12\textsuperscript{th} TPMDC 2016

International Conference on
Transportation Planning and Implementation Methodologies for Developing Countries

19 - 21 December 2016

Abstract Booklet

Organized by
Transportation Systems Engineering
Department of Civil Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400076, India
International Conference on
Transportation Planning and Implementation
Methodologies for Developing Countries

19 - 21 DECEMBER 2016

ABSTRACT BOOKLET

ORGANIZED BY
TRANSPORTATION SYSTEMS ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY BOMBAY
POWAI, MUMBAI 400076, INDIA
PREFACE

The Transportation Systems Engineering Group (TSEG) of IIT Bombay started an International Workshop/Conference series about 22 years back by making the first announcement in the WCTRS (World Conference on Transport Research Society) Newsletter. The first Workshop of the series was successfully conducted in December 1994 on Impact Evaluation and Analysis of Transportation Projects in Developing Countries, IEATP-94. The second Workshop of the series, Transportation Planning and Implementation Methodologies for Developing Countries, TPMDC-96 was conducted in December 1996. Starting from the year 1996, international workshops on TPMDC are conducted biannually and this year marks the twelfth of its kind. The 12th TPMDC is being held in December 2016 with special emphasis on emerging trends and transportation infrastructures.

The TSEG of IIT Bombay is actively involved in the national and local level transport planning, traffic operation and management, pavement design, materials characterization, highway safety, geometric design, intelligent transportation systems and freight transport activities in India. Likewise, many of the agencies in developing countries have gained lot of expertise in transportation planning and significant innovations have been made to address the current issues. This conference will be an ideal forum to share and exchange the experience among the transportation professionals of the developing and developed nations. The conference will deal with modern techniques and methodologies of transportation planning evolved and used innovatively for developing countries which can be of use to even developed nations of the world. This conference will highlight the application of tools and techniques in transportation infrastructure planning, management, implementation, operation and maintenance, pavement materials, design and construction. The three days of conference sessions will consist of around 250 selected presentations by the delegates. The major themes of the conference are Planning and Network Modeling, Analysis, Design, and Evaluation of Pavement Systems, Traffic Flow Theory and Modeling, Safety, Security, Emergencies, and Environment, Travel Behavior Modeling, Public Transportation, Pavement Materials and Construction, Highway Geometric Design, Freight Transportation, Pedestrian and Non-motorized Transportation, Traffic Operations and ITS.

- Organizing Committee
TPMDC 2016
IIT BOMBAY

IIT Bombay, set up by an Act of the Parliament, was established in 1958, at Powai, a northern suburb of Mumbai. Today the institute is recognized as one of the major centre of academic excellence in the country. Over the years, there has been dynamic progress at IIT Bombay in all academic and research activities and there has been a parallel improvement in facilities and infrastructure, to keep it on par with the best institutions of the world. The idea and ideals on which such institutes are built evolve and change with national aspirations, national perspectives and trends worldwide. IIT Bