Survey and (g) Topographic Survey. Analyses of data were carried out to assess the desired traffic and transportation characteristics of each corridor.

Detail of various traffic and transportation characteristics, physical parameters, limitations and site constraints, performance parameters, suggested traffic and transportation management plans, infrastructure improvement plans and other measures, recommendations and policy guidelines for efficient and safe transport system operation along each link of the selected corridors and for the city road network is presented and described in the report. Detail of suggested traffic and transportation management plans and infrastructure improvement plans for a typical corridor are presented below.

Corridor – 1 Faizabad Road – Ashok Marg – Kanpur Road (Chinhat Crossing – Amar Shahid Crossing – Polytechnic Badshah Nagar – Nishalganj – Ashok Marg – Charbagh Railway Stations – Alambagh – Airport).
For the purpose of detailed study the corridor was divided into eleven small links between twelve intersections. Details of proposed traffic management plan, traffic management measures, recommendations and transport infrastructure improvement plans for various sections (links) and nodes (intersections) of the corridor are presented in the report. The brief of proposed traffic management plan, infrastructure improvement proposals and geometric design of Hazratganj – Royal Hotel – Wallington Hotel Link and Wallington Hotel – Maharana Pratap Chowk – Link and intersections of the corridor are presented in Fig. 115.

Recommendations

- Keeping in view the varying widths of available right of way, it is recommended to ensure uniform width of R.O.W. for links depending upon its location in the inner or outer part of the city and land-use by removing encroachments or acquisition.

- To enhance the patronage of public transport in the outer areas along the corridor it is recommended to introduce reliable and efficient public transport to reduce the dependability of commuters on private and intermediate modes of transport.

- In view of the higher percentage of NMT vehicles in traffic and share of passenger flow by NMT along the corridor, it is recommended to segregate NMT traffic from MV traffic by providing well maintained NMT lanes along the corridor with lighting/boarding, resting and parking facilities along with safe crossing at intersections.

*Fig. 115: Proposed traffic management plan and infrastructure improvement plan for the links, and design of Royal hotel and Wallington intersections*
To provide minimum number of cuts in median and integrate various entries/ exits to streamline the traffic flow along the corridor.

- To regulate pedestrian flow along the corridor and crossing across the corridor and intersections by providing railing barrier along median and side walks with openings only at designated zebra crossings with provision for exclusive pedestrian phase at intersection signal.

- To provide appropriate road markings, signage system and lighting for guiding the road users.

- On-street parking may strictly be removed from the entire corridor and may be shifted to off-street parking. Strict enforcement is recommended in order to make the proposed traffic and transport management plan successful and safe.

- To plan and assess the feasibility of providing elevated road along sections of the corridor passing through heavily built up areas where, R.O.W. is limited for enhancement of capacity and segregation of smaller (local) and longer (through) trips through congested areas of the city in the long run.

New Infrastructural R&D Facilities Developed / Procured

a) Computer Controlled Retro Reflectometer Laboratory

This Institute has procured new equipment viz. Computer Controlled Retro Reflectometer for measuring coefficient of Retro-Reflectivity of Road Signs, Road Studs, Reflective Sheet and Reflective Cloth at different observation and entrance angles in the laboratory. This equipment has R&D applications in studying human behavior in perceiving information from retro reflective control devices.

b) Driver Simulator System was installed for Testing and Evaluation of Drivers
Annual Report 2010-11
Traffic & Transportation Planning
Transport Planning and Environment

CSIR-Central Road Research Institute
PROJECT TEAM MEMBERS OF TRANSPORT PLANNING AND ENVIRONMENT DIVISION
Study of Non-Methane Hydrocarbons in the Atmospheric Environment of Delhi Region

This study has been sponsored by Department of Science & Technology. Non-methane hydrocarbons play an important role in the atmospheric chemical reactions that cause photochemical smog, acid deposition and greenhouse gases. Hydrocarbons are one of the primary ingredients in the chemical process that produce smog on the urban and regional scale. Non-methane hydrocarbon in the presence of sunlight and oxides of nitrogen in the atmosphere are considered as the precursors for ozone as well as peroxy acyl nitrates (PAN) production at ground level.

The elevated concentration of ozone and its precursors i.e. non-methane hydrocarbons at ground level are of particular concern, because of the harm to human health and vegetation due to the carcinogenic nature of these compounds. India has air quality standard for SO2, NOx and aerosols i.e. SPM, RSPM but National ambient air quality monitoring programme in India has not yet scaled out any AQI level for the ozone over the region of India.

It is very important to study non-methane hydrocarbon 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, which 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.

Autosampler for the collection of ambient air is procured from ENTECH USA along with SUMMA Canister (Fig 116).

![Air collection using autosampler along with SUMMA Canister](image1)

![Ozone Monitor](image2)
Passive air collection was done from various sites like traffic zones, residential areas, power plants, industrial area of Delhi to make source inventories of non-methane hydrocarbons. Simultaneously ozone level is also monitored using ozone monitor at the same place same time for maximum ten hours in a day (Fig. 117).

To characterize air for lower non methane hydrocarbons cryotrapping system is fabricated in National Physical Laboratory for the characterization of NMHC in air (Fig. 118).

Air was collected from traffic zone, residential area of Delhi and analyze for lower non methane hydrocarbons. Air was collected in early hours in the month of January, April, June, and September from various zones on weekly basis. Numbers of non-methane hydrocarbons like n butane, acetylene, propane, ethane were analyzed in the atmospheric air of that particular region during the month of June and September 2010. Simultaneously ozone concentration was also monitored at that location.

The concentration of various non-methane hydrocarbons in the month of June and September 2010 of Delhi is shown in the Table XIX.

### Table XIX

**Concentration of Non-methane Hydrocarbons in Delhi Region**

<table>
<thead>
<tr>
<th>Month</th>
<th>June</th>
<th></th>
<th></th>
<th>Acetylene</th>
<th>September</th>
<th></th>
<th></th>
<th>Acetylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Butane</td>
<td>Propane</td>
<td>Ethane</td>
<td></td>
<td>Butane</td>
<td>Propane</td>
<td>Ethane</td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>0.887</td>
<td>0.895</td>
<td>0.897</td>
<td>0.756</td>
<td>0.868</td>
<td>0.832</td>
<td>0.786</td>
<td>0.798</td>
</tr>
<tr>
<td>Residential</td>
<td>0.675</td>
<td>0.688</td>
<td>0.543</td>
<td>0.434</td>
<td>0.702</td>
<td>0.435</td>
<td>0.521</td>
<td>0.293</td>
</tr>
<tr>
<td>Industrial</td>
<td>0.587</td>
<td>0.675</td>
<td>0.648</td>
<td>0.854</td>
<td>0.469</td>
<td>0.587</td>
<td>0.576</td>
<td>0.812</td>
</tr>
<tr>
<td>Power plant</td>
<td>0.888</td>
<td>0.964</td>
<td>0.342</td>
<td>0.763</td>
<td>0.765</td>
<td>0.432</td>
<td>0.298</td>
<td>0.687</td>
</tr>
<tr>
<td>Background</td>
<td>0.389</td>
<td>0.278</td>
<td>0.245</td>
<td>0.298</td>
<td>0.212</td>
<td>0.188</td>
<td>0.156</td>
<td>0.132</td>
</tr>
</tbody>
</table>

It was observed that concentration of lower non-methane hydrocarbons is always dependent on the weather condition, wind direction, activity related to area etc. It was also observed that areas with high traffic volumes give higher concentration of non-methane hydrocarbons (Fig. 119).
Application of Carbon Footprint in Passenger Transport Sector

The term carbon footprint has been growing in popularity over the past several years, primarily due to the heightened awareness of climate change. Carbon footprint is "the total set of greenhouse gases (GHG) emissions caused by an organization, event or product". It is a measure of the impact of our activities on the environment, and in particular on climate change. Carbon Footprint relates to the amount of greenhouse gases that are producing in our day-to-day lives through burning fossil fuels for electricity, heating, transportation etc. It is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

Public transport modes and the non-motorized modes play significant role in providing sustainable transportation. Many mega cities of India including Delhi have planned for the rail based metro systems as well other mass transit systems like Bus Rapid Transit, elevated sky bus, monorail systems and electric trolley buses. However, there is lack of comprehensive detailed studies which focus on the comparison of these different options of modes contributing towards the lower carbon footprint. The aim of the present study is to estimate and forecast the environmental impact of different travel mode options available for commuters.

This is based on demand estimation for different modes. Since demand depends on the complete trip profile including the access and egress trips; this need to be considered in environmental impact assessment. A complete study on trip profile of the commuters of different modes will be used to estimate the carbon foot prints for different mode-combination trips (trip profile including access, egress and main line haul mode). Based on present commuters' information, a model
Development of Microscopic Traffic Simulation Model using VISSIM and PARAMICS to Develop Speed-Flow Equations and Roadway Capacity for High Speed Corridors

An attempt has been made for the first time in the country to explicitly study the free speed profiles and speed-flow characteristics on various types of multi-lane highways covering four-lane, six-lane and eight-lane divided carriageways in plain terrain. In order to assess these characteristics, extensive data on Time Mean Speed (TMS) and Space Mean Speed (SMS) under free flow conditions coupled with traffic flow data was collected on sites spread over different regions of India. Figure 120 shows the free speed characteristics of multi-lane highways ranging from four to eight lanes divided carriageways. From the data collected, free speed profiles of different vehicle types and speed-flow equations on high speed corridors have been developed using traditional and microscopic simulation models. Towards this end, microscopic traffic simulation softwares namely VISSIM and PARAMICS have been utilized. The road network developed significantly in VISSIM software environment is shown in Fig. 121. The simulation model is able to reduce the error (from 3 ~ 34% to 0.1 ~ 18%) as compared to traditional method, as can be seen in Fig. 122. Further, capacity norms developed for these high speed corridors were also evolved from the speed-flow equations as shown in Fig. 123. As can be seen, the estimated roadway capacity is 5574, 7733 and 9796 PCU/hr/Direction for four, six and eight-lanes divided carriageways respectively.
The impact of typical Indian driving behavior, for example how the lane change behavior affects roadway capacity on multi-lane highways, has also been assessed through microscopic simulation approach. It has been estimated that there is a reduction of 3 to 9 percent in the estimated capacity as shown in Fig. 124. On a eight-lane divided urban expressway, PARAMICS software has been used to model vehicular behavior such as virtual lanes etc. The speed-flow equations developed and the estimated roadway capacity of eight-lane divided urban expressway is presented in Fig. 125. Further, the impact of virtual lanes and lane change on capacity is assessed using developed simulation model. It has been found that there is a 15 and 9 percent reduction in capacity due to the restriction of virtual lane and restriction of lane respectively, as shown in Fig. 126. It can also be seen that free speeds are increasing only marginally. Finally, the Design Service Volume (DSV) for various multi-lane highways under the prevailing heterogeneous traffic conditions has been evolved with reasonable

![Free Speeds on Eight-Lane](image1)

![Free Speeds of Heavy Vehicles and Autos significantly increased from four-lane to six-lane while marginally increased from six-lane to eight-lane](image2)

![Free speeds of TW & Car marginally increased from four-lane to six-lane while significantly increased from six-lane to eight-lane](image3)

**Fig. 120: Free speed characteristics of multi-lane highway**

![Simulation of vehicles in VISSIM on four-lane divided carriageway](image4)

**Fig. 121: Simulation of vehicles in VISSIM on four-lane divided carriageway**
**Fig. 122: Validation of microscopic traffic simulation model**

![Graph showing error rates for different traffic models.](image)

- Error is ranging between 0.3 and 10% for Four Lane
- Error is ranging between 0.1 and 16% for Six Lane
- Error is ranging between 2 and 18% for Eight Lane

**Fig. 123: Speed flow equations and roadway capacity for multi-lane highways**

(a) Four-Lane
![Graph showing speed-flow relationship for Four Lane.](image)

(b) Six-Lane
![Graph showing speed-flow relationship for Six Lane.](image)

(c) Eight-Lane
![Graph showing speed-flow relationship for Eight Lane.](image)

\[
Y = Speed \text{ in Km/hr}  \\
X = Flow \text{ in PCUs / Hour}  \\
Y = 47.676 + 1227.013 + 0.232X^{1.84}  \\
R^2 = 0.764  \\
\text{Capacity} = 9796 \text{ PCUs/hr/ln}  \\
\]
Fig. 124: Impact of lane change behaviour on roadway capacity

Fig. 125: Roadway capacity on an eight-lane divided urban expressway

Fig. 126: Impact of virtual lane and lane change on roadway capacity on an eight-lane divided urban expressway

degree of confidence. The outcome from this study is expected to form an important input for developing Road User Cost (RUC) models, exclusively for multi-lane highways.

Consultancy Assignments

Mobile Combustion: GHG Emission Inventory for Transport Sector in India

As reported earlier (Annual Report 2009-10), the study has been sponsored by GEF/UNDP/MoEF through PMC, MoEF at Winrock International India, New Delhi.

The United Nations Framework Convention on Climate Change (UNFCCC) has embarked on the process of monitoring/estimating the greenhouse gas (GHG) emissions on a continuing basis globally. The task of inventorying the contributions of transport sector towards GHG emissions in India 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 (CO₂, CH₄, N₂O, CO, NOₓ and NMVOC) for transport sector in India covering road, rail, aviation and marine navigation. India’s Initial National
Communication Report was submitted to UNFCCC in 2004. 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.

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 for transport sector in India has been generated for CO₂, CH₄, N₂O, CO, NOₓ and NMVOC using top-down approach for the period 1995 to 2007 using IPCC 1996 and 2006 methodology protocols. The greenhouse gas emissions are normally reported in CO₂-equivalent values (refers
to the sum of CO₂, CH₄ and N₂O emissions. Figure 127 shows the trend of energy consumption and CO₂ emissions from transport sector.

The total energy consumption in transportation sector has increased at a CAGR of 4 per cent from 1160 PJ in 1994 to 1920 PJ in 2007. The uncertainty component, associated with fuels sold through the network of retail outlets, has been considered while apportioning the fuel consumption for generating GHG emission inventory for road transport sector. Besides major fuel types, the minor fuel types have been taken into account for each mode of transportation for completeness. The energy consumption in transportation sector is dominated by road transport with a share of 87.3 per cent followed by 7.4 per cent for domestic aviation, 4.3 per cent for railways and nearly 1 per cent for marine navigation. Transportation sector has emitted 141.92 million tonnes (MT) of CO₂-equivalent emissions in 2007 of which 138.98 million tonnes (MT) was emitted as CO₂, 17.89 kilo tonnes (KT) as CH₄ and 8.25 kilo tonnes (KT) as N₂O. Out of the total emissions, the share of road transport has been estimated at 87 per cent followed by 7.2 per cent for aviation, 4.8 per cent for railways and 1 per cent for marine navigation. The CO₂ equivalent emissions have increased between 1994 to 2007 at a CAGR of 4.5 per cent. The share of transportation sector has been estimated at 7.5 per cent of India’s total GHG emissions in 2007.

The revised final report was submitted in November 2010 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.

**Noise and Vibration Study Along Metro Railway Corridor, at Tapan Sinha Memorial Hospital, Chanditala, Kolkata**

Noise and vibration assessments are the key elements in an environmental impact assessment process, especially for mass transit projects. Kolkata enjoys the rare distinction of being the first city in India to operate a high-speed mass transit system. The first phase of Kolkata metro runs through the densely populated areas and operates mostly underground. Now, the second phase of Kolkata Metro, which is an elevated corridor, is also operational. In some areas, it runs very close to the sensitive land use such as schools, hospital and parks. A nine-storied multi-specialty hospital (Tapan Sinha Memorial Hospital) at Chanditala is currently under construction abutting the metro corridor (Fig. 128).

**Fig. 128: A view of hospital abutting metro corridor**

CSIR-CRRI, New Delhi

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A study has been carried out to observe the noise and vibration levels being generated due to metro rail operation and on the basis of observed values the counter measures are suggested. The observed noise level of the train is 95.6 dB(A) (Fig. 129), while vibration level is very high i.e. 128 VdB in Y direction and 125 VdB in Z direction (Fig. 130).

These values are very high at the pier of hospital as well as at the pier of metro structure, as per US norms, since it crosses the threshold limit of 65 VdB. On the other hand British Standard and ISO Standard follow the acceleration. Conversion of VdB in acceleration mode comes out to be 3.2 m/s^2 and 3.9 m/s^2 respectively. Therefore, it is a serious concern in case of hospital.

Continuous exposure time due to metro operation is 2.04 hours out of the total metro operation schedule of 16 hours.

There are no Indian guidelines available for vibration; hence, the European Union / USA Guidelines were used. EU guideline focused on impact of vibration on human in building L_a x,y & z directional vibration, and thus it is monitored in terms of acceleration (m/s^2), while USA guideline says that it will be in VdB.

The various sources of noise/vibration found at near Tapan Sinha Memorial Hospital are due to the metro railway corridor passing between two hospital, high speed of metro train at turning point (55km/h), vehicular traffic at the entrance, generator for battery back-up, various medical instruments & huge crowd (public) etc.

Noise and Vibration due to metro railways are found to be very high due to the old technology being used for metro operation and track. At present, no measures are being taken to stop/minimise the noise and vibration.

Air born vibration and ground born vibration is very high at this site (which is 150m in length). In addition, due to sharp turning, poor maintenance, old structural design and higher length of metro trains (eight numbers of coaches), secondary air born noise and vibration are also very high at this site.

When measured/calculated values are compared with daily exposure graph, Nomogram for A8, exposure point and VdB (Vibration in decibel) and Acceleration at 3m (which is 3.2 m/s^2 in z direction), it is found that site is at extremely uncomfortable level.

Following measures have been recommended.
A) Recommendations at Source

- Complete loop of polycarbonate sheet of 8mm is required at the parapet wall up to 150m length for stopping the noise to 15 dBA level and stopping the vibration to 15 VdB level.
- Rail pads may be used to cover-up the opening near the track to prevent vibration at the hospital.
- Up to 2m height of parapet wall, absorptive noise barrier may be used along with polycarbonate sheet, in the length of 150m on either side.
- A9" thick brick wall will be provided around the Circular Pillars which will absorb ground vibration up to 10 VdB.

B) Recommendations at Receiver End

- At ground level and up to 1m below the depth of structure, Rubber pad insulator is required along the structure (3 side vibrations) for prevention of vibration up to 10 VdB.
- The open space between pillar to Hospital filling of river sand in about 1 m depth from the Hospital will be used. In this way, vibration can be brought down to the level of 12 VdB.
- Window, opening in front and in two sides of structure (except the door) will be firmly fixed and air conditioned.
- On both sides of window, 6mm perforated glass sheet at 300mm interval may be provided to maintain Air born vibration to the level of 10 to 12 VdB and noise to the level of 15 dBA noise.
- Elevation of hospital may be slightly changed, is possible/feasible.

Comprehensive Traffic and Transportation Studies of Goa

Goa is India’s smallest state in terms of area (an area of 3,702 km²) and the fourth smallest in terms of population. On 30th May 1987 Goa was made India’s twenty-fifth state with Panaji its capital. Located on the west coast of India in the region known as the Konkan, it is bounded by the state of Maharashtra to the north, and by Karnataka to the east and south, while the Arabian Sea forms its western coast.

The state is divided into two districts: North Goa and South Goa. Panaji is the headquarters of the north Goa district and Margao of the south district and 11 talukas. As per 2001 census, the state has a population of 1.35 million residing in 359 villages and 44 towns (50 percent of population resides in urban areas).
There is a steady growth of population from the year 1990 onwards as shown in Fig. 131. The population growth increased travel needs thus the vehicle population is increasing at an exponential growth rate, it has gone up from 0.33 million in 2001 to 0.727 million in 2010 (Fig. 132). In addition to this vehicles from other neighboring states also enter Goa as it is popular tourist place. However the road infrastructure has not been able to keep pace with the increasing vehicle growth.

The major economic of Goa is based on tourism industry and in the year 2006 it has catered to 2.5 million tourists. The in-state vehicles coupled with tourist movement put a tremendous burden on the road infrastructure. This mismatch between supply and demand of infrastructure has culminated in increasing congestion, accidents, and air pollution. Two hundred and sixty five people lost their lives in road accidents in 2005 as against 360 in the previous year.

Two National Highways (NH-17 and NH-4A) are passing through this state (Fig 133) covering about 263 kms of length and account for about 50 percent of total accidents.

The visits has been made behest of Government
of Goa to assess traffic problems and highlighted to go for the need of in depth studies for quantification and evolving short term and long term solutions. Accordingly the objectives of the study are formulated as follows:

- To work out a traffic/ transport system management plan to ease the existing traffic problems in Goa state and to optimize the use of existing infrastructure.
- To estimate the future travel demand in the Goa state and develop a transport systems plan along with the identification of the infrastructure to accomplish the plan implementation.

**Methodology**

Keeping the objectives and resources allotted for the present study in view. The study methodology was proposed in Fig. 134 as follows.

**Field Surveys and Data Analysis**

Traffic surveys are completed in most of the cities. In some cities traffic surveys are under progress. The preliminary traffic analysis in Panaji was as shown in Fig. 135.

In addition to the above field studies, recently the axle load surveys at mining locations have been conducted as shown in Fig. 136. The data regarding the existing/ alternative mining routes and the analysis of axle loads is under progress.

![Comprehensive Traffic and Transportation Studies of Goa](image)

*Fig. 134: Study methodology*
Fig. 135: Traffic flow variation and composition

Fig. 136: Axle load Surveys and traffic volume counts are under progress at mining routes in South Goa
PROJECT TEAM MEMBERS OF ROAD DEVELOPMENT PLANNING AND MANAGEMENT DIVISION
Development of GIS Based National Highway Information System

CRRI has undertaken a task to develop GIS based National Highways Information System (NHIS) under the aegis of Ministry of Road Transport and Highways, Government of India. It proposes to develop comprehensive database for about 50,000 km of National Highways (except the roads under NHDP Phase I & II) in GIS environment, which is to be achieved through collection and collation of road related data for one time from both primary and secondary sources. The major objective of the project is to develop GIS based Information system through which highways data management system can be established.

As a part of the module on GIS applications, software has been developed in GIS environment. The software enables multi-task operations to enter, upload, store, analysis and retrieve the data base from desktop as well as Web based system. The software includes various highway information as sub-modules viz., (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. There are three categories of users who can access the Web based GIS-NHIS application viz., Administrators, Engineers and Normal users. Desktop based NHIS application helps the user to have a control over the database. The desktop user will be able to perform all sorts of modifications over the database and able to prepare the inputs files for HDM for further analysis.

The database has been created by generating a unique NHID for each segment of National Highways, which is KM based. To provide a temporal look to the software system 1:1 million scale digital map has been prepared, where all major roads and cities are identified. The KM level spatial data were incorporated using the DGPS data collected through Network Survey Vehicle (NSV). The NSV also collects primary data such as road geometrics, pavement condition, and distance which are also synchronized with the DGPS data has been incorporated in the software. About 35000 km of DGPS spatial data along with primary data collected using NSV has been incorporated in the software. Twenty officials from Ministry of Road Transport and Highways have been given hands-on training on the operation of the software. Figure 137, 138 & 139 show snapshots of the software being developed.

**Fig. 137**: Map shows typical home page of the system
Fig. 138: Main modules of GIS based national highway information system

Fig. 139: Data extraction from GIS based national highway information system
Data Information and Management System (Supra Institutional Project)

The objective of the sub task, under Supra Institutional Project (SIP), is to develop the Data Information Management System (DIMS) towards making logical decisions about the budget requirement and allocation of funds there of maintenance of pavements based on optimal life cycle costs of high speed corridors. The proposed system provides integration of Storage Area Network (SAN) with the computational servers including web server, application server, data base server and GIS workstation. Figure 140 presents the proposed architecture of the data information and management system. The main benefit of this system is to provide efficient and effective centralised data information system and computational facilities.

Micro Simulation based Driving Cycle in Delhi City for Sustainable Transport System

Micro simulation based driving cycle for various types of vehicle for Delhi city is being studied. The objective of this study are (i) to derive the driving cycle and compare it with existing regulatory driving cycle using micro-simulation and real-world data and (ii) to estimate the emission based on real-world driving cycle for Delhi.
In this study, the real world driving cycle is being carried out on selected seven routes in Delhi City as shown in Table XX. These routes represent different types of lane, connectivity, land-use pattern, etc. to capture the road and travel related parameters. It covered almost all part of the Delhi city with variations in route characteristics. The survey is being carried out using GPS based Performance Box (Fig.141), which is fitted in different type of vehicles. Questionnaire also has been developed to capture the driver related parameters. In first instance, the survey was carried out in four routes on pilot basis for car only. In addition, traffic volume data was also collected in selected locations (mid points) of these routes.

Development of Multimodal Level of Service (MMLoS) Measure for Urban Roads in India (Empower Project)

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, delay, and safety. Indian road traffic distribution is based on space sharing instead of lane sharing. Traffic on Indian city roads consists of a variety of modes varies from bicycle to multi axle motorised modes. Therefore, there is a need to measure level of service for different travel modes and provide suggestions for space sharing approach for different travel modes in urban areas.

Table XX
Selected Route for Driving Cycle Studies

<table>
<thead>
<tr>
<th>Route</th>
<th>Name of Routes</th>
<th>Route Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>R001</td>
<td>Allmore to India Gate via Ashram-NH2</td>
<td>6 lane</td>
</tr>
<tr>
<td>R002</td>
<td>CRRI to Nizammuddin to Noida More via DND to Bharat Nagar</td>
<td>Part 6 lane, DND Expressway and part suburban arterial</td>
</tr>
<tr>
<td>R003</td>
<td>Karol Bagh- DB Gupta Road- Rohtak Road-MM Margh-Aryasamaj Road-</td>
<td>Market Residential</td>
</tr>
<tr>
<td>R004</td>
<td>BRT Corridor- Dr. Ambedkar Nagar Terminal to Pragati Maidan via Mool Chand</td>
<td>BRT Corridor</td>
</tr>
<tr>
<td>R005</td>
<td>Ring Road- 2 Part</td>
<td>Main Arterial</td>
</tr>
<tr>
<td>R006</td>
<td>Outer Ring Road- Three Part</td>
<td>Main Arterial</td>
</tr>
<tr>
<td>R007</td>
<td>East Delhi</td>
<td>Different traffic mix and composition lane 2, 3 lane</td>
</tr>
</tbody>
</table>
The main aim of this study is to develop a methodology for evolving the Level of services for Indian urban roads. The objectives of the study are:

- To develop ‘Level of Service’ (LOS) measure for different modes of travel (walk, cycle, rickshaw, car, motorised two wheelers, bus) on Indian roads.
- Developing multimodal Level of Service (MMLOS) for roads assigning higher weightages for sustainable modal trips such as walk, cycle, cycle rickshaw and public transport.

The approach methodology for the study is shown in Fig. 142.

The study aimed to develop sustainability factor (SF) by evolving higher weightage for sustainable modes i.e. pedestrians, cyclist, cycle rickshaws and public transport. The value for sustainability factors assumed as: 1 for sustainable modes and 0 for private motorized vehicles and 0.5 for commercial vehicles are considered for study. These values can be further improved based on vehicle occupancy. Field survey has been carried out in selected locations of arterial corridors in Delhi. The data analysis is in progress.

Travel Time Related Performance Measures for Evaluation of Sustainable Road Transportation System (Empower Project)

The traditional measurement of average travel time may not be able to explain the
complete experience of the road users in the transportation system as these measures neglect the variability of travel time. Also the existing congestion measure depend on average travel time, unable to quantify the performance of the transportation system in terms of sustainability. Therefore, there is a need to investigate travel time based performance measures to evaluate the transportation system. These performance measures would help decision maker and planner of the system to prioritize the new transportation projects and policies. Improving travel time variability would directly improve the economic, environmental and social benefits of the system. Travel time varies mainly due to uncertainties from supply side, demand side and various external factors of the system.

The objectives of the study are:

- To identify various performance measures for evaluating sustainability of road transportation system.
- To analyze variability of performance measures under various uncertainties (from demand side factors and supply side factors)
- To evaluate sustainability of road transportation system for current and future transportation system scenarios.

The approach methodology for the study is shown in Fig. 143.

Field survey has been carried out in selected locations of urban corridors in Delhi (on NH 2) and Chennai (on NH 45). The data analysis is in progress.
Evaluation of Operational Efficiency of Highway Network Using Travel Time Reliability Measure

The main objective of this study is to analyze the stochastic travel time distribution under uncertain factors of traffic volume (demand side factor) and pedestrians crossing at unsignalized location which is an impediment to traffic flow. Modelling travel time variation under these uncertainties, a stochastic simulation modelling technique has been considered for evaluation of the effect of these factors on travel time variation. Figure 144 illustrates the concept of uncertainty propagation of travel time, in this each point of the response surface (calculated output function (PDF) of these inputs. The Stochastic Response Surface Method is considered to model the stochastic variation of travel time by influence of explanatory parameters.

Stochastic Response Surface Method (SRSM) is one of the ideal conventional sampling based method for uncertainty analysis and this is accomplished by approximating both inputs and outputs of the uncertain system through stochastic series of well-behaved standard random variable (SRV). A second order polynomial approximation is considered in the study to model the travel time variation influenced by two independent variable $\xi_1$ and $\xi_2$ and the mathematical expression was presented at equation:

$$Y = a_0 + a_1 \xi_1 + a_2 \xi_2 + a_3 (\xi_1^2) + a_4 (\xi_2^2) + a_5 \xi_1 \xi_2 \ldots \quad \text{(Eqn. 1)}$$

SRSM model was applied to an urban arterial corridor of 4km long on National Highway 2 of Delhi-Mathura Road, Delhi. (Fig. 145) Consistent video graphic data in morning and evening hours was collected for estimating travel time through vehicle license plate matching. One week consistent data from 24th Aug. to 28th Aug. 2009, in the morning (8.30 to 10.30am) and evening peak hour (4.00pm to 6.00pm) have been collected. This study mainly focused on travel time variation of ears (includes small and big cars).
Second order SRSM model was considered to approximate the response of travel time (Eq. 1). Set of model input points for traffic volume and pedestrian volume at the points were generated by using transformation technique. For lognormal distribution \( \exp(\mu + \sigma E_t) \) equation was used for transformation. Further these model coefficients were considered for estimating travel time for the collocation points generated for 2nd order polynomial equations (Eq. 2). The unknown coefficients in Eq. 1 considered for SRSM model are solved by using singular value decomposition method and the corresponding coefficients \((a_0, a_1...a_5)\) are estimated and presented in equation 2.

\[
Y = 754.83 + 75.33E_t + 7.41E_t^2 + 2.22(E_t^{2.1}) + 0.722(E_t^{2.1}) + 0.1E_tE_t^2 \quad \text{(Eq. 2)}
\]

Travel Time estimated by SRSM model and MLR models are compared against with actual travel time and presented in Fig. 146.

It was observed that SRSM probability distribution is immoral (having one maximum at 784 sec) and follows the actual travel time distribution. Whereas travel time distribution obtained by MLR models are bimodal frequency curves having two peaks, one maximum at 665 seconds and the other maximum at 797 seconds. For the results it was observed that MLR models are unable to map the worst case scenarios. SRSM models are capable to analyze the stochastic behaviour of uncertain variable. The observable difference between the estimated distribution of SRSM model and actual distribution can be improved by increasing the number of uncertainty parameters in the model. Figure 147 demonstrate the three dimensional stochastic response surface fits computed value of travel time very well. From this figure it can be observed that the gradient of travel time variation curve due to impact of pedestrian volume (Z12) is steep, this emphasizes that the travel time variation due to random pedestrian crossing at Okhla more, is very much significant on travel time variation for the study area.

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

On highways, accessibility of crossing commuters generally been counted as an obstruction to the mobility of main highway commuters. A study methodology is shown in Fig. 148. The study was carried out in two different sections on National Highway No.8:
one with 4 lane wide roads, at village Vav, (Fig. 149) and other at 6 lane wide road, at village Pipodara, in Surat District, Gujarat, India. The objective is to understand how the people of these two villages do access their neighbourhood area of the other side of the national highway. Households and pedestrians’ surveys have been carried out at both the locations. Apart from this; speed data (spot speed of different vehicles on highway at different locations) accidents information, traffic volume count on highway and crossing of highway pedestrians’ counts have also been collected.

Descriptive analysis shows different factors have an impact on accessibility i.e. landuse, road crossing facilities, width of road, speed of different vehicles, portion of village and the other side of the road along with the type of activities, distance from highway, etc. Accessibility of pedestrians has been measured considering all mentioned variables and also the number of road crossing made for different purposes and by different modes. A binary logit model has been developed to see the difference in accessibility at both the locations considered for this study. Further, a mobility index has been developed based on the characteristics of traffic flow of highway commuters and vehicle ownership of Vav and Pipodara people. Figure 150 presents the line diagram of studied area. Line spacing on both the sides of highway presents the density of activities. i.e. closer lines represents more activities (at Pipodara towards Kim) and wider spacing shows less activities (at Vav in all four arms of the intersection).

The preliminary analysis of the survey data shows that there is a higher value of vehicular speed at Vav which is a 4 lane wide road area for all types of vehicles compared to a 6 lane wide location i.e. Pipodara. However, one can assume higher speed at wider road i.e. 6 lane at Pipodara but the approach area towards the intersection is quite different in both the cases.
Fig. 148: Conceptual and methodological framework for accessibility and mobility impact on neighborhoods due to expressway.
In case of Pipodara, there are more activities adjacent to road compare to Vav.

The available accident data for both the cases i.e. 4 lane and 6 lane road (as shown in Table XXII), shows that total number of accidents per kilometre is higher in case of 4-lane road i.e. 13.48 accidents per km for the period of 15 months compared to 11.70 accidents per km in case of 6 lane road. However, it is important to note that population of Vav is 2.5 times more than Pipodara and total accidents/km/unit population is higher for Pipodara. Further, fatal accidents/km/unit population is higher for Vav as speed is higher at Vav which is generally considered as a major contributing factor for fatal accidents. Comparison of minor accidents/km/unit population, this is higher at Pipodara and one important contribution could be the higher pedestrians’ crossings per unit population at Pipodara.

Based on developed neighbourhood accessibility index, values have been calculated for commuters of Vav and Pipodara. Table XXII shows 85th percentile and average accessibility index value for three different distance ranges i.e. distance of any household from highway is less than 0.5 km, distance between 0.5 and 1 km and when distance is more than 1 km. Figure 151 shows comparison
Table XXI

<table>
<thead>
<tr>
<th>Accident Type</th>
<th>Number of accidents per km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stretch I (4 lane)</td>
</tr>
<tr>
<td>Total accidents</td>
<td>13.48</td>
</tr>
<tr>
<td>Fatal accidents</td>
<td>1.19 (9)</td>
</tr>
<tr>
<td>Grievous accidents</td>
<td>3.82 (28)</td>
</tr>
<tr>
<td>Minor accidents</td>
<td>8.44 (63)</td>
</tr>
</tbody>
</table>

of average accessibility index for both the locations. This indicates that accessibility is higher for Pipodara in all ranges of distances. Further, the decrease in accessibility with the increase of distance between house and highway reduces the accessibility in both the cases.

Present study shows results for two case specific studies, at both the locations the accessibility has been measured for the different kinds of households. Further, mobility and safety has been discussed in terms of speed and classified number of accidents. Based on preliminary

Table XXII

<table>
<thead>
<tr>
<th>Village/L Distance</th>
<th>Dist &lt; 0.5 km</th>
<th>0.5 km &lt; Dist &lt; 1.0 km</th>
<th>Dist &gt; 1 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipodara (Average)</td>
<td>3.008</td>
<td>2.129</td>
<td>1.394</td>
</tr>
<tr>
<td>Pipodara (85th percentile)</td>
<td>4.726</td>
<td>2.905</td>
<td>1.690</td>
</tr>
<tr>
<td>Vav (Average)</td>
<td>2.623</td>
<td>1.725</td>
<td>1.119</td>
</tr>
<tr>
<td>Vav (85th percentile)</td>
<td>1.048</td>
<td>2.814</td>
<td>2.201</td>
</tr>
</tbody>
</table>

Fig. 151: Comparison of accessibility index at Vav and Pipodara
analysis, some general observations as listed below:

- Increased mobility of highway commuters has an inverse relationship with the accessibility of pedestrians crossing the highway.
- Increased mobility also results in reduced safety.
- Safety and accessibility have a proportional relationship.

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

The major objective of the study is to develop a methodology for measurement of traffic congestion, quantify the magnitude of the congestion, and suggest the measures to mitigate the traffic congestion. This study describes systematic bottleneck identification and analysis for selected urban arterials (Inner Ring Road, Outer Ring Road, and one CBD Arterial) of New Delhi city.

A detailed analysis of vehicles' speed profiles and congestion delays for traffic during peak and off-peak periods is performed based on conducted field surveys.

The approach methodology of the study has been presented in Fig. 152.

A probe vehicle attached with GPS (V-Box) device is used to collect the data. The data collected during survey are speed, travel time, delay, and road inventory by different modes like car, bus, two wheeler and three wheeler. In addition, the travel time details and delay time and reasons, and the road inventory details like land marks, cross road locations, signal locations, flyover locations etc. along with vehicle speedometer readings were collected.

The collected data (sample) depicting the speed profile of the selected section for different vehicle for the inner ring road is presented in Fig. 153.

The GPS data collected by probe vehicle are used to identify the accurate location and duration of bottlenecks. The parameter used to identify the bottleneck is speed drop, because speed changes much more sharply than any other parameter when a bottleneck is activated. It also provides a more sensitive indicator.
Modelling of Driving Cycle for Road Network Development Plan in Urban Area and Suburban Area – A Case Study in NCR

The objective of this study is to model the driving cycles and to develop the efficiency of road network plan by minimising the delays and congestion and to find the effect of road geometry, traffic volume, speed-limit on driving cycle. On pilot basis initially the study was carried out in Ghaziabad city of National Capital Region. Six routes were selected to represent overall driving cycle pattern and driving conditions of the city. The selected routes for the driving cycle survey are shown in Fig. 154. The total lengths of the selected routes are 29.4 km.

The selected route represents all sorts of variations such as partly managed / manually operated during the peak-hours signals and some uncontrolled signals. The road width varies from 5.5, 7.5 and 12 m and with single/two lanes both way along with median 1.5 m in some sections. A sample of seven car drivers was chosen for the survey and survey was carried out for five

---

Table XXIII
Summary of the Bottlenecks on the Selected Corridor

<table>
<thead>
<tr>
<th>Road Name</th>
<th>Number of Bottle Necks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holiday</td>
</tr>
<tr>
<td>Inner Ring Road</td>
<td>31</td>
</tr>
<tr>
<td>Outer Ring Road</td>
<td>10</td>
</tr>
<tr>
<td>CBD Arterial</td>
<td>30</td>
</tr>
</tbody>
</table>
continuous days. Preliminary data analysis was carried out for speed characteristics and the results are presented in Table XXIV. It shows that the average real world driven speed on all over selected roads in the city was 48.73 km/h (S.D. 9.15 km/h), the average regulatory safe limit was 50 km/h.

The results show that perceived preferred speed by driver was higher than regulatory speeds which challenge the credibility of assigned speed limit. Even observed speeds on three roads were higher than regulatory speed limit, which were driven in different off peak and peak hours of morning and evening time.

### Table XXIV

<table>
<thead>
<tr>
<th>Route number</th>
<th>Name of Road</th>
<th>Average Maximum Speed-kmph</th>
<th>Standard Deviation Maximum Speed kmph</th>
<th>Average preferred speed by driver kmph</th>
<th>Standard Deviation preferred speed kmph</th>
<th>Regulatory Speed kmph</th>
</tr>
</thead>
<tbody>
<tr>
<td>R001</td>
<td>Merrut Teraha NH58 to NH24 ByPass</td>
<td>44.9</td>
<td>3.9</td>
<td>67.40</td>
<td>5.99</td>
<td>50</td>
</tr>
<tr>
<td>R002</td>
<td>Hapur Road</td>
<td>54.45</td>
<td>3.29</td>
<td>100.50</td>
<td>6.0</td>
<td>50</td>
</tr>
<tr>
<td>R003</td>
<td>Ambedkar Road</td>
<td>41.48</td>
<td>3.37</td>
<td>56.94</td>
<td>4.64</td>
<td>50</td>
</tr>
<tr>
<td>R004</td>
<td>NH 24 to NH58 Hapur Chungi</td>
<td>56.194</td>
<td>3.51</td>
<td>60.92</td>
<td>5.05</td>
<td>50</td>
</tr>
<tr>
<td>R005</td>
<td>Vivekanand to Rajnagar</td>
<td>57.87</td>
<td>3.29</td>
<td>103.81</td>
<td>5.92</td>
<td>50</td>
</tr>
<tr>
<td>R006</td>
<td>Nasirpur fatak to NH2</td>
<td>35.8</td>
<td>5.6</td>
<td>45.80</td>
<td>7.18</td>
<td>50</td>
</tr>
</tbody>
</table>

CSIR-CARI, New Delhi
147

Scanned by CamScanner
Estimation of Number of Cycle Rickshaws in the Vicinity of Delhi University Area – North Campus

Rickshaws are widely used mode for short distance trips as well as feeder service for metro rail and public buses. In order to understand their role particularly in colonies/campuses, a study has been proposed to estimate number of cycle rickshaws plying in given area. A study has been initiated on pilot basis to estimate number of cycle rickshaws plying in around Delhi University’s North Campus with the area of approximately 4 square kilometres. The cycle rickshaw stands are shown in Figs. 155 & 156).

Based on collected data regarding the cycle rickshaws passing on roads in the campus and standing at stands at different location in the campus; the total number of cycle rickshaws have been estimated using two different methods.

Method 1: Estimation of cycle rickshaws based on cycle rickshaw counting on roads and stands.

Method 2: Estimation of cycle rickshaws based on cycle rickshaw puller’s income and cycle rickshaws on roads.

Consultancy Assignments

Evaluation Study on Use of On-Site Visualization Method for Monitoring of Safety Management at Construction Site

Japan International Construction Agency in association with Kobe University, Japan has installed safety system at AIIMS Metro Station to monitor the safety of retaining wall during construction of the underground station. CRRI in association with JICA has evaluated the system acceptability and safety awareness level among various stakeholders at construction site. The system known as On Site Visualization (OSV) method is used for arbitrary structures encountered during construction or operation of infrastructure. In the OSV method, Light Emitting Sensors are used as the key technology which provide visual information regarding anticipated incidents. It is also useful in understanding the stability of the all kind of structures including surrounding buildings around the construction, detect the abnormalities and it facilitates the
quicker reactions to evacuate the workers and also minimize further structural damages.

The system installed in front of AIIMS Metro Station is used to monitor the safety of inclination of retaining wall which was constructed for underground metro station (Fig. 157), similarly, the system was also installed at one adjacent building (Safdarjang Hostpital Nurse Hostel) to monitor its stability during the construction of underground metro. This system uses deformation sensor to measure the displacement which is shown by a designed color of LED in real-time. The same concept can be applied for monitoring of stain, inclination, earth pressure, water pressure, temperature, etc. Lights (LED) showing current level of deformation etc. with simple color code. BLUE, generally expresses a safe condition while the RED expresses the dangerous one. The present system has got four types of color code ranging from Blue, green, yellow and red depending upon the severity of the inclination of the retaining wall and vertical building.

The main objective of the study is to evaluate the use of On-Site Visualization (OSV) method by considering the following evaluating criteria:

- Safety awareness and consciousness among various stakeholders during construction.
- Recognizing OSVs and safety issues
- Effectiveness of OSV techniques
- Contribution of OSV to the safety activities/management
- Improvement of safety mind/consciousness through OSV activities

Scope of the study includes identification of parameters, to prepare survey questionnaire on random sample basis for various stakeholders such as workers, residents of nurse building, road users around the site and site engineers/officers/scientists.

In order to fulfil the objectives and scope of the study, the methodology adopted is presented in Fig. 158. The approach for methodology mainly consists of interaction and discussion with JICA team and Prof. Akutagawa for identification of parameters to evaluate the safety system and to design the questionnaires for various groups namely site workers, nurse building residents, road users and site engineers/officers/scientists. The random sampling has been decided based on the size of the various groups.

Data collected have been analyzed to understand the level of safety knowledge, safety experience of workers, engineers and road users and also to examine the use of OSV monitoring method. Some important parameters for various groups are considered and analyzed. The analysis have been carried out in two types (i) grading the opinion in four/three grade point scale and
(ii) categorization of the choice of the opinion expressed. Some of the recommendations from the study are as follow:

- Various stakeholders feel that OSV method is useful and provides additional safety measures with a warning system.
- OSV method may further improved by consideration of sensor interface with audio visual system.
- Also during changes of color, the sensor lights (LED) should be blinked for sometimes to warn the people about the color changes.
- A dashboard type safety message based on the OSV at entrance of the work site will be quite beneficial information to the people at the site.
- The safety monitoring system like OSV should be assessed and incorporated at the (DPR) design stage itself depending upon the site conditions.

Consultancy Services for conducting the Road Safety Audit for PPP Projects on DBFO Basis

National Highways Authority of India (NHAI) is engaged CRI to conduct road safety audit for certain PPP projects under DBFO basis. As a part of the project, the data related to various aspects including inventory has to be collected and collated in the GIS based Road Information System being developed by NHAI. Training-workshop were organised to various stakeholders of the projects. GIS based RIS, data requirements, data availability, collection and uploading has been imparted.

Environmental Impact Assessment (EIA) for preparation of detailed project report (DPR) for third phase of Delhi-Metro Rail Corporation – Social Impact and R&R Studies

As a part Environmental Impact assessment (EIA) study of proposed third phase of metro alignments, the social impact and rehabilitation and resettlement study has been carried out in the proposed six corridors viz., (i) Anand Vihar-Dhaula Kuan (ii) Mukundpur-Rajouri Garden (iii) Ashok Park-Delhi Gate (iv) Central Secretariat - Red Fort (v) Jahangirpuri-Badli (vi) Malviya Nagar-Kalindi Kunj-Noida. Total length of corridor is 74.12 km as proposed during in 2010. The surveys such as Census of Tree to be affected, visual land use survey and utilities. socio-economic pattern of user's opinion survey and project affected family/ person and socio-economic surveys were carried out.
PROJECT TEAM MEMBERS OF PLANNING, MONITORING AND EVALUATION DIVISION
R&D management is the main activity of this Division which inter-alia covers Planning, Monitoring & Evaluation of R&D Projects, issues concerning Intellectual Property and Business Development, attending to technical queries and technical audit and assistance to Director, Management Council (MC) and Research Council (RC) on the project related matters.

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

**Planning Activities**

**12th Five Year Plan Proposal**

PME coordinated the development of 12th Five Year Plan project proposals which have been identified as Supra Institutional projects and Network projects. Supra projects will be taken up by CRRI and Network projects will be developed jointly with other CSIR Labs i.e., AMPRI, IMMT, NIEST, CBRI, CMERI, CSIO etc.

**Annual Plan 2010-11**

The Annual Plan 2010-11 document for CRRI contained information related to research work plan to be carried out. The financial requirements for these projects were also mentioned.

**CRRI Budget**

The financial requirements are defined on Plan and Non-Plan basis. Plan items include all research components whereas Non-Plan items cover infrastructural support. The plan requirements of the Institute for the years 2009-10 and 2010-11 (Budget Estimate) has been prepared.

**Registration of Project Proposals**

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. Registration and Technical scrutiny of in-house R&D projects is also carried out.

**Development and Regular Maintenance of Project Database**

A Project Database has been developed which is regularly updated incorporating addition of new projects, and 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 and also maintains the cash inflow of all the projects.

**Intranet Site for Information**

Continual improvement of PME Intranet site and web based “Online Projects Information/Enquiry System” to facilitate the F&A section/Stores and Purchase section and R&D divisions for various purposes.

**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) which 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.

The division also calls for progress report of all the on-going projects in the Institute for processing. This exercise is meant to monitor and 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 leader 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 review.

In-house Projects

Project Identification and Monitoring Committee monitors 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 a project, a presentation is made by the Project Leader to incorporate suggestions if any made by the committee members. The details of new Projects taken up and completed during the year 2010-11 are given in the Annexure I in the page 244 to 245.

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. 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, ECF generated was 1417 lakhs.

Expenditure Monitoring

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

Evaluation Activities

Activities Related to Technical and Service Tax Audit

Technical Audit and Service Tax Audit were carried out by CAG and the Service Tax authorities respectively. PME coordinated between the audit party and the Divisions to respond to the audit queries. Service Tax audit under EA-2000 was carried out by the authorities for the period from 2005 to 2010.
CRRI Outstanding Performance Award Scheme

To promote healthy competition amongst various divisions ‘Best Performing Division’, awards were processed each year based on the annual performance.

RC Secretariat

Acted as Secretariat to provide full support to RC Secretary in carrying out activities for organizing RC Meetings. Follow up actions were taken up as per the minutes of the meeting.

Miscellaneous

Projects' 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.

Management of Various Project Proformae

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

Technical Queries

Handles technical queries pertaining to various projects being handled by various R&D Divisions of the Institute. Also interact with various divisions of CSIR regarding the preparation of Annual Plans, Five Year Plans of the Institute, Management of Plan Projects, etc.

Service Tax Payment

On receipts of amounts under externally funded projects, Service Tax is paid to the Government on monthly basis.

Post Graduation Research Programme in Engineering (PGRPE)

Recognizing the importance of both housing and roads, the two prime infrastructure areas 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 the two year PG research course on “Engineering of infrastructure and Disaster mitigation (Buildings/Roads)”. The Programme is designed to give in-depth exposure and hands on R&D experience to the candidate. In the earlier phase, the PGRPE programme was coordinated by the division and then made as a separate entity under Academy of Scientific & Industrial Research (AcSIR). CSIR has invited applications for the two-years full time residential Post Graduation Research Programme in Engineering in the cutting edge technologies.

Parliament Queries

During the year, replies to about sixty Parliament questions were prepared after collecting, compiling and collating information from various divisions of the Institute.
Considering the need of effective management of technology portfolio of the Institute, TMCD Cell has been constituted in 2009-2010.

Major activities carried out during the year are:

**I. Technology Management Activities:**

1. **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 be taken as technology gate-keeper for the entire profession including IRC and BIS
   - To bring out State-of-Art on important topics

2. **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 is brought out.

3. **Product Development Initiatives**

   TMCD Cell has also undertaken development of various products as a systemic activity and by involving various agencies.

4. **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.

**II. Business Development Activities:**

1. **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.

   Particular mention needs to be mention about the interaction made with AEM, GDA, PMA, CDAC, Aurigo, AIMIL, PWD Mizoram, PWD Lucknow, HSRTC etc.

2. **MoU/Agreements**

   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 signing of MoU/ Agreements documents.

3. 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.

4. 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. 13, 2010 at Nagpur 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 get the information for GRRRI every year
- 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

The website has been developed and is under testing.

III. 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.
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:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Title of the Course</th>
<th>Duration with Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Pavement Engineering &amp; Materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design, Construction and Quality Control of Flexible Pavements</td>
<td>Aug. 18-20, 2010</td>
</tr>
<tr>
<td></td>
<td>Rigid Pavements : Design, Construction and Quality Control Aspects</td>
<td>Nov. 22-28, 2010</td>
</tr>
<tr>
<td></td>
<td>Pavement Evaluation Techniques and their Applications for Maintenance and Rehabilitation</td>
<td>Dec. 06-10, 2010</td>
</tr>
<tr>
<td>B.</td>
<td>Geotechnical Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geotechnical and Landslide Investigation for Highway Projects</td>
<td>Sept. 13-17, 2010</td>
</tr>
<tr>
<td>C.</td>
<td>Bridges and Structures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bridge Diagnostics, Performance Evaluation and Rehabilitation</td>
<td>June 21-25, 2010</td>
</tr>
<tr>
<td>D.</td>
<td>Traffic &amp; Transportation Planning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road Safety Audit</td>
<td>Oct. 25-28, 2010</td>
</tr>
<tr>
<td></td>
<td>Environmental Impact Assessment (EIA) and Environmental Clearance Process for Roads &amp; Highway Projects</td>
<td>Dec. 20-22, 2010</td>
</tr>
</tbody>
</table>
Planning, Design, Construction and Maintenance of Rural Roads

On the request of Provincial Road Development Authority, Sri Lanka, a training programme was organised for Technical Staff of Provincial Road Development Authority (WP), Sri Lanka from Aug. 2-11, 2010. Twenty-five participants attended the programme.

Project Preparation, SBD, Quality Assurance and Maintenance of Rural Roads

On the request of National Rural Roads Development Agencies (NRRDA), CRRI successfully organized customized training programme for the engineers involved in PMGSY (in five batches) as per details given below:

i) Sept. 6-11, 2010 (Thirty-two participants)

ii) Sept. 20-25, 2010 (Thirty-two participants)

iii) Oct. 18-23, 2010 (Thirty-two participants)

iv) Nov. 29 – Dec. 04, 2010 (Thirty-six participants)

v) Jan 3 – 8, 2011, (Thirty-eight participants)

Training Programme on Design, Construction and Maintenance of Roads under PMGSY for RES, Lucknow

On the request of Rural Engineering Services, Lucknow, CRRI conducted two customized training programme for their engineers as per detail given below:

i) March 7 -12, 2011 (Twenty-five Participants)

ii) March 14-18, 2011 (Twenty-five participants)

International Course on Dissemination of Highway Development and Management (HDM-4)

An International course on Dissemination of Highway Development and Management was organised from Sept. 27-Oct. 8, 2010. Twenty-nine participants from India and abroad (Uganda, Bangladesh, Afghanistan etc.) attended the programme.

GIS Based National Highways Information System

Under T-5 Scheme of MORT&H, a training programme on Software Development was organised for Ministry and CRRI officials from Oct. 28-30, 2010. Twenty-five participants attended the programme.

Highway Development & Management (HDM-4)

On the request of Tan Roads, Tanzania an International training programme on HDM-4 was organized for four Officers of TANROADS, Tanzania from Dec. 20, 2010 to Jan. 14, 2011.

Collection of Road Roughness Data Using ROMDAS and DCP

On the request of MMM Groups Canada, the Institute organized a customized training programme for the engineers of Road Construction Department, Bihar from Feb 28 – March 2, 2011. Fifteen 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 on page 201-202.

Publications

CRRI Annual Report for the Year 2009-2010 – Bilingual

The report is the profile of achievements of the Institute during the year 2009-2010. 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 2009-2010.

General Report on Road Research Work Done in India during 2009-2010

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 2009-2010. 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 36 by Indian Roads Congress. The report was presented by CRRI in the 71st Annual Session of Indian Roads Congress at Nagpur from Nov. 11-14, 2010.

CRRI Newsletter

During the year, three 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 clippings 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 through CRRI Advertisement

To popularise the Institute’s past R&D achievements and present R&D programmes, capabilities, facilities and expertise, the Institute issued various advertisements at various forums.

One such forum was the scientific documents brought out by various organizations on different occasions. The Institute got published its various advertisements in the documents brought out by various organizations on different occasions.

Publication 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 drafting, scrutiny and execution of agreements / MoUs for various externally funded projects and cooperation with other organizations for undertaking joint projects.

Exhibitions

The Institute participated in the following Technical Exhibitions:

2. Technical Exhibition during the 71st Annual session of Indian Roads Congress at Nagpur from Nov 11-14, 2010.


7. International Seminar cum Exhibition on National Road Development Strategies & Road Safety on Improved Highways organised by the School of Planning and Architecture, New Delhi from 14-16 March, 2011.

Technology Transfer and Business Development

The division is actively engaged in technology transfer and marketing of Institute’s knowledge base through active coordination of promotional activities and professional channels. Scrutinizing proposals of contract research and consultancy assignments of externally funded project.

Visitors

Visits of distinguished professionals and delegates from various organizations related to road transportation from India and abroad to CRI 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. These organizations maintain their databases including R&D activities, Organizational Heads, etc. of the Member Institutions and regularly seek the updated information. The updated information on CRI were provided to various organizations and the annual subscriptions were paid to continue the membership. The Institutional membership of the Institute is given on page 213.
Training Programme on Planning, Design, Construction and Maintenance of Flexible Pavements, PERT & CPM Etc
June 14-19, 2010

A view of inaugural session of Training Programme organised at Shillong

Dr. Sunit Bose, Head Flexible Pavement Division delivering lecture to the Engineers of PWD, Govt. of Meghalaya at Shillong
Training Programme on
Bridge Diagnostics, Performance Evaluation & Rehabilitation
June 21-25, 2000
Organized by:
Central Road Research Institute, New Delhi

Inaugural session of Training Programme

A view of inaugural session of Training Programme

CSIR-CRRI, New Delhi
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 89,000 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, IRD, TRANSDOC from TRANSPORT CD, COMPENDEX, PIARC CD ROUTE, and All BIS (Indian) Standards including Civil Engineering, all ASTM Standards were provided through digital library for quick retrieval of information.
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 386 (01.04.2010-31.03.2011) 54270
Total No. of books as on 31.03.2011 688
Maps 655
Microforms 122
Videocassettes
Periodicals titles received regularly 200
Softwares and IT Services

Intranet service (http://INTRANET/http://172.16.10.100) 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 is also available.

Installation and configuration of Scientific Softwares like ARC-GIS, Mx-Read, HDM, NISA, Heads & SPSS, Geo4 and TransCAD also provided.

The website of CRRI (www.crридom.gov.in) provides information related to CRRI such as scientific, administration, training programmes, events, tenders, history, recruitment and other activities etc.

E-mail facility for all the technical and administrative staff of the Institute also available.

The Trend Micro Corporate Antivirus Solution is provided to all the servers, client nodes and roaming client laptops.

Internet Services

The Internet Service of this Institute is upgraded to 1GBPS for the implementation of NKN related activities. CISCO ASA 5520 Firewall and IWSS are implemented for Security and to scan transmitted data for viruses and outbound data for leaks to unwarranted users.

Training Programmes

Training Programme were conducted for Gr. I, Gr. II and Administrative Staff for upgrading their computer skills in latest MS Office Suites, E-mail, Internet and LAN fundamentals for the implementation of ERP.

Computer facility to all Training Programmes, Seminars/Conferences etc. organized at CRRI is provided. Video Conferencing facility also managed.

LAN Platform

Local Area Network (LAN) of CRRI uses Switch CISCO Catalyst 4507R-E (Layer 3 Redundant Supervisor), CISCO 48 ports 2960G (Layer 2) work group switches, CISCO ASR 1002 Router, CISCO ASA 5520 Firewall, CISCO 1113 Access Control Server and CISCO Net Manager IP for its functionalities and operations.

HP 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.

The wireless LAN is operational at Council Hall, Conference Room and Computer Centre at present. The proposal of Wireless LAN connectivity for PGRPE Class Rooms, PED Labs, Guest House, Main Stores and Canteen is under progress.
Provided Technical Services in:

1. Design and Development of Mechanical Equipment required by R&D divisions
2. Repair R&D Equipment (Mechanical & Electrical)
3. Air Conditioner Repairs
4. Repair of Infrastructural Facilities including Furniture

Design and Development

Following equipments were developed during the year:

1. Development of 4 Beam Casting Moulds for BAS division for the Project No.SSP-4488 titled “Study of corrosion susceptibility of steel reinforcement protection with anti corrosive coating/ special treatment in ordinary and high performance concrete (Fig 159).

These moulds are portable moulds.
• These can be opened from all sides for easy removal of Beams after casting.

The moulds are very rugged and can be put to use for casting several beams.
• All parts are interchangeable.

2. Development of V-Box Mounting Device for Tata Truck for TPE division for the Project SIP-30 titled “Fuel consumption study under varying gradient” (Fig 160).

The V-Box mounting device was specially designed for use in Tata truck taking into consideration the very little space available for its mounting.
• It is designed to minimize the shock transmission to the V-Box.
• It can be used in other types of vehicles also

3. Change in LVDT mountings as per field requirements for BAS division for the project titled “Instrumentation and Evaluation of Bridges on West Central Railway Bridges”
• The dimensions for 50 nos. of the magnetic LVDT mounting were changed to suit the site requirements.
Repair of R&D and Other Equipment

Following equipments were repaired:
1. Automatic Soil Compaction Machine
2. Compression Machine
3. Automatic Bitumen Compactors
4. Marshall Hammer
5. Core Cutting Machine
6. Sample Casting Moulds
7. Direct Shear Machine
8. CBR Moulds
9. UTM
10. Rut Depth Measuring Device
11. Repair of Gym Equipment Weight Lifting
   Tread Mill Twister Paddling Machine
   (Fig 161)

Research Projects Undertaken

Associated in the following R&D Projects during the year:

1. "Creation of R&D Resource Base Facilities available at CRRI" an In-house Project.
2. "Fuel Consumption Studies" - R&D Project of TPE Division.
3. "Instrumentation and Evaluation of Bridges on West Central Railway Corridor" of Bridges and Structures Division.

Fig. 161: A View of repaired equipments
Quality Management

Quality Management ensures 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 activity 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 (MRM)

After the internal quality audits, the findings of the audit and its reports were discussed in detail during the Management Reviewed Committee chaired by Director. CRRI findings 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.

ISO 9001:2008 Implementation Programme

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 and the changes and clarifications issued by International Organization of Standardization (ISO). 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 smoothly 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 training programme for Internal Quality Auditors Training comprising a batch of 20 officials of the Institute. The main objective of the programme was to make the training to understand the Quality Management System concept and the emphasis on clauses which can be used as a tool to check 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 above 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 in the existing documentation system. The Quality Manual related to ISO 9001:2008 was issued and implemented in the Institute. The Institute was audited by BIS i.e., the certification agency for ISO 9001:2008 Quality Management System during November 2010. Finally, certification has been awarded to CRRI as ISO 9001:2008 Research Organisation w.e.f. December 2010. The scopes of certification include "Research and Development in the Field of Roads and Road Transportation including Design, Testing, Consultancy Service and Training in Highway, Bridge and Transportation Engineering".
Rajbhasha

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 were 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 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 encouraged to write their research papers in Hindi and as an incentive, they were given cash prize and certificates were given 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 on monthly basis. 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 eighth issue of the 'Sadak Darpan', the scientific magazine in Hindi has been finalized and is under the process of publication.

MEMBERS OF RAJBHASHA
National Technology Day

National Technology Day was celebrated at CRRI on May 11, 2010. On this occasion, a film on "Cutting Carbon Footprints" produced jointly by National Geographic Channel, CSIR and Ministry of Science and Technology, Ministry of Earth Science was screened for the audience. "Cutting Carbon Footprint" is a 48 minutes film that shows seriousness about Global Warming and also encourages individuals to take required actions. It will definitely reinforce, in each and every citizen, moral and social responsibility towards our Earth planet. Further, it is expected to urge everyone to try and reduce Carbon emissions in order to leave behind a healthy planet for generations to come. Earlier Sh. T. K. Amla, HOD-IIT gave a brief account of the background of National Technology Day. In his address Dr. S. Gangopadhyay, Director, CSIR-CRRI highlighted the usefulness of this film and mentioned how an average Indian family can lead a much healthier lifestyle and save money by following greener and environmentally friendly processes both at home and at workplace.

Nirman Samagrai"- Vision 2030:

"Rashtriya Sangoshti-2010 on Nirman Samagraiya Vision-2030" in Hindi was organized by Central the Institute in collaboration with Central Building Research Institute and AMPRI, Bhopal, May 12-13, 2010. This seminar was supported to NHA, BIS, Indian Oil Corporation, Shell Bitumen India Pvt. Ltd., Bithchem, Tikitar, Ooms Polymer Modified bitumen Pvt. Ltd., Teena Overseas Ltd., Slurry Tech Private Limited and International Consultant and Technocrat. Seminar was attended by about two hundreds participants from the Institute and different organisations. The seminar was inaugurated Shri Bir Singh Parmira, Secretary, Hindi Department, Ministry of Home Affairs, Govt. of India. Prof. Prem Krishna, Ex-Head, Civil Engineering Department, Indian Institute of Technology, Roorkee was the Chief Guest. The two-day meet comprises five technical sessions which included presentation on technical aspects. In the closing ceremony, Ms. Mohini Hingorani the Chief Guest encouraged the Scientists to use Hindi in S&T subjects. Prof S.K. Bhattacharya, Director, CSIR-CBRI mentioned that this is first technical Seminar in Hindi in which three CSIR labs are working together. Dr. S. Gangopadhyay, Director, CSIR-CRRI emphasized the need to use Hindi in Scientific work. During the Seminar, a poster competition was organized. The Chief Guest gave Prizes to the young Scientists and winner of poster Competitions.

Workshop on Accident Recording & Analysis Procedures for India

A National workshop on Accident Recording and Analysis Procedures for India was organized on July 9, 2010 at CRRI, New Delhi with the following objectives:

(i) To evolve uniform accident recording form incorporating the views of all stakeholders so that accurate and timely national accident records are available. Also to have a system for doing in-depth analysis of accidents and critically examine thereby the causes of accidents.
(ii) To evolve a system by which accident recording and investigation units can be set up in each state.

The workshop was attended by about 100 delegates from various organizations like Ministry of Road Transport & Highways (MORTH) (Road Safety Cell), National Crime Bureau, National Highways Authority of India, Bureau of Police Research and Development, Indian Roads Congress (IRC) etc. Besides, officials from various Traffic Police Departments, Medical professionals, academicians from IIT’s, NGO’s, PWDs, and private organizations etc. attended the Workshop.

During the workshop, presentations were made on data recording and analysis procedures followed by National agencies like MORTH, NHAI and National Crime Bureau as well as by traffic police departments of different states like Delhi, Mumbai, Haryana etc. It was brought out that the accident recording formats as adopted by the three national bodies are quite different from the one adopted by different states.

CRRI’s presentation brought out the procedures followed Nationally and Internationally. The major shortfalls in the present system which is mainly in F.I.R.‘s were highlighted and recommendations provided for improving the existing system.

The following major conclusions were drawn:

1. Data collection format could be simplified and mode of data collection can be modernized through the use of GIS / GPS devices.

2. Old IRC codes, related to accident recording systems and analysis should be updated periodically.

3. A need was felt for giving intensive training to the accident recording and analysis personnel so that the causative factors can be easily identified and future remedial measures & research can be suggested. Computerized accident recording system coupled with the use of latest technologies for accident analysis is also needed to simulate the possible causes of accidents.

4. Regular publication of accident reports should be brought out to make public more conscious and to get more focused thoughts on future research by researchers/ academicians so as to reduce accidents. The terminology used in reports/recording system should be standardized so that these are universally understood.

5. Highway agencies should set up their own accident investigation system to assess the deficiencies in the road system in order to provide necessary remedial measures. Priority should be given to collect accurate and reliable data for NH, SH & urban areas which cover about 75 percent of total fatal accidents.

6. There is a strong need to set up a nodal agency which should collect, analyze and disseminate data through online.
Engineers Day

Engineers Day was celebrated at CRRI on Sept. 15, 2010. On this occasion, Dr. S. Gangopadhyay, Director, CSIR-CRRI addressed the Scientists and Technical Officers of the Institute. A technical presentation on "Demand Estimation by Public Transport System" was made by Dr. Mukti Advani, Scientist of the Institute.

CSIR Foundation Day

CSIR Foundation Day was celebrated at CRRI on Sept. 27, 2010. As part of CSIR Foundation Day celebrations, the Institute organized various competitions for CRRI staff and their wards. The day was designated as Open Day to enable visit of general public and students. At the outset Sh. T.K. Amla, Head Information Liaison & Training gave the genesis of CSIR Foundation Day celebration. Around 100 students of 10th & 12th Class visited the institute. The main function was organized in the afternoon.

Dr. S. Gangopadhyay, Director, CRRI extended a warm welcome to the guests and presented a brief account of R&D activities and achievements made during the year. Sh. D.P. Gupta, Director-General (Retd.), Ministry of Road Transport and Highways, New Delhi was the Chief Guest and delivered foundation day lecture on “Opportunities for Research and Technology Initiatives in Highway Sector”. In his lecture, Shri D.P. Gupta mentioned that CSIR is truly an Institution which is multidimensional and multifaceted and is working for upliftment of living conditions of people of India. He recalled the contributions of CRRI in the field of roads and road transportation. Shri Gupta expressed his deep regards to the ex-scientists of CRRI for their splendid contributions and also to the serving scientists for their sense of commitment. Prizes were given away by Chief Guest to the winners of various competitions organized earlier. The employees of CRRI, who had completed 25 years of service in CSIR and those who have retired during Aug 2009 to Sept. 2010 were also honoured and mementos presented to them. The function was graced by invited guests, distinguished scientists, employees, ex-colleagues, students and ended with vote of thanks by Sh. Sudhir Mathur, HOD (GTE) & AC (HRP).

Vigilance Awareness Week

Vigilance Awareness Week was observed at CRRI during Oct 25 to Nov 1, 2010. On Oct 25, 2010 a pledge was taken by all the staff members. Banners and posters were displayed. Sh. Deepak Goyal, Joint Secretary, Rajya Sabha Secretariat delivered a lecture on Legislative Initiatives in Administrative Vigilance. In his lecture Sh. Goyal gave insight into various legislative initiatives that are being considered for administrative vigilance. He also stressed upon the importance of the highest degree of self ethics which need to be maintained by all of us as citizens of India. Every contributions, no matter however small it may be, is significant enough and would yield results if pursued sincerely. Sh. Jitender Parasar, Controller of Administration, highlighted the importance and purpose of organizing vigilance awareness week. In his address, Dr. S. Gangopadhyay, Director, CSIR-CRRI stated that we all have to make collective and concerted efforts to do away with the demon of corruption in public life. A debate on ‘Role of Right to Information in Preventing Corruption or Sting Operation for Preventing Corruption – Justified or Not’,
was organized for CRRI staff. Vote of thanks was given by Shri B.K. Singh, Administrative Officer, CSIR-CRRI.

Renewal Audit for IS/ISO 9001:2008 – Quality Management System

The renewal Audit of ISO 9001:2008—Quality Management System Certification was carried out by a team of auditors from Bureau of Indian Standards on Nov, 1-2, 2010 and has been completed successfully. BIS auditors recommended that the Institute Quality Management is effectively in place as per the requirements of ISO 9001:2008. The required renewal license will be issued by BIS in due course.

Road Safety Week

Road Safety Week was observed at CRRI during Jan 1-7, 2011. On Jan 5, 2011, a function was held in the Institute. Sh. Satyendra Garg, Joint Commissioner of Police, Delhi delivered a keynote lecture on “Road Safety”. Sh. Garg touched upon various issues related to road safety in his lecture. Dr S. Gangopadhay, Director, CSIR-CRRI also addressed on this occasion. Sh. Garg distributed Retro-Reflective Stickers to CRRI staff members.

Workshop-cum-Training on NHAI’s sponsored project on “Consultancy Services for Conducting Road Safety Audit for PPP Projects on DBFO Basis”

National Highways Authority of India (NHAI) has awarded a Consultancy Service to CRRI for Conducting Road Safety Audit for PPP Projects on DBFO Basis. Under this project, a workshop was organized on Jan 13-14, 2011 at CRRI with the following objectives.

i) To train Road Safety Audit (RSA) Team, Projects Directors, Independent Engineers on Road Safety Audit Process.

ii) To finalize the methodology to be adopted for conducting audit at development and construction stages.

This workshop was attended by a total of 51 delegates which included officers from NHAI, PO’s from respective packages, Independent Engineers and CRRI' audit team.

Dr. S. Gangopadhay, Director, CSIR-CRRI gave his welcome address by welcoming all members of the technical committees and delegates from different Govt. departments. Dr Nishi Mittal, Head, Traffic Engineering and Safety Division gave a background to the project and spoke about the objectives of workshop.

The inaugural address was delivered by Shri R.P. Khandelwal, CGM and In-charge, Road Safety Cell of NHAI. Shri Khandelwal explained various activities undertaken on Road Safety. Comprehensive audit of all packages of LMNHP projects completed to the full satisfaction of World Bank; Work done so far; on going activities and other related activities initiated by Road Safety cell of NHAI. Shri D.P. Gupta addressed the delegates and highlighted various important aspects related to Road Safety and Safety Audits carried out in India. The inaugural session was concluded with Vote of thanks by Dr. K. Ravinder, Scientist CSIR-CRRI. The two-day
meet comprised five technical sessions which included presentations on different aspects of road safety/road safety audits. In the panel discussion, issues related to Construction & pre-opening stages of RSA and the approach/methodology to be followed were discussed and finalized.

**Indo-US Workshop on Transportation and Greenhouse Gas Emissions**

CSIR-Central Road Research Institute in association with Texas Transportation Institute organized a workshop on “Transportation and Green House Gas Emissions” at New Delhi on Feb 10-11, 2011. The workshop was supported by Indo-US Science and Technology forum and was attended by 100 participants representing the private sector, public sector, universities and research institutions from both India and United States. The overall goal of this workshop was to discuss the current trends and research in the areas of transportation and greenhouse gas emissions, and subsequently to identify research needs and potential areas of collaboration between India and the US.

The workshop consisted of an opening session which included an address by Dr. Arabinda Mitra of the Indo-USSTF and a welcome address by Dr. S. Gangopadhyay, Director- CSIR-CRRI. This was followed by a series of five technical sessions spanning two days, in which topics ranging from broad policy overviews, inventory methods, sources and mitigation strategies, technological solutions, modeling approaches, policies and programs, and other transportation sector interventions were covered. The final plenary session of the workshop was a guided brainstorm session in which participants discussed the areas for future research and potential collaboration.

It was agreed that while policies, needs, and the local context may vary between India and the US, the topic of greenhouse gas emissions from the transportation sector was the one that could provide many opportunities/avenues for future research and collaboration – for example in mitigation strategies, inventory and modeling approaches and innovative data collection and its use. The workshop gave an opportunity to the research community and industry in India and the US to learn from each other while tackling these global issues.

**National Science Day**

As an annual feature to commemorate the discovery of Raman effect, the Institute celebrated National Science Day on Feb 28, 2011. On this occasion, Dr. Partha Chakraborty, Professor, Department of Civil Engineering and Dean, Students’ Affairs, Indian Institute of Technology, Kanpur, graced the occasion as Chief Guest and delivered the National Science Day Lecture on ‘God’s Design: From Evolution to Optimisation’. During the function Sh. T.K Amla, Head, IIT highlighted the importance of National Science Day celebration. At the outset, Dr. S. Gangopadhyay, Director CSIR-CRRI welcomed and introduced the Chief Guest. He conveyed his thanks to the Chief Guest for sparing his valuable time inspite of his very hectic schedule.

The programme was also attended by many old colleagues of CRRI.
Third Indian Young Geotechnical Engineers Conference

The Third Indian Young Geotechnical Engineers Conference (IYEGEC) was organized by Indian Geotechnical Society, Delhi chapter (On behalf of Indian Geotechnical Society) at Central Road Research Institute (CRRI), New Delhi on March 25-26, 2011. The conference was inaugurated by Dr. S. Gangopadhyay, Director, CSIR-CRRI and also released the proceedings of the conference. The Guest of Honor for the function was Prof. K. S. Rao, President, Indian Geotechnical Society. More than 130 delegates comprising students and young researchers from different educational Institutes of the country attended the conference. There were 12 plenary lectures from noted professionals in the two day conference. About 30 presentations were made by enthusiastic young geotechnical engineers of their research work, in six technical sessions, chaired and co-chaired by eminent professionals. Apart from technical deliberations, a job fair was organized wherein young engineers attended the interview conducted by Golder Associates Pvt. Ltd and AIMIL (I) Pvt Ltd. The presentations made by the young geotechnical engineers were judged by five distinguished judges and four best papers were selected. The valedictory function was chaired by Sh. Ravi Sundaram, Chairman, IGS Delhi chapter, Co-chaired by Sh. Jai Bhagwan and organizing secretaries Dr. Vasant G. Havanagi and Dr. R. Ayothisraman. The conference ended with distribution of mementoes to the judges, Participation certificates to the young engineers and with best research paper awards.

Hindi Pakhwada (Fortnight)

Hindi fortnight was organized from Sept. 1 to 14, 2010. Competitions such as Essay writing, Hindi noting and drafting, Hindi General Knowledge & Translation, On the spot Hindi speech and Technical Paper Presentation competitions were organized during fortnight. About one hundred and fifty employees took part in these competitions.

Dr. S. Gangopadhyay, Director, CRRI presided the inaugural function on Sept. 1, 2010. He urged all employees and officers to compulsorily make use of Hindi in day to day official work.

Shri Chetan Chauhan, former cricketer and social worker graced the occasion as Chief Guest on Sept. 14, 2010. 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.
- IRC Commendation Certificate for the paper entitled 'Review of Environmental Laws and their Applicability to Roads / Highway Project.' The Award was given during 71st IRC Annual Session at Nagpur in Nov. 2010

- Best Article Award by Association of State Road Transport Union for the paper entitled ‘Updation of Road User Cost for Economic Evaluation of Road Projects’ Published in the Journal of Traffic Management

- IGS Delhi Chapter Leadership Award 2009 for Outstanding Contribution in the Area of Geotechnical Engineering by Indian Geotechnical Society of India
Other Activities
of the Institute
Events

Dr. S. Gangopadhyay, Director, CSIR-CRRI
addressing the staff on National Technology Day

Inaugural session of the workshop

A view of workshop on accident recording & analysis procedures for India
Technical presentation by Dr. Mukti Advani, Scientist during celebration of Engineers Day

Dr. S. Gangopadhyay, Director CSIR-CRRI, planting tree on World Environment Day
Other Activities
of the Institute
Events

Dr. S. Gangopadhyay, Director, CSIR-CRRl addressing the staff

Sh. D.P. Gupta, Director-General (Retd.), MORTH, delivering Foundation Day Lecture

Sh. Sudesh Kumar, Scientist explaining working of instrumentation to the school Children

Annual Report 2010-11
Other Activities of the Institute Events

Dr. S. Gangopadhyay, Director CRRI speaking on the occasion of Road Safety Week

Sh. Satyendra Garg, Joint Commissioner of Police, Delhi delivering lecture during Road Safety Week

Release of Road Safety Sticker
Other Activities
of the Institute
Events

A view of the workshop on Road Safety Audit

A view of the inaugural session of Road Safety Audit Workshop cum-Training

The inaugural session of IS/ISO 9001:2008 Quality Management System Auditing
A view of the technical session of Indo-US workshop

Dr. Arabinda Mitra, Executive Director, IUSSTF delivering inaugural address

US delegation at CRRI

CSIR-CRRI, New Delhi

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Other Activities of the Institute Events

Glimpses of National Science Day Celebration
Other Activities of the Institute

Events

Dr. S. Gangopadhyay, Director, CRRI releasing the conference proceedings

CRRI delegation with officials from RDA, Sri Lanka

Dr. S. Gangopadhyay, Director, CRRI presenting bouquet to Prof. D.V. Singh, RC Chairman

CSIR-CRRI, New Delhi

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Other Activities
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<td>Dr. K. Ravinder</td>
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<td>SIAM, Conference on Safe Convention, Chandigarh, May 5, 2010</td>
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<td>Transport and Road Planning Issues for Enhancing Safety in Hazardous Goods Transport</td>
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<td>Need for Different Stages of Road Safety Audit for National Highways</td>
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<td>9</td>
<td>Road Safety Education in India</td>
<td>National Institute of Disaster Management, NIDM, New Delhi, Aug. 27, 2010</td>
<td>Dr. Nishi Mittal</td>
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<td>10</td>
<td>The Use of Oil Well Drill Cuttings and Road Making</td>
<td>Interactive Session on Current Environmental Sessions in Exploration and Production Industry, ONGC, New Delhi, Aug. 19, 2010</td>
<td>Dr. A.K Mishra</td>
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<td>11</td>
<td>Load Testing of Concrete Bridges</td>
<td>NCCBM, Ballabghar, Sep 29, 2010</td>
<td>Dr. S.K Sharma</td>
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<td>12</td>
<td>Design of Concrete Pavements</td>
<td>Workshop on Cement Concrete Roads – Experience Sharing, CMA &amp; Ultra Tech Cement, Oct 8, 2010</td>
<td>Sh. Binod Kumar</td>
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<td>13</td>
<td>Estimation of Roadway Capacity of Multi-Lane Inter-City Corridors</td>
<td>CISTUP, Oct. 2010</td>
<td>Dr. S. Velmurugan</td>
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<td>14</td>
<td>EIA and Environmental Clearance Process in India</td>
<td>IGFRI Dehradun, Nov 6, 2010</td>
<td>Dr. Niraj Sharma</td>
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<td>S.No</td>
<td>Topic</td>
<td>Place and Date</td>
<td>Presented By</td>
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<td>15</td>
<td>Design Construction and Quality Control Aspects of Concrete Roads</td>
<td>CII, Kanpur, Nov. 9, 2010</td>
<td>Dr. Rakesh Kumar</td>
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<td>16</td>
<td>Concrete Pavement: Distress and Repair Strategies</td>
<td>CII, Kanpur, Nov. 9, 2010</td>
<td>Dr. A.K. Mishra</td>
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<td>18</td>
<td>Design, Construction and Quality Control Aspects of Concrete Pavement for Rural Roads</td>
<td>CII, Gorakhpur, Dec. 27-28, 2010</td>
<td>Dr. Rakesh Kumar</td>
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<td>19</td>
<td>Concrete Pavement: Distresses and Repair Strategies</td>
<td>CII, Gorakhpur, Dec. 27-28, 2010</td>
<td>Dr. A.K. Mishra</td>
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<td>20</td>
<td>Third Party Quality Control for Road and Bridge Works as per Contract, Specifications and Field Projects</td>
<td>BMFPTC Capacity Building Program for JNNURM Project at Thiruvanthapuram, Feb. 1-2, 2011</td>
<td>Sh. J.K. Goyal</td>
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<td>21</td>
<td>Impediments to Road Safety Audits in India</td>
<td>Traffic Infra-Tech Seminar, MORTH, Feb. 3, 2011</td>
<td>Dr. Nishi Mittal</td>
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<td>22</td>
<td>Human Factor in Road Safety: R&amp;D Approaches</td>
<td>Workshop on Quality @ Road Safety, Road Safety Adds to the Quality of Life, SIAM &amp; Maruti Suzuki, Feb. 16, 2011</td>
<td>Dr. Neelima Chakraborty</td>
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<td>23</td>
<td>Role of Intelligent Transport Systems in Road Safety</td>
<td>Seminar on Intelligent Transport System, New Delhi, Feb. 22, 2011</td>
<td>Dr. Nishi Mittal</td>
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<tr>
<td>25</td>
<td>GIS Technologies for Planning and Management of Road Network—with Case Studies.</td>
<td>Conference on Road Planning Design and Construction India 2010, New Delhi</td>
<td>Dr. B.K. Durai</td>
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<td>26</td>
<td>GIS-RIS Application in Road Safety Issues</td>
<td>Training Workshop on Road Safety Audit, Haks-ITE Ltd., Coimbatore, Chennai, Bangalore, March, 2011</td>
<td>Dr. B.K. Durai and Sh. A. Mohan Rao</td>
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<td>27</td>
<td>Highway Planning &amp; Design</td>
<td>2nd Semester Students, School of Planning and Architecture, Delhi</td>
<td>Dr. Devesh Tiwari</td>
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<td>28</td>
<td>Highway Planning &amp; Design</td>
<td>3rd Semester Students, School of Planning and Architecture, Delhi</td>
<td>Sh. K. Sitaramanjaneyulu</td>
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<td>S. No.</td>
<td>Area of Training</td>
<td>Staff Nominated</td>
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<td>1</td>
<td>Reservation in Service and Maintenance of Rosters</td>
<td>Sh. Madhu Erampalli, Ms. Laiza Jangpangi, Sh. A Mohan Rao</td>
<td>9-12th April 2010</td>
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<td>2</td>
<td>Short Term Course on “Advanced Sensing Technologies for Civil Engineers”</td>
<td>Mr. Abhishek Mittal</td>
<td>14-16 May 2010</td>
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<td>3</td>
<td>Capacity Building of Scientists and Technologists on Technology Diplomacy</td>
<td>Sh. Suresh Chandra, Sh. R.C. Aggarwal</td>
<td>31st May-4th June 2010</td>
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<td>4</td>
<td>“Purchase Effectiveness” : A Skill Enhancement Programme for common cadre Section Officer</td>
<td>Sh. S.G. Verma</td>
<td>28th June-1st July 2010</td>
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<td>5</td>
<td>Short Term Course on “Statistical Modelling of Systems (SMS 2010)”</td>
<td>Dr. Neelam J. Gupta</td>
<td>28th June-4th July 2010</td>
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<td>6</td>
<td>Training Programme on NISA Software, Bangalore</td>
<td>Dr. R.K. Garg, Dr. Suraj Prakash, Dr. Rajeev Goel</td>
<td>8-10 June 2010</td>
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<td>7</td>
<td>Road Safety Auditors IRF, New Delhi</td>
<td>Ms. Kamini Gupta, Dr. E. Madhu, Sh. Subhash Chand, Sh. A.M. Rao, and Dr. Neelima Chakraborty</td>
<td>12-16 &amp; 19-23, July, 2010</td>
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<td>8</td>
<td>Refresher Programme for Section Officer (F&amp;A)</td>
<td>Sh. Dheeraj</td>
<td>16-21st August, 2010</td>
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<td>10</td>
<td>9th Advanced Computer Applications for Administrative Personnel of the DST</td>
<td>Sh. Vinod Kumar, Smt. Kamlesh Kapoor</td>
<td>6-12, Sep. 2010</td>
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<td>11</td>
<td>Advanced Computer Applications for Administrative Personnel of the DST</td>
<td>Sh. Rakesh Kumar</td>
<td>6-12, Sep. 2010</td>
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<td>12</td>
<td>DST Sponsored Training Programme on “Communication and Presentation Skills” for Scientists for Programme-II</td>
<td>Sh. R.K. Srivastava and Sh. R.K. Panigrahi</td>
<td>6-11 Sept. 2010</td>
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<td>13</td>
<td>DST Sponsored Training Programme on “Science Administration and Research Management”</td>
<td>Dr. Sangita Sh. K. Sitaramananjayudu</td>
<td>6-11 Sept 2010</td>
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<td>14</td>
<td>Certificate in Project Management with Specialisation in Roads and Transportation (CIPM-RT)</td>
<td>Sh. J.K. Goyal</td>
<td>10-19 Sep. 2010</td>
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<tr>
<td>16</td>
<td>Training Workshop for Accelerating Commercialisation of Technology and Innovation</td>
<td>Dr. Ravinder Kumar</td>
<td>29th Sept-2nd Oct. 2010</td>
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<td>18</td>
<td>Training Programme on Corrosion Diagnosis and Durability Enhancement of Concrete Infrastructures</td>
<td>Sh. S.K. Verma</td>
<td>4-8 Oct. 2010</td>
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<td>19</td>
<td>Training workshop for Application of Driving Cycle for Low Carbon Buses - Gas</td>
<td>Dr. Ravinder Kumar</td>
<td>15-30 Nov 2010</td>
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<td>20</td>
<td>Diploma Course in Computer Hardware Maintenance</td>
<td>Sh. Anil Kumar and Sh. Shibal</td>
<td>21st Nov 2010 to 20th May 2011</td>
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<tr>
<td>21</td>
<td>4 Months Online Certificate Course in “Cyber Laws”</td>
<td>Sh. Jitender Parasar Sh. A. Saurikhi Sh. R.C Agarwal Sh. S. Mariappan</td>
<td>Nov 2010 to Feb 2011</td>
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<td>23</td>
<td>Training cum Workshop on Production of Certified Reference Material</td>
<td>Dr. Sippy Chauhan</td>
<td>01-04 Feb 2011</td>
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<td>24</td>
<td>Orientation Training Programme for Section Officer and Private Secretaries</td>
<td>Sh. Vinod Kumar</td>
<td>1-16 Feb 2010</td>
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<tr>
<td>25</td>
<td>Advanced Course on Structural Health Assessment and Management</td>
<td>Dr. Rajeev Kumar Garg</td>
<td>23-25 Feb 2011</td>
</tr>
</tbody>
</table>
- Dr. Rajeev Goel, Scientist was deputed to Cavtat, Croatia during May 3 to 6, 2010 to present a paper in the IABSE – Fib Conference in Structural Engineering – Development and Needs for International Practice.

- Following Scientists were deputed to Lisbon during May 24 to 28, 2010 to attend 16th International Road Federation {IRF} Meeting.
  a) Dr. Nishi Mittal – To present paper in the meeting
  b) Sh. T.K. Amla – To organize CRII Exposition in India Pavilion
  c) Dr. Neelam Jain – Poster Presentation of the paper.

- Dr. Rakesh Kumar, Scientist was deputed to Ancona, Italy from June 28 to 30, 2010 for chairing a Technical Session of the International Conference on Sustainable Construction Material and Technology.

- Sh. Pradeep Kumar, Scientist & Sh. Y V Rao, Tech Officer were deputed to Australia from Sept. 25th to Oct. 17th 2010 to attend the Training programme on “Vehicle Mounted Road Condition Survey System” at ARRB, Melbourne, Australia from Sept. 27 to Oct. 8th and 24th ARRB Conference 2010 at Melbourne, Australia from Oct.12th to 15th 2010.

- Sh. K Sitramanjunayulu, Scientist was deputed to Australia from Oct.10th 2010 to 17th 2010 to attend the ARRB Conference at Melbourne, Australia.

- Dr. Ravinder Kumar was deputed to Edinburgh, UK to attend the Training Workshop from Nov. 1st to 15th 2010.

- On the invitation of Provincial Road Development Authority (Western Provinces), Sri Lanka, a delegation comprising Dr S Gangopadhyay, Director, Dr Sunil Bose, Scientist & Sh. T.K. Amla, Scientist visited Sri Lanka from Oct. 27 to 31, 2010 for S&T Co-operation in the area of Road & Road Transportation and Assessment of Training Needs of various Provinces of Sri Lanka.

- Dr Ronu Mathur, Scientist was deputed to Cartagena (Colombia) to attend ISO – TC/71 Meeting as an Indian delegate of BIS from September 20 to 24, 2010.
<table>
<thead>
<tr>
<th>Student Name</th>
<th>Course Being Pursued</th>
<th>Title of the Training / Research Project</th>
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<tbody>
<tr>
<td>National Institute of Technology, Warangal</td>
<td>Master of Civil Engineering</td>
<td>Speed flow Characteristics and Capacity of Multi-Lane Highways Development of Speed Flow on High speed Corridors</td>
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<tr>
<td>Ms. N. Sabitha</td>
<td>Master of Civil Engineering</td>
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<tr>
<td>Ch. Vineesha</td>
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<tr>
<td>Ch. Devilling Memorial Engg. College, Sirsa, Haryana</td>
<td>B.Tech.</td>
<td>A Study on Dry Lean Concrete Containing PPC</td>
</tr>
<tr>
<td>Mr. Ranjeet Kumar</td>
<td></td>
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<tr>
<td>Earth Science, Jiwaji University, Gwalior (M.P.)</td>
<td>M.Sc. in Remote Sensing &amp; GIS</td>
<td>Study of Influence of Geomorphic factors on Slope Failure (Kalasaar Region). A GIS based approach</td>
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<tr>
<td>Mr. Parimal Singh Tomar</td>
<td></td>
<td>do -</td>
</tr>
<tr>
<td>Mr. Vikas Baboo</td>
<td></td>
<td>do -</td>
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<tr>
<td>Mr. Dheerendra Singh Tomar</td>
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<tr>
<td>Bengal Engineering and Science University, Shibpur</td>
<td>B.Tech.</td>
<td>Design of Superstructure of a T-Girder Bridge</td>
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<tr>
<td>Debabrata Paulit</td>
<td></td>
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<tr>
<td>Prabin Adhya</td>
<td></td>
<td></td>
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<tr>
<td>University School of Environment Management, Guru Govind Singh Indraprastha University, Delhi</td>
<td>M.Sc. (Environment Management)</td>
<td>Real Time Monitoring of Volatile Organic Compound (Benzene) at Petrol Pump, Okhla More and CRRI Main Gate</td>
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<tr>
<td>Ms. Manisha Gaur</td>
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<tr>
<td>Nidhi Prabhakar</td>
<td></td>
<td>do -</td>
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<tr>
<td>Neja Sharma</td>
<td></td>
<td>do -</td>
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<tr>
<td>Ridhi Saluja</td>
<td></td>
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<tr>
<td>Al-Falah School of Engineering &amp; Technology, Dhauj, Faridabad</td>
<td>B.Tech. (Mechanical Engineering)</td>
<td>Maintenance of Air Conditioner and Refrigeration</td>
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<tr>
<td>Mr. Abdul Hasan</td>
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<tr>
<td>Mr. Deepak</td>
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<tr>
<td>Mr. Verun</td>
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<tr>
<td>Echelon Institute of Technology, Faridabad</td>
<td>B.E. (IT)</td>
<td>Web Designing</td>
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<tr>
<td>Ms. Neha Gaur</td>
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<tr>
<td>Mr. Ankur Aggarwal</td>
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<tr>
<td>Mr. Abhishek Gupta</td>
<td></td>
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<tr>
<td>Mr. Harish Bhatia</td>
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<td>IIIMT, Noida</td>
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<tr>
<td>Mr. Himanshu Gupta</td>
<td>B.Tech (ECE)</td>
<td>Instrumentation in Highway Engineering</td>
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<td>National Institute of Technology, Surat</td>
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<tr>
<td>Mr. Gojbiya Ashok K.</td>
<td>Master of Civil Engineering</td>
<td>Road Safety Audit of Major Arterials Passing Through Ghaziabad City</td>
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<tr>
<td>Mr. Bansode Chandrakant E.</td>
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<td>National Institute of Technology, Karnataka, Surathkal</td>
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<tr>
<td>Mr. Sunil Kumar J.C.</td>
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<tr>
<td>Mr. Dipindaas C.D.</td>
<td>M.Tech. (Civil)</td>
<td>Design of Pre-stressed Bridge</td>
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<td>Ms Kishor S Masti</td>
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<tr>
<td>Mr. Sunanth K</td>
<td></td>
<td>Study on Travel Time Behaviour</td>
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<td>NMIMS MPSTME, Shirpur Campus Mumbai (Maharashtra)</td>
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<tr>
<td>Mr. Kishori Nandan</td>
<td>B.Tech. (IT)</td>
<td>Visual Inspection Module in Bridge Maintenance Management System</td>
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<td>NIT, Calicut</td>
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<tr>
<td>Ms. Neena M. Joseph</td>
<td>M.Tech. (Civil)</td>
<td>Study on effect of lane change behaviour of Highways using microscopic simulation</td>
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<td>Ramya S.R.</td>
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<td>Driving Characteristics and Assessment of Drivers</td>
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<td>Sh. Premod Kumar</td>
<td>B.Tech. (CS)</td>
<td>Road Transport R&amp;D Network</td>
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<tr>
<td>Sh. Vaibhav Tayal</td>
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<tr>
<td>Ms. Avni Jain</td>
<td>B.Tech. (Civil)</td>
<td>Design of superstructure of RC Slab Bridge</td>
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<td>Mr. Adhitya Harne</td>
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<td>Kasturba Polytechnic for Women, Pitampura, New Delhi</td>
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<tr>
<td>Ms. Ranju Kumari</td>
<td>Diploma in Civil Engineering (PHE)</td>
<td>Practical Training on Test of Cement and Concrete</td>
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<tr>
<td>Ms. Shikha Aggarwal</td>
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<tr>
<td>Ms. Reshi Verma</td>
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<td>Gani Zail Singh College of Engineering &amp; Technology, Bhatinda, Punjab</td>
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<tr>
<td>Mr. Farooq Khan</td>
<td>B.Tech. (Civil)</td>
<td>Pavement Evaluation Technique</td>
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<tr>
<td>Mr. Mohit Bajaj</td>
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<td>Basic Concepts of Pavement Evaluation Technique</td>
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<td>Centre for Environmental Science &amp; Technology, BHU, Varanasi</td>
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<tr>
<td>Mr. Sanju Kumar Sinha</td>
<td>M.Sc Tech.</td>
<td>Characterisation of Heavy Metals in Roads Run Off</td>
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<td>Mr. Vijay Kumar Yadav</td>
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<td>Investigation of Toxic Heavy Metals in Roads Run Off</td>
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<tr>
<td>Ms. Karen Virani</td>
<td>B.Tech. (Civil)</td>
<td>Road Traffic and Air Pollution in Delhi</td>
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<td>Anna University, Chennai</td>
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<tr>
<td>Mr. R Chandra Pratap</td>
<td>M.E. (Transportation Engg)</td>
<td>Impact of Flyovers on Traffic Congestion</td>
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<td>Mr. V Ramesh</td>
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<td>Road Safety Audit</td>
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<td>Modelling Traffic Time Variation</td>
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<td>Ms. K Pratibha</td>
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<tr>
<td>Ms. Revathi A</td>
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<td>Preliminary analysis on Road Accidents on State National Highways</td>
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<td>Ms. Sathiny Quintail M</td>
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<td>Evaluating the Facilities for Bus Users on Bot Corridors in Delhi</td>
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<td>Birla Institute of Technology, Pilani</td>
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<tr>
<td>Ms. Kavita Jain</td>
<td>B.Tech. (Civil)</td>
<td>Role of Transport Planning in Environment</td>
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<td>Ideal Group of Institutions, Ghaziabad</td>
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<tr>
<td>Mr. Sandeep Saxena</td>
<td>B.E. (Civil)</td>
<td>Studying the Hydraulic Characteristics of Heavy Vehicle Simulator (HVS)</td>
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<tr>
<td>Mr. Kapil Kumar</td>
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<tr>
<td>SRM University, Ramapuram, Campus-Part, Vadapalani, Chennai</td>
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<tr>
<td>Ms. Ashwarya R</td>
<td>B.Tech. ECE</td>
<td>Instrumentation in Highway Engineering</td>
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<td>RASTA Center for Road Technology</td>
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<tr>
<td>Mr. Niranjan G Hiremath</td>
<td>M.Tech.</td>
<td>Driver Psychology &amp; Behaviour on Roads</td>
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<tr>
<td>S.No.</td>
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<td>2.</td>
<td>Professor Shinchi Akutagawa, Dept. of Civil Engineering, Kobe University, Japan.</td>
<td>April 15, 2010</td>
</tr>
<tr>
<td>3.</td>
<td>A Three Member delegation from Fraunhofer - Gesellschaft, Germany.</td>
<td>April 26, 2010</td>
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<td>5.</td>
<td>Mis Metalite International Pvt. Ltd., New Delhi, SINAK Corporation USA.</td>
<td>June 18, 2010</td>
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<tr>
<td>7.</td>
<td>Sh. Arindam Saha, Additional Director, CDAC</td>
<td>July 12, 2010</td>
</tr>
<tr>
<td>8.</td>
<td>Prof. Vivek Tandon, an Eminent Academician and Researcher, Texas University, USA.</td>
<td>Aug. 12, 2010</td>
</tr>
<tr>
<td>9.</td>
<td>Prof. S.P. Palaniswamy</td>
<td>Sept. 23, 2010</td>
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<tr>
<td>10.</td>
<td>Dr. A. Amudeaswari (Director, IFCPAR), New Delhi</td>
<td>Oct. 1, 2010</td>
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<tr>
<td>12.</td>
<td>Mr. Paolo Papeschi from IDS, Italy &amp; Mr. Peter Vanjaarsveld, CEO, IDS, Australia.</td>
<td>Nov. 11, 2010</td>
</tr>
<tr>
<td>15.</td>
<td>Dr. Nagui M. Rouphail, Director, Institute of Transportation Research &amp; Education &amp; Professor of Civil Engineering, North California State University, Raleigh, USA</td>
<td>March 9, 2011</td>
</tr>
<tr>
<td>S.No.</td>
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<td>Highway Research Board</td>
<td>Dr. S. Gangopadhyay</td>
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<td>HRB Identification, Monitoring &amp; Research Application Committee</td>
<td>Dr. S. Gangopadhyay</td>
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<td>3</td>
<td>Highway Research Board Core Group</td>
<td>Sh. U. K. Guruvittal</td>
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<td>4</td>
<td>Accreditation of New Materials and Techniques</td>
<td>Dr. S. Gangopadhyay</td>
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<td>Dr. PK. Jain</td>
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<td>Dr. S. Gangopadhyay</td>
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<td>H-1 Transportation Planning, Traffic Engg. &amp; Road Safety Committee</td>
<td>Dr. Purnima Parida</td>
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<td>Dr. Lakshmy P.</td>
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<td>H-3 Rigid Pavement Committee</td>
<td>Dr. S. Gangopadhyay</td>
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<td>4</td>
<td>H-2 Flexible Pavement Committee</td>
<td>Dr. S. Velmurugan</td>
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<td>5</td>
<td>Highway Specifications &amp; Standards Committee</td>
<td>Dr. Nishi Mittal</td>
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<td>6</td>
<td>Bridge Specification &amp; Standards Committee</td>
<td>Dr. Sunil Bose</td>
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<tr>
<td>7</td>
<td>B-2 Load and Stresses Committee</td>
<td>Dr. Lakshmy P.</td>
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<td>8</td>
<td>Managing Committee of Indian National Group of the International Association of Bridges &amp; Structural Engineering</td>
<td>Dr. Ram Kumar</td>
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<td>Chief Engineer Committee</td>
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<td>G-2 Human Resource Development</td>
<td>Sh. T.K. Amla</td>
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<td>11</td>
<td>G-7 Official Language Committee</td>
<td>Dr. S.D. Sharma</td>
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<td>G-9 Disaster Mitigation Committee</td>
<td>Dr. Kishor Kumar</td>
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<td>G-4 Mechanisation Committee</td>
<td>Sh. R.S. Bhardwaj</td>
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<td>H-4 Embankment, Ground Improvement and Drainage Committee</td>
<td>Sh. Sudhir Mathur</td>
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<td>15</td>
<td>H-6 Road Maintenance and Asset Management</td>
<td>Sh. U. K. Guruvittal</td>
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<td>H-5 Rural Roads Committee</td>
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<td>17</td>
<td>H-8 Urban Roads, Streets &amp; Transportation Committee</td>
<td>Dr. P. K. Jain</td>
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<td>Dr. S. Gangopadhyay</td>
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<td>Dr. Purnima Parida</td>
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## Membership of the Staff on Various Technical Committees

<table>
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<tr>
<th>S.No.</th>
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<th>Position held</th>
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<tr>
<td>18</td>
<td>H-8 Composite Pavement Committee</td>
<td>Dr. Sunil Bose</td>
<td>Member</td>
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<td>19</td>
<td>B-4 Concrete (Reinforced &amp; Prestressed) Structures</td>
<td>Dr. Rajeev Goel</td>
<td>Member</td>
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<td>20</td>
<td>B-5 Steel and Composite Structure</td>
<td>Dr. Lakshmy P.</td>
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<td>B-6 Bearings Joints &amp; Appurtenances</td>
<td>Dr. Sunaj Prakash</td>
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<td>22</td>
<td>B-8 Maintenance and Rehabilitation Committee</td>
<td>Dr. V. V. L. K. Rao</td>
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<td>23</td>
<td>G-3 Environment Committee</td>
<td>Ms. Anuradha Shukla</td>
<td>Member</td>
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<td>G-5 Instrumentation Committee</td>
<td>Dr. Lakshmy P.</td>
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<td>P. Prasanna Kumar</td>
<td>Co-convenor</td>
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<td>Dr. R. K. Garg</td>
<td>Member-Secretary</td>
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Bureau of Indian Standards, New Delhi

<table>
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<th>S.No.</th>
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<tr>
<td>1</td>
<td>Civil Engineering Division Council, CED</td>
<td>Director</td>
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<td>Standards Advisory Committee</td>
<td>Dr. Lakshmy P.</td>
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<td>Executive Council</td>
<td>Director</td>
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<td>Cement &amp; Concrete Sectional Committee, CED 2.1</td>
<td>Dr. Ram Kumar</td>
<td>Member</td>
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<td>5</td>
<td>Building Lime &amp; Gypsum Products Sectional Committee, CED4</td>
<td>Sh. Sudhir Mathur</td>
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<td>6</td>
<td>Flooring, Wall Finishing &amp; Roofing Sectional Committee CED5</td>
<td>Dr. S. D. Sharma</td>
<td>Alternate-Member</td>
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<td>7</td>
<td>Soil Engineering Sectional Committee CED23</td>
<td>Sh. Sudhir Mathur</td>
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<td>Rock Mechanics Sectional Committee, CED18</td>
<td>Dr. Kishor Kumar</td>
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<td>Dr. Pankaj Gupta</td>
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<td>Dr. S. Gangopadhyay</td>
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<td>Concrete Reinforcement CED54</td>
<td>Dr. Ram Kumar</td>
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<td>Geotechnical Investigation, Testing and Instrumentation (43.1)</td>
<td>Sh. U.K. Guruvittal</td>
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<td>14</td>
<td>Interlocking Block Pavement (ICBP) Committee</td>
<td>Dr. S. D. Sharma</td>
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<td>15</td>
<td>Earthquake Engineering Sectional Committee CED 39 in drafting group PG7</td>
<td>Dr. Ram Kumar</td>
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<td>16</td>
<td>Bitumen, Tar &amp; Their Products Sectional Committee, PCD - 6</td>
<td>Director</td>
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<td>Dr. Sunil Bose</td>
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<td>Dr. P.K. Jain</td>
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<td>17</td>
<td>Method of Test for Bitumen, Tar &amp; Their Products Sectional Committee, PCD 6:1</td>
<td>Dr. P.K. Jain</td>
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<td>Dr. Sumil Bose</td>
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<td>Hill Area Development Engineering Sub-Committee, PCD-56</td>
<td>Dr. Kishor Kumar</td>
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<td>Cyclone Resistance Design of Structures, CED-57</td>
<td>Dr. R.K. Garg</td>
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<td>Cement Matrix Products CED-53</td>
<td>Dr. Ram Kumar</td>
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<td>Environment Protection and Waste Management</td>
<td>Ms. Anuradha Shukla</td>
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<td>Dr. Neeraj Sharma</td>
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<td>Dr. Ram Kumar</td>
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<td>Dr. Suraj Prakash</td>
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<td>24</td>
<td>Expert Group on Modified Bitumen Emulsions</td>
<td>Dr. P. K. Jain</td>
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<td>25</td>
<td>BIS-FICCI Task Force to Formulate Specifications for Major Technical Areas of Textiles</td>
<td>Sh. Satish Pandey</td>
<td>Member</td>
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<td>Sh. U.K. Guruvittal</td>
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<td>26</td>
<td>Export Group Specifications for Cold Bituminous Ready Mix for Pavement Maintenance</td>
<td>Dr. P. K. Jain</td>
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<td>27</td>
<td>Export Group and Round Robin Testing of Modified Binder for Viscosity Test for Modified Bitumen (Revision of IS 15462-2006)</td>
<td>Dr. P. K. Jain</td>
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Ministry of Road Transport & Highways (MoRTH) 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                |

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

<p>| 1     | Executive Committee                                                        | Sh. A. Saurikhia            | Honorary Secretary    |</p>
<table>
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<th>S.No.</th>
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<tr>
<td>1</td>
<td>Ministry of Rural Development, Govt. of India</td>
<td>PMGSY Empowered Committee</td>
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<td>Dr. B. K. Durai</td>
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<td>Review of Project Work of PG Student</td>
<td>Dr. S. Gangopadhyay</td>
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<td>Delhi Pollution Specification Committee</td>
<td>Dr. Anil Singh</td>
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<td>Dr. Ram Kumar</td>
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<td>National Institute of Disaster Management</td>
<td>Committee to Formulate Guidelines for Construction of Saline Embankment</td>
<td>Sh. U. K. Guruvittal</td>
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<td>Advanced Materials and Process Research Institute, Bhopal</td>
<td>Management Council</td>
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<td>Centre for Development of Stone (CDS)</td>
<td>Group on Roads and Mass Concrete Work</td>
<td>Dr. A. K. Misra</td>
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<td>National Rural Roads Development Authority (NRRDA)</td>
<td>Governing Body</td>
<td>Dr. P. K. Kanchan</td>
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<td>Sh. B. M. Sharma</td>
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<td>Expert Advisory Committee to Review Standards, Specification and Design of Rural Roads Under PMGSY</td>
<td>Dr. P. K. Kanchan</td>
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<td><strong>National Highways Authority of India</strong></td>
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<td>1</td>
<td>Committee to Review of All Toll Related issues</td>
<td>Dr. B. K. Durai</td>
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<td>2</td>
<td>Technical Appraisal and Review Committee for Development of Fibre Reinforced Plastic-Roadside Barriers</td>
<td>Dr. Nishi Mittal</td>
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<td>Technical Scrutiny</td>
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<td>Dr. Devesh Tiwari</td>
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<td>GIS Expert</td>
<td>Sh. Pradeep Kumar</td>
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<td>1</td>
<td>Committee on Subway</td>
<td>Sh. Subhash Chand</td>
<td>Technical Member</td>
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<td><strong>National Physical Laboratory</strong></td>
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<td>Dr. S. Gangopadhyay</td>
<td>Member</td>
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• Australian Road Research Board (ARRB)
• Bureau of Indian Standards, Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi
• Indian Institute of Bridge Engineers (IIBS), 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 Marga, 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 DC, USA
• 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 for Information Science, NISCAIR Building, Hillside Road, New Delhi
• Indian Group of Geotextiles, Central Board of Irrigation & Power, Malcha Marg, Chanakyapuri, 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
Marketable Products and Services

Intellectual Property (Patents)

Patented Process Released so far to the Industry
- Bitumastic Joining 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 (Pat. No. 90470)
- Improvements in or relating to the Manufacture of Reactive Surkhi (Pat. 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)
- Rototiller (developed jointly by MERAD & CRRI)
- Pavement Paint Marking Machine (developed jointly by CMERI Durgapur and CRRI)
- Vertical Profile Meter
- Polymer modified bitumen
- SBS Modified bitumen
- Crum 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

Process Ready for Exploitation
- A Process for the Production of Magnesium Phosphate Cement for Emergency Repair of Concrete Pavement
- A New Paving system for desert areas
- 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 Benkleman Beam
- Concrete Abrasion Resistance Tester
- Ready Made Mix for Patch Repair
- Bitumen Emulsion
- Portable Ponding-cum-Debris Expulsion Equipment
- Design of a Mobile Visual Inspection Unit

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 Programmes
- Testing & Calibration
### 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:

<table>
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<th>TITLE OF THE COURSE</th>
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<td><strong>A. PAVEMENT ENGINEERING &amp; MATERIALS</strong></td>
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<tr>
<td>• Design, Construction and Maintenance of Flexible Pavements</td>
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<td>• Rigid Pavements: Design, Construction &amp; Quality Control Aspects</td>
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<td>• Pavement Evaluation Techniques and their applications for Maintenance and Rehabilitation</td>
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<td><strong>B. ROAD DEVELOPMENT PLANNING &amp; MANAGEMENT</strong></td>
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<td>• International Course on Dissemination of HDM-4</td>
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<tr>
<td>• Geo-Spatial Technology (GIS, GPS, RS etc) for Road and Transportation</td>
<td>(5 days)</td>
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<td><strong>C. GEOTECHNICAL ENGINEERING</strong></td>
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<tr>
<td>• Planning, Design, Construction &amp; Maintenance of Rural Roads (PMGSY)</td>
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<td>• Geotechnical and Landslide Investigations for Highway Projects</td>
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<td><strong>D. BRIDGES &amp; STRUCTURES</strong></td>
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<tr>
<td>• Bridge Diagnostics, Performance Evaluation and Rehabilitation</td>
<td>(5 days)</td>
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<td><strong>E. TRAFFIC &amp; TRANSPORTATION PLANNING</strong></td>
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<tr>
<td>• Traffic Engineering and Transportation System Management</td>
<td>(5 days)</td>
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<td>• Urban and Regional Transportation Planning</td>
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<td>• Driver Diagnostics, Performance, Evaluation and Training</td>
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<td>• Environmental Impact Assessment (EIA) and Environmental Clearance Process for Road &amp; Highway Projects</td>
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<td>• Road Safety Audit</td>
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<td>• Vibration and Noise Measurement and Analysis</td>
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**Customized Tailor Made Programmes:**
In addition to the above, CSIR-CRRI also organises customized tailor made programmes as per the clients requirements.

Course Fee: The course fee 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. Amla, Head & Course Organiser, Information, Liaison & Training Division, Central Road Research Institute, P.O.CRRI, Delhi-Mathura Road, New Delhi – 110 025 (India). Phone: 011-26921939, Fax: 011-26845843, 26830480
Telefax: 011-26921839, E-mail: tkamla.crriric, mkmaena.crriric
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<th>S.No.</th>
<th>Topic</th>
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<tr>
<td>1)</td>
<td>Recent Trends of the Emissions Characteristics from the Road Construction Industry</td>
<td>Dr. Sippy K. Chauhan, Dr. Sangita Anuradha Shukla, Dr. S. Gangopadhyay</td>
<td>Environment Science Pollution Research, Vol 17, pp.1493-1501, 2010</td>
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<td>2)</td>
<td>Updation of Road User Cost for Economic Evaluation of Road Projects.</td>
<td>Dr. S. Velurugan, Dr. E. Madhu, Dr. K. Ravinder Dr. S. Gangopadhyay</td>
<td>Indian Journals of Transport Management, May, 2010</td>
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<td>3)</td>
<td>Travel Time Reliability Measurement for an Urban Corridor – A Case Study</td>
<td>Dr. S. Gangopadhyay, Dr. Ch Ravi Sekhar, Dr. B. Kanga Durai</td>
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<td>4)</td>
<td>Innovative Strategies for Maintenance and Rehabilitation of Metropolitan City Roads – A Case Study</td>
<td>M.N Nagabhushan, Dr. PK Jain, Dr. PK Kanchan</td>
<td>Highways Research Journals, Vol 3, No 1, pp. 33-43, Jan-June, 2010,</td>
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<td>Dr. Nishi Mitral, V. Sankar</td>
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<td>Safety Belt: Safety Potential Untrapped</td>
<td>Dr. Surinder Mohan, R.K. Bajpai, Dr. S. Gangopadhyay</td>
<td>Urban Transport Journal, pp. 73-79, July 2010,</td>
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<td>9)</td>
<td>Health Impacts of VOCs (Volatile Organic Compounds)</td>
<td>Rina Singh, Anuradha Shukla, Dr. S. Gangopadhyay</td>
<td>Indian Journal of Air Pollution Control pp. 41-47, Sep. 2010,</td>
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<td>11)</td>
<td>Optical Fibre Sensors in Concrete Structures</td>
<td>Y.C. Tiwari, Lakita Jangpangi</td>
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<td>12)</td>
<td>Full Scale Performance Study on Crush Rubber Modified Bitumen and Conventional Bitumen in Bituminous Concrete</td>
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<td>Indian Highways, Vol. 38, No 10, October, 2010,</td>
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<td>Rajesh Gupta, Shankhadas, Dr. Devesh Tiwari, J.K Gopal</td>
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<td>Sadak Akrosh or Karyangan Yojana</td>
<td>Dr. Neelima Chakraborty Dr. Nishit Mitra Shalini Sharma</td>
<td>Bharatya Vegyanik evam Anusandhan Patrika, CSIR, Dec. 2010</td>
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<td>18)</td>
<td>Recommendations for Driver Licensing and Traffic Law Enforcement in India Aiming to Improve Road Safety</td>
<td>Ashish Verma Dr. S.Velmurugan Dr. Neelima Chakraborty Sushma Srinivas</td>
<td>Special Issue of Journal of Current Science, IISc, Bangalore</td>
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<td>19)</td>
<td>Influence of Types of Coarse Aggregates on Coefficient of Thermal Expansion of Concrete</td>
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<td>Manuscript No. MTENG-218, ASCE Journal of Materials in Civil Engineering, USA.</td>
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<td>Sustainability of Crossing Facilities for Pedestrian and Cyclists</td>
<td>Dr. Mukti Advani Kamini Gupta Dr. B.K. Durai</td>
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<td>27)</td>
<td>Pedestrian Safety at Urban Intersections in Delhi</td>
<td>Dr. Nishi Mittal</td>
<td>Indian Journal of Transport Management, CIT, Pune, Vol 34, No.2 ISSN 0972-5695</td>
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<td>28)</td>
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<td>Civil Engineering &amp; Construction Review, 23:88-96</td>
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<td>31)</td>
<td>Environmental and Road Safety Consideration during Transportation of Hazardous Materials by Road</td>
<td>Dr. Niraj Sharma</td>
<td>Indian Highways, pp. 59-76, Feb. 2011</td>
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<td>Motorcycle Emission – Effect of Driving Cycle in Urban and Rural Areas</td>
<td>Dr. Ravinder Kumar</td>
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<td>Measuring Travel Time Reliability of Road Transportation System</td>
<td>Dr. Ch. Ravi Sekhar</td>
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| 1     | International Conference on Transportation Science and Technology Congress (TRANSTEC), New Delhi, April 4-7, 2010 | • Vehicular Emission Norms Vs Vehicle Pollution Loads in Delhi  
• Traffic Characteristics of Delhi | Dr. K. Ravinder, Dr. E. Madhu, Dr. S. Gangopadhyay  
Dr. E. Madhu, Dr. K. Ravinder, Dr. S. Veimurugan | Dr. K. Ravinder  
Dr. E. Madhu |
| 2     | JICA Seminar On-line Site Visualization, April 15, 2010                           |                                                                                | Dr. P. Lakshmy  
D. C. Sharma | Dr. K. Ravinder |
| 3     | India Infrastructure Summit, 10 FICCI, New Delhi, April 26, 2010                   |                                                                                | Dr. K. Ravinder | |
| 4     | 11th ESRI India User Conference, ESRI India, Noida, April 21-22, 2010              | Application of GIS for Infrastructure Projects in Roads and Transportation Sector | A. M. Rao, Dr. B.K. Durai  
Dr. B. Kangadurai  
T. K. Amla  
Dr. Neelam J. Gupta  
A. M. Rao  
Dr. Ch. Ravi Sekhar  
Dr. S. D. Sharma  
K. Sitaramanjaneyulu  
Pradeep Kumar  
R. C. Agarwal | |
<p>| 5     | International Conference on Design and Construction of Urban Transport Structures, National Bridge Research and Development Centre, Hyderabad, April 23-25, 2010 | Fatigue Study of Prestressed Concrete Beam | Dr. Suraj Prakash | Dr. Suraj Prakash |
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|       | • उद्यम रूप एवं पवित्रिक कौशल का प्रमुख नियोजन ने उपयोग – प्रमुख सिद्धांत कृत्य | अन्वेषण कितात्त्व एवं डा० प्रमोद कुमार जैन | |
|       | • राडियो निर्माण में आवश्यक अनुच्छेद एवं अवधारणा पद्धति का उपयोग | ऊष्ठ के रहस्य | |
|       | • समापन चरित्र के अवधारणा (वहन नियोजन) प्रदर्शन – समापन रूप का रहस्य, रहस्य और अवधारणा पद्धति में उपयोग | डा० अनुराधा रिहाई, पंकज गोयल, डा० रेखा मिश्र एवं डा० रे. जे. भिक्षु | |</p>
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<td>* भ - वर्ण - एक नार्यकाल सहस्री सहखलों के निर्माण में</td>
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<td>* भ - रहाण सत्यनिषिद्ध क्षेत्रों में सहखलों की सुसंधा एवं प्राप्तिक प्रक्रिया : प्रौढ़गतिवर्त्त</td>
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<td>गुरुवीर जैन, रामपाल एवं दी. निरंद कुमार जैन</td>
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<td>* Assessment of Residual Life of Existing RCC Bridges</td>
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<td>* Impact of Motorists not Sharing the Road with Motorist</td>
<td>Dr. Nishi Mittal</td>
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<td>* Impediment of Road Safety Audits in India</td>
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<td>Dr. Sunil Bose</td>
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<td>Dr. Ch. Ravi Sekhar</td>
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<td>Dr. S. Gangopadhyay, Dr. Sunil Bose, M.N. Nagabhushan, K. Sitaramanjaneyulu, Ambika Behl, Abhishek Mittal, Gajender Kumar, Girish Sharma</td>
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<td>8th International Conference on Short and Medium Span Bridges-2010, Canada, Aug. 3-6, 2010</td>
<td>Performance of Pre-stressed Bridges as per Indian Codes under Fatigue Loading</td>
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<td>Enhancement of Haul Road Serviceability by using Flyash</td>
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<td>Dr. VVLK Rao Sushil Kumar Narender Kumar</td>
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<td>Dr. Ch. Ravi Sekhar Dr. Mukti Advani</td>
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<td>• Laboratory Investigation on the Performance of Warm Mix Based Thin Stone Matrix Asphalt Mix for Urban Roads</td>
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<td>Dr. Sunil Bose &lt;br&gt; R.K. Panigrahi &lt;br&gt; Abhishek Mittal &lt;br&gt; M.P. Singh</td>
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<td>Dr. E.Madhu &lt;br&gt; Dr. K.Ravinder</td>
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<td>Anuradha Shukla &lt;br&gt; Dr. Niraj Sharma &lt;br&gt; Dr. Rakesh Kumar</td>
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<td>Conference on Cement Concrete Roads – Experience Sharing, CMA, Pune, Oct. 8, 2010</td>
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<td>Conference on Road Planning Design and Construction India, FICCI, New Delhi. Dec. 13-14, 2010</td>
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<td>Dr. B.K. Durai</td>
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<tr>
<td>51</td>
<td>Indo-US Workshop on Nanotechnology in the Science of Concrete, CBRI, Roorkee, Dec. 14-15, 2010</td>
<td></td>
<td></td>
<td>Dr. Rakesh Kumar</td>
</tr>
<tr>
<td>S. No</td>
<td>Name of the Seminar</td>
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<td>Author</td>
<td>Attended By</td>
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<td>53</td>
<td>15th HKSTS International Conference, December 11 – 14, 2010</td>
<td>Modeling Accident Occurrence and Severity for Selected High Speed Corridors.</td>
<td>S. Padma, Dr. E. Madhu, Dr. S. Velumurugan, K. Sitaranjanmsony, Dr. S. Gangapadhyay</td>
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<td></td>
<td></td>
<td>• Genesis of Coal and Chemical Composition and its Significance for Use in Road</td>
<td>R.K. Panigrahi, U.K. Guruvittal, Sudhir Mathur</td>
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<tr>
<td>55</td>
<td>DST Round Table Workshop on Thrust Area for R &amp; D in Civil Infrastructure Technologies, SERC, Chennai, Dec 21 – 22, 2010</td>
<td></td>
<td>Dr. Lakshmy P.</td>
<td>No. of Scientist</td>
</tr>
<tr>
<td>56</td>
<td>3rd Urban Mobility Transport Regional Conference on Sustainable Urban Transport, Accessible and Inclusive Cities, Institute of Urban Transport, New Delhi, Dec 3 – 5, 2010</td>
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<td>57</td>
<td>Indo-Singapore Workshop on Advances in Smart Materials and Structures, IIT, Delhi, Dec. 12, 2010</td>
<td></td>
<td>Dinesh Ganvir</td>
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<td>58</td>
<td>9th International Workshop on Transportation Planning and Implementation Methodologies in Developing Countries (TPMDC), IIT Bombay, Mumbai Dec 15-17, 2010</td>
<td>Capacity Estimation of Eight Lane Divided Urban Expressways Under Heterogeneous Traffic Through Microscopic Simulation Models</td>
<td>Dr. E. Madhu, Dr. S. Velumurugan, Dr. K. Ravinder, Dr. E. Madhu, A. Mohan Rao</td>
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<td>Evaluation of Infrared based Automatic Vehicle Counters Cum Classifiers (AVCC) under Indian Traffic Conditions</td>
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<td>Impact of Flyovers on Traffic Congestion – A Case Study of Delhi</td>
<td>Dr. K. Ravinder, Dr. S. Velumurugan, Dr. E. Madhu, A.M. Rao, Dr. K. Ramachandra Rao, Dr. B.K. Durai</td>
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<tr>
<td>S. No</td>
<td>Name of the Seminar</td>
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<td>Author</td>
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<td>60</td>
<td>International Workshop on Nanopolymer Cement and Concrete, Annamalai University, Annamalai Nagar, Dec 7, 2010</td>
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<td></td>
<td>Dinesh Ganvir</td>
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<tr>
<td>60</td>
<td>18th Global Symposium on Managing Infrastructure Project and Lessons Learnt from Best Practices from Asia Pacific Region, New Delhi, Dec 8-9, 2010</td>
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<td>P.S. Prasad</td>
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<td>61</td>
<td>International Conference IMC-Fib days 2010, Institution of Engineers (India), Jan, 14-15, 2011</td>
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<td>T. K. Amla</td>
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<td>62</td>
<td>Workshop on Sustainable Option of Rigid Pavements, ICJ and Ultra Tech Cement Ltd., Indore, Jan. 8, 2011</td>
<td></td>
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<td>Dr. P. Lakshmy</td>
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<td>63</td>
<td>Conference on Geospatial World Forum, GIS Development, Hyderabad, Jan, 18-21, 2011</td>
<td>GPS Based Data Collection Technologies for Roads</td>
<td>A.M. Rao, Dr. B. K. Durai, Kamini Gupta</td>
<td>Dr. K. Ravinder</td>
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<td>64</td>
<td>Workshop on Cement Concrete Pavements, CMA &amp; Star Comants, Guwahati, Jan 22, 2011</td>
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<td>65</td>
<td>All India Seminar on Energy Management through Renewable Source &amp; Efficient Technologies, IE, Bhopal Jan 8-9, 2011</td>
<td>New Govt. Policies on Energy Efficiency</td>
<td>Subodh Kumar</td>
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<td>67</td>
<td>Seminar on Civil Engineering Building Images, INAE, New Delhi, Jan. 29, 2011</td>
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<th>S. No</th>
<th>Name of the Seminar</th>
<th>Title of Paper</th>
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<th>Attended By</th>
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</thead>
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<tr>
<td>68</td>
<td>National Workshop on Road Infrastructure and Traffic Planning in Jaipur City, Kauthiya Institute, Jaipur, Jan. 29, 2011</td>
<td>Quality Control During Construction of Roads</td>
<td>Abhishek Mittal, Dr Sunil Bose</td>
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<td>70</td>
<td>Conference on Landslide Hazards Consequences and Challenges, CSIR-CRRI Roorkee, Feb. 11-12, 2011</td>
<td>• A Review of Instrumentation, Monitoring &amp; Early Warning for Landslide</td>
<td>Lalita Jangpangi, Shobhit Singhal</td>
<td>P. S. Prasad, Anil Kahi, Inder S. Negi</td>
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<td>S. No</td>
<td>Name of the Seminar</td>
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<td>75</td>
<td>International Seminar on Reducing Carbon Footprint in Road Construction, IRC &amp; PIAAC, New Delhi, Feb 17 – 19, 2011</td>
<td>• Warm Bituminous Mixes: Road to Sustainable Development</td>
<td>Dr. Sunil Bose, Ambika Behl, Girish Sharma, Gajender Kumar</td>
<td>Dr. S. Gangopadhyay, Sudhir Mathur, Dr. P. K. Jain, B.M. Sharma, Dr. B.K. Durai, Anuradha Shukla, Dr. Sippy K. Chauhan, Dr. Kirli Bhandari, Y.V. Rao, Dr. Ravinder Kumar, Dr. Mukti Advani, Dr. Rakesh Kumar, Abhishek Mittal, Dr. N. K. S. Pandhirt, Girish Sharma, Gajender Kumar, Dr. P. Parida, T. K. Amla, C. Kamaraj, Dr. Vasant G. Havanagi, A. K. Sinha, Ambika Behl, Sanjay Deori</td>
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<td></td>
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<td>• Indian Experiences on Microsurfacing: An Innovative Technology for Reduction of Greenhouse Gas Emission</td>
<td>Sanjay Deori, B. M. Sharma, Y.V. Rao, Dr. S. Gangopadhyay</td>
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<td>• Development of Sustainable Roads with Emulsion Based Cold Mix in High Rainfall Areas</td>
<td>Dr. N. K. S. Pandhirt</td>
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<td>• Construction of Embankment Using Copper Slag Waste Material</td>
<td>Dr. Vasant G. Havanagi, A. K. Sinha, Sudhir Mathur</td>
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<td>• Economic Analysis of a Soyabean Based Asphalt Polymer for Preventive Maintenance of Roads</td>
<td>Abhishek Mittal, Sunil Kumar, Gajender Kumar, Girish Sharma</td>
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<tr>
<td>76</td>
<td>Workshop in Air Quality EU-India Action Plan Support Facility-Environment, CPCB, New Delhi, Feb. 18, 2011</td>
<td></td>
<td>Dr. Anil Singh</td>
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<td>77</td>
<td>Intelligent Transport System India, IDPC, New Delhi, Feb. 21, 2011</td>
<td></td>
<td>Dr. B. K. Durai, A.Mohand Rao, Dr. Ch. Ravi Sekhar, Dr. Nishi Mittal</td>
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<td>78</td>
<td>International Conference on Cities and Climate Change, New Delhi, Feb. 21-22, 2011</td>
<td></td>
<td>Anuradha Shukla</td>
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<td>79</td>
<td>Advance Course on Structural Health Assessment and Management of Bridges, SERC, Chennai, Feb. 23-25, 2011</td>
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<td>Dr. Rajeev Kumar Garg</td>
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<td>80</td>
<td>Round Table Conference on Concrete Roads &amp; While Topping Experience and Success in USA, ICI &amp; Ultra Tech Cement, New Delhi, Feb. 25, 2011</td>
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<td>Binod Kumar</td>
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<td>S. No</td>
<td>Name of the Seminar</td>
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| 81    | National Get-together on Road Research and Its Utilization, CRRI, March 5-6, 2011, New Delhi | - New and Innovative Technologies for Bituminous Construction Specifications in India  
- Innovative Use of Waste Material for Road Infrastructure  
- Application of Intelligent Transportation Systems (ITS) for Traffic Management System under Indian Traffic Conditions  
- Emerging Trends of R&D in Bridge Engineering  
- Safety and Efficient Management of Road Network in Landslide Prone Areas | Dr. Sunil Bose, M. N. Nagabhushan, Abhishek Mittal, Ambika Behl  
U. K. Guruvittal  
Sudhir Mathur  
Dr. S. Velmurugan  
Dr. K. Ravinder | No. of Scientists |
| 82    | International Seminar on National Road Development Strategies and Road Safety on Improved Highways, School of Planning and Architecture, New Delhi, March 14-16, 2011 | - Application of GIS Road Safety Projects  
- Night Time Road Safety Enhancement due to Visibility of Retro-Reflective Road Signs  
- Role of Pedestrian Crossing Facilities on the Accessibility of Villagers at Two Junctions of NH-8  
- Techniques for Monitoring Safety Management at Construction Site | A.M. Rao, Dr. B.K. Durai  
Dr. Surinder Mohan  
Dr. S. Gangopadhyay  
Dr. Mukti Advani, Dr. B.K. Durai, Dr. Neelam J. Gupta | Dr. S. Gangopadhyay  
Amuradha Shekla  
Dr. P. Parida  
Dr. E. Madhu  
Dr. Ravinder Kumar  
Subhash Chand  
Dr. Surinder Mohan  
Dr. J. Nataraju  
T. K. Amla  
Dr. B. K. Durai  
Dr. Mukti Advani  
Dr. Ch. Ravi Sekhar  
S. Padma |
| 83    | 3rd Indian Young Geotechnical Engineering Conference, IGS, New Delhi, March 25-26, 2011 | Geotechnical Investigation and Stability of Retaining Walls: A Case Study | J. Ganesh, Kanwar Singh, Dr. S. Saha, Jai Bhagwan, Sudhir Mathur | No. of Scientists |
| 84    | Conference on Road Safety at Design Stage, MORTH, New Delhi, March 31st, 2011 | | | Dr. Nishi Mittal |
Staff of the
CSIR-Central Road Research Institute
As on 31st March, 2011

Director
Gangopadhyay S. (Dr.), M.Tech. (Transportation System), M.Sc. (Transportation), Ph.D.

Road Development Planning and Management (R&D)
Kanchan P.K. (Dr.), Ph.D (Maths) Scientist-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.) (Retired on April 2010)
Dwivedi S.N., M.A.
Gupta Kamini, M.Tech. (Transportation Engineering)
Gupta S.K, Diploma in Draughtsmanship (Mech)
Gupta Neelamal., (Dr.), M.Sc., M. Phil (Computer Application), Ph.D. (Numerical Analysis)
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Ravinder Kumar (Dr.), M.E (Transportation Engineering), Ph.D.

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Jeet Ram, Non Matric
Kumar Ashok, B.A.
Kumar Narendra, Matric
Ram Sagar, Matric
Singh Satyabir, SSC, ITI (Printing)

Bridges & Structures (BAS)
Ram Kumar (Dr.), M.E., Ph.D., (on Deputation)

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Garg R. K. (Dr.), M.Tech. Ph.D.
Gaharwar S. S., M.E. (Structure) (On Deputation)
Goyal J. K., M.E. (Structures)
Goel Rajeev (Dr.), M.E. (Structural Engineering), Ph.D.
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
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Yogender K. Singh, Dip. Electronics

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Ram Lakhan
Rajveer Singh, Non Matric
Satish Kumar, B.A.
Verma Surender Kumar

Traffic & Transportation Planning (TTP)
Gangopadhyay S. (Dr.), M.Tech. (Transportation System), M.Sc. (Transportation), Ph.D. (Area Advisor)

Traffic Engineering & Road Safety (TES)
Mittal Nishi (Dr.), M.A. (Eco.), Ph.D (Head)

Scientists/Technical Officers
Biswa K., Draughtsman
Chakraborty Neelima (Dr.), M.A., (Psycho.), PG. 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 Cianid, ME (Highways)
Surinder Mohan (Dr.), M.Sc. (Physics), PG Diploma in Ecology & Environment, Ph.D
Umnap S.K., B.Com
Velmurugan, S. (Dr.), M.E., Ph.D. (Transportation Engineering)

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Bhel Sushma, Intermediate
Mehto Jag Lal, Non Matric
Munreja Dateep, B.Com.
Raj Bala, Non Matric
Rama Ranjan

Transport Planning & Environment (TPE)
Shukla Anuradha, M.Sc., M.Tech. (Corrosion Science), PG. Diploma in Ecology & Environment Science (Head)

Scientists/Technical Officers

Akhtar Nasim, M.Tech. (Environmental Engg.)
Bhandari Kiriti (Dr.), M.Sc. (Environmental Engg.), Ph.D.
Chander Bhan, M.A. (Eco) (Retired on March 2011)
Chauhan Sippy K (Dr.), Ph. D (Chemistry)
Errapalli Madhu (Dr.) M. Tech (Transportation Planning), Ph. D
Kamal C., M. Tech
Padma S., M.Tech.
Parida Purnima, (Dr.) M.A. (Economics), M.Tech., Ph.D
Pradeep Kumar P. V., M.E., (Mech.) MBA
Ravinder 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 Nirej (Dr.), M. Tech., Ph.D.

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Daya Ram, B.A.
Kumar Devender, Matric, ITI (Motor Mech.)
Devi Shakuntla, Non Matric
Sethi Sarita, B.A.
Singh Brij Mohan, Matric

Pavement Engineering & Materials (PEM)
Flexible Pavement (FP)

Base Sunil, (Dr.) M.Tech (Highways), Ph.D.
(Head) Retired on January, 2011

Jain P. K. (Dr.) Ph.D. (Chemistry) (Head) (w.e.f. March 1, 2011)

Scientists/Technical Officers

Bhel Ambika, M.Tech (Chemical Engineering) (On Study Leave)
Gajendra Kumar, M. Tech (Transportation)
Mittal Abhishek, M.Tech. (Transportation Engg.)
Nigam B.S., B.A.(Retired on November, 2010)
Nagabhushana M.N., M.Sc. (Highway Engg.)
Kumar Narendra, B.A.
Pandey Satish, B.E. (Civil) (On Study Leave)

Pundir N. K. S. (Dr.), PhD (Chemistry)
Sangeeta (Dr.), Ph.D. (Polymer Chemistry)
Sharma Girish, M.Tech (Chemical Engineering)
Shukla Manoj, M.E (Transportation) (On Deputation)
Singh Surender, ITI

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Amit Kumar
Hembran Panchanan
Rishi S. K., B.Com., Diploma in Book Keeping & Accountancy
Raghusaran
Saini Karuna, B.A.
Rigid Pavement (RP)
Mathur Renu (Dr.), M.Sc., Ph.D. (Head)

Scientists/Technical Officer
Binod Kumar, M.E. (Highway Development Engineering)
Dinesh V. Ganvir M.E. (Highways & Transportation)
Goeel Pankaj, M.Tech
Jain A. K., M.E. Hons. (Transportation Engg.) (on Deputation)
Maheshwari R. K. (Dr.), M.Sc. (Chemistry), Ph.D. (Retired on January, 2011)
Mishra A. K. (Dr.), M.Sc. (Chemistry), Ph.D., Pant Ashok, Higher Secondary
Rakesh Kumar (Dr.), M.Tech, PhD (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
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
Pardesi R. C., B.Sc.
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
Sagar A. K., B.Sc. Engg. (Civil), MBA, M.Tech.

(Environmental Engg.)
Sharma S.D., (Dr.), M.Sc. (Chemistry), Ph.D (Retired on July 2010)
Singh Ajaypal, 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.)
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 (Retired on October, 2010)
Singh Mahinder Prasad
Singh Pratap, Metric JTI
Verma Pushpa, M.A.

Geotechnical Engineering (GTE)
Mathur Sudhir, 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. (Highways)
Jai Bhagwan, M.Sc. (Physics)
Khan Farhat Zahoor, M.Tech. (Geotechnical)
Kumar Kshor (Dr.), Ph.D. (Geology Engineering)
Mukherjee Deepak, M.Sc. (Applied Geology)
Murugesan.V., SSLC
Staff of the
CSIR-Central Road Research Institute
As on 31st March, 2011

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)
Singh Kanwar, M.Tech. (Geotechnical Engg.)
Sinha Anil Kumar, M.Tech. (Geotech. Engg.)
Seni S. K., M.E. (Civil)
Swami R. K., M. Sc. (Chemistry)
Vasant G. Havangoni, (Dr.), M.Tech, Ph.D. (Highway &
Geotech Engg).
Yadav O. P., M.Sc. (Physics) (Retired on April 2010)
Kanaujia V. K., B.E. (Civil)

S&T and Supporting Staff
Hari Ram, Non Matric
Jamdar Mehta, Non Matric
Saha Sunil Chander, Matric
Surinder Kumar, Non Matric
Ved Prakash, Inter
Vijay Singh, Non Matric

HRD & Project Management (HRP)
Sudhir Mathur, M.Tech (SM & FE)
(Area Advisor)

Planning Monitoring & Evaluation (PME)
Jain P.K. (Dr.) Ph.D (Chemistry) (Head) (upto February
28, 2011)
Saurikhia A., M.Sc. (Env. Engg.), PGDPM, AMIE
(Head) (w.e.f. March 1, 2011)

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, M S (Software System)

Sharma Rekha (Dr.), M.Sc., Ph.D. (Retired on March
2011)

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-
PDM (TQM), C. Engr. (I)
Arora Anita, M.Sc. (Chemistry)
Jain Kavita, M.Com
Jeevan Lal, Intermediate
Meena M. K., M.Tech. (Civil)
Singh Rajbir, B.A, ITI (Retired on Oct. 2010)

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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)
(Rechristened ERP Cell w.e.f Feb.3,2011)
Saurikhia A., M.Sc. (Env. Engg.), PGDPM, AMIE(Nodal

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Staff of the
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Scientists/ Technical Officers
Kamla Masih, MCA

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Kapoor Kumalesh, M.A.
Prakash Dinesh, Non-Matric
Sinha Preeti, BCA

Quality Management
Bharadwaj, R. S., M.Sc., Associateship in Information Science, M.Phil (Science Communication & Journalism) (Head)

Scientists/ Technical Officers
Kannan S., M.Sc.

S&T and Supporting Staff
Kumar Sunil, B.A.

Computer & Networking (CCN)
Mukhopadhyay D. (Dr.), Ph.D (Applied Maths) (Head) (Retired on December 2010)
Dutta R. N., M.Sc. (Operational Research) (Head) (w.e.f. January 1, 2011)

Scientists/Technical Officer
Mariappan S., Diploma in Computer Technology
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
Manpreet, B.Tech.
Shiv Lal, Non-Matric

Instrumentation (INS)
Prasanna Kumar P., M.Sc. (Physics) (Head) (upto March 7, 2011)

Sharma D. C, B.E. (Elect), M.Tech (Computers) (Head) (w.e.f. March 8, 2011)

Scientists/Technical Officers
Chadda Renu, M.Sc. (Botany)
Jangpangi Lalita, ME (Control and Instrumentation)
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 V. P., Matric, ITI, Diploma in Electrical Trade
Tiwari Y. C., M.Sc. (Physics)

S&T and Supporting Staff
Shukla Jai Prakash, Matric
Paswan Bhawesh
Singh Lokeshwar, M.Sc. (Electronics)

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.
Gola Kewal Krishan
Harish Kumar, ITI
Sharma N. K, Diploma in Mechanical Engg.
Sharma Ashok Kumar, ITI, ITI (Motor Mech.)
Singh Bir, ITI
Singh Gurdeep, Non-Matric
Singh Bhim, Non-Matric
Singh Satnam
Mohd. Irshad, Dip in Draftsmanship (Mech.)

S&T and Supporting Staff
Kishan Swaroop, ITI (Electrical/Wireman Course)
Kumar Om, B.A., ITI
Staff of the
CSIR-Central Road Research Institute
As on 31st March, 2011

Civil Section
Jai Bhagwan, M.Sc. Physics (Head)

Scientists & Technical Officers
Dass: Shankh, Diploma (Civil Engg.)
(on Deputation)
 Krishna Kant, Diploma (Civil Engg.)
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
Mehta, Raj Kishore, Non-Matric
Singh Bhanwar, Non-Matric
Varsh Vaibhav
Vinit Kumar (resigned w.e.f. Nov. 1, 2010)
Vinoj Kumar, Non-Matric

Horticulture
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.

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 Hukum (Retired on May 2010)
Singh Lakhbir, H.Sc, ITI (Motor Mech.)
Singh Mohan, Higher Secondary
Sunil Kumar
Sunil Dutt, Non-Matric

Documentation & Library Services (DLS)
Ashok Kumar, (Dr.) MSc, M.I.I.Sc, Ph.D, (Area Advisor & Head)

Scientists/Technical Officers
Aggarwal Neera, M.A., B.I.I. Sc., Associateship in Information Science

S&T and Supporting Staff
Rangarajan, Dip. in Mech. Engg.
Sharma, Dev Dutt, Matric

Post-Graduate Research Programme (PGRP)
Jain P. K. (Dr.), Ph.D. (Chemistry) (Coordinator)
Lohani G. C., B.A., LLB

Rajbhasha Unit
Dinesh Kumar, Non Matric
Khutthan Santosh, B.A.

Estate Services (ESS)
Bose Sunil, (Dr.) M.Tech (Highways), Ph.D. (Area Coordinator) (Retired on Jan. 2011)
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
Grover Sunil, B.E. (Civil)
Meena Muni Raj, B. Tech (Electrical)
Singh D. V., M.Sc.

S&T and Supporting Staff
Bhatt Pankaj
Mohan Lal, Non Matric.
Prem Chand, Non Matric
Singh Babban, B.A
Shabbuddin Khan, Non Matric
Sheo NAND Prasad, Matric
Tata Chand, Dip.in Civil Engg.
Tete Fuljen (Expired on Nov. 28, 2010)
Vikram Singh, Non Metric

Directorate
Gauba A. K, Intermediate
Jetly Pushpa, B.A.
Singh Kartar, Matric
Singh Madhu Sudan, Non Matric
Saini Sunita, HSc

Administration
Jitender Parasar (Controller of Administration)
Verma Simesh (Administrative Officer) (Transferred or Aug. 31, 2010)
Singh B. K., (Administrative Officer) (Joinad on Aug. 26, 2010)
Bhoga Balmiki, Non Matric (Retired on Oct. 2010)
Kumar Vijay, HSc
Mehta 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 (VRS on Jan. 2011)
Chopra Rajeev, Sr. Sec.
Devi Sumitra, Non Matric
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. (Retired on Aug. 31, 2010)
Verma Kamlesh, M.A., Certificate in Library Science
Vinod Kumar, B.A. (Officiating Section Officer)

Establishment-II
Joon R. C., M.A. (English) (Section Officer)
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 Narendra, M.A.
Talwar Baldev
Verghese Kunjumol, Senior Secondary

Personnel Cell
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 (Officiating Section Officer)

Vigilance Cell
Singh Vandana D., (Section Officer)
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 Tak Chand, B.A.

Finance & Account Section
Changloi H., F&AO (Joined on Sept. 23, 2010)
Indora Jai Prakash, F & AO
Gurmeet Kaur, SO, F&A
Jain M.K., Controller of Finance & Accounts
(Transferred on Sept. 30, 2010)
Malik Neelam, Matric
Nagi Vikas Singh
Phool Chandra, M.A.
Sharma Bishan Dass, B.A.
Singh Ajit Kumar, B. A.
Singh Balbir
Singh Dheeraj, Section Officer, F&A (on Deputation)
Singh Jagdish, Matric
Singh Maharaj, B.A. (Transferred on May 24, 2010)
Shiv Narain, Non-Matric

Purchase Section
Rath Debraj (Store and Purchase Officer)
(Joined on Aug. 25, 2010)

Dussey Virender Kumar
Kumar Vijender, Matric
Singh Jai
Shah Ram Badan, Matric
Singh Randhir, Non-Matric
Verma Veena, M.A.
Laliteshwar, Steno

Store Section
Marwaha Vijay Kumar, B.Com
Bairagi K.
Chhachhia Sumer Singh
Kukreti, C.M., HSc
Kumar Bijender
Paswan Gore Lal, Matric
Singh Jaswant
Verma, S.G., SO, Store and Purchase

Security, Guest House and Canteen

Security
Mani Chinta, Matric (Retired on Sept. 2010)
Prakash Om, Non-Matric
Singh Dharam, (Core Taker)
Singh Ram, Non-Matric

Guest House
Acharya Keshav Ram
Balmiki, Ramsai
Bariya Rajesh
Lal Sohan, Non-Matric (Retired on Aug. 2010)
Narayan Chet
Prakash Braham, Non-Matric
Siddiqui Fasih Ahmed (Manager)
Singh Rajbir
Singh Rajpat
Suraj
Prof. D. V. Singh  
FNAE, FNA, FASc, FNASc, FIE  
1002, Sun breeze Apartments  
Tower B, Vaishali, Sector V  
Ghaziabad-201 010  

Chairman

Dr. S. Arunachalam  
Scientist ‘G’  
Structural Engineering Research Centre  
CSIR Campus, TTTI Taramani  
Post Bag No. 8287  
Chennai-600 113  

Member
(DG’s Nominee)

Lt. Gen. M. C. Badhani, VSM  
DG, Border Roads  
Seema Sadak Bhawan  
Ring Road, Delhi Cantt.  
New Delhi-110 010  

Member  
(External Member)

Prof. S. K. Bhattacharyya  
Director  
CSIR-Central Building Research Institute  
Roorkee-247 667  

Member
(Sister Lab)

Shri S. K. Puri  
Additional Director General  
Ministry of Road Transport & Highways  
Transport Bhawan  
New Delhi-110 001  

Member  
(External Member)

Dr. Anil K. Gupta  
Director  
Advanced Materials and Processes Research Institute  
Hoshangabad Road, Bhopal-462 064  

Member
(Cluster Director)

Prof. M. R. Madhav  
Professor  
“SUTEJA” 159, Road No. 10  
Banjara Hills  
Hyderabad-500 034  

Member  
(External Member)

Dr. S. Gangopadhyay  
Director  
CSIR-Central Road Research Institute  
Delhi-Mathura Road, P.O. CRRI  
New Delhi-110 025  

Member
(Director, Lab)

Prof. B. B. Marwah  
Executive Director  
NC College of Engg. & Technology  
Ishrana, Panipat  
(Haryana)  

Member  
(External Member)

Head or His Nominee  
Planning & Performance Division  
Council of Scientific & Industrial Research  
Anusandhan Bhawan  
Rafi Marg, New Delhi-110 001  

Member
(Permanent Invitee)

Dr. L. R. Kadiyali  
Chief Engineer (Retd.), MoRTH  
RZ-44, Bhawani Kunj  
Behind D-2 Vasant Kunj  
New Delhi-110 070  

Member
(External Member)

Secretary, RC  
Dr. P. K. Jain  
Scientist “G” & Head PME  
CSIR-CRRI, New Delhi-110 025  
E-mail: pramodj.crri@nic.in  
Phone: 26921835 (Ext. 223)  
M: 9910113992  

Member

Shri Kandaswamy  
Chief Engineer  
Ministry of Road Transport & Highways  
1, Parliament Street  
New Delhi-110 001  

Member  
(Agency Representative)
Management Council of CRRI

Dr. S. Gangopadhyay  
Director  
CSIR-CRRI  
New Delhi  
Chairman

Prof. S.K. Bhattacharyya  
Director  
CSIR-CBRI  
Roorkee  
Member

Dr. Kishor Kumar  
Sci. F  
CSIR-CRRI  
New Delhi  
Member

Dr. Purnima Parida  
Sci. E-II  
CSIR-CRRI  
New Delhi  
Member

Sh. Binod Kumar  
Sci. E-I  
CSIR-CRRI  
New Delhi  
Member

Sh. Subhash Chand  
Sci. E-I  
CSIR-CRRI  
New Delhi  
Member

Sh. Naresh Kumar Sharma  
Gr. III (6)  
CSIR-CRRI  
New Delhi  
Member

Head, RPBD & PME  
Member

Sr. CoFA/CoFA/F&AO  
Member

Sr. COA/COA/AO  
Member-Secretary
## List of Completed Inhouse Projects

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Seismic Resistant Design of Bridges: Performance of Concrete Bridges under Seismic Forces</td>
<td>Dr. R.K. Garg</td>
</tr>
<tr>
<td>2</td>
<td>Environment Risk Assessment and Safety Consideration in Transportation of Hazardous Materials by Road</td>
<td>Dr. Niraj Sharma</td>
</tr>
<tr>
<td>3</td>
<td>Study of Thermal Effects for the Design of Rigid Pavements through Instrumentation of Concrete Pavements at CRRI, New Delhi</td>
<td>Dr. Lakshmy P.</td>
</tr>
<tr>
<td>4</td>
<td>Seismic Response Study of Earth Embankment</td>
<td>Dr. Suraj Prakash</td>
</tr>
<tr>
<td>5</td>
<td>Study of Strength of Concrete vis-a-vis Grades of Cement in Market</td>
<td>Dr. Renu Mathur</td>
</tr>
<tr>
<td>6</td>
<td>Detailed Performance Evaluation of Micro-surfacing on Various Delhi Roads</td>
<td>Dr. Sangita</td>
</tr>
<tr>
<td>7</td>
<td>Validation of the Relationship between Time Mean Speed and Space Mean Speed</td>
<td>Mrs. S. Padma</td>
</tr>
<tr>
<td>8</td>
<td>Development of a Correlation between Corrosion Rate of Steel in Concrete Measured by Galvapulse (NDT) Equipment and Gravimetric Method</td>
<td>Dr. VVLK Rao</td>
</tr>
<tr>
<td>9</td>
<td>Influence of Driver Characteristics on Fuel Consumption of Vehicles</td>
<td>Sh. P.V. Pradeep Kumar</td>
</tr>
<tr>
<td>10</td>
<td>Simplification of Design Live Loads on Highway Bridges</td>
<td>Sh. J.K. Goyal</td>
</tr>
<tr>
<td>11</td>
<td>Development and Design of Thin Stone Matrix Asphalt (TSMA) mixtures as Preventive Maintenance, Treatments for Flexible and Feasibility of its Application on Rigid Pavements</td>
<td>Dr. P. K. Jain</td>
</tr>
<tr>
<td>12</td>
<td>Stabilisation of Black Cotton Soil with Pond Ash and Cement</td>
<td>Sh. Alok Ranjan</td>
</tr>
<tr>
<td>13</td>
<td>Detailed Analysis of Slopes through Finite Element Method</td>
<td>Dr. Sukumar Saha</td>
</tr>
</tbody>
</table>
## List of new In-house projects taken-up during the year

<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Variability in Vehicle Fuel Consumption under Controlled Conditions</td>
<td>Sh. P.V. Pradeep Kumar</td>
</tr>
<tr>
<td>2</td>
<td>Accessibility and Mobility Impact on Neighborhoods due to Expressways/High Speed Corridor</td>
<td>Ms. Mukti Advani</td>
</tr>
<tr>
<td>3</td>
<td>Effect of Bottom Ash/Pond Ash as Replacement of Fine Aggregate in Concrete</td>
<td>Sh. J.B. Sen Gupta</td>
</tr>
<tr>
<td>4</td>
<td>Modelling of Driving Cycle for Road Network Development Plan in Urban and Suburban Areas Applying GPS-A Case study in NCR</td>
<td>Dr. Ravindra Kumar</td>
</tr>
<tr>
<td>5</td>
<td>Creation of R&amp;D Resource Base Facilities available at CRRI</td>
<td>Sh. Naresh Kumar Sharma</td>
</tr>
<tr>
<td>6</td>
<td>To Investigate the Effect of Road Traffic on Indoor Air Quality within Metro Stations</td>
<td>Dr. Kirti Bhandari</td>
</tr>
<tr>
<td>7</td>
<td>नोकरा से टेंटर नोकरा को जोड़ने वाले यमुना एक्सप्रेस वे पर होने वाली दुर्घटनाएं एवं उनमें बुद्धि की दर के मुख्य कारणों की जाँच एवं उनके निर्वाण</td>
<td>Sh. Harcharan Singh Nagar</td>
</tr>
<tr>
<td>8</td>
<td>Performance Evaluation of High Performance Mixes laid at DSIIOC Industrial Area in Bawana</td>
<td>Ms. Ambika/Mr. Girish</td>
</tr>
<tr>
<td>9</td>
<td>Study on Suitability of Synthetic Fiber Reinforced Concrete for Construction of Concrete Pavements in Indian Conditions</td>
<td>Dr. Rakesh Kumar (Sh. Pankaj Goel)</td>
</tr>
<tr>
<td>10</td>
<td>Micro Simulation based Driving Cycle in Delhi City for Sustainable Transport System</td>
<td>Dr. Ravindra Kumar</td>
</tr>
<tr>
<td>11</td>
<td>Estimating the Carbon Footprint of Commuting in Urban Areas</td>
<td>Dr. Kirti Bhandari</td>
</tr>
<tr>
<td>12</td>
<td>Travel Time Related Performance Measures for Evaluation of Sustainable Road Transportation System</td>
<td>Sh. Ravi Shekhar</td>
</tr>
<tr>
<td>13</td>
<td>Development of Multimodel Level of Service (MMLoS)</td>
<td>Ms. Mukti Advani</td>
</tr>
</tbody>
</table>
MEMBERS OF FINANCE & ACCOUNTS SECTION

MEMBERS OF PURCHASE & STORE SECTION

MEMBERS OF CIVIL TEAM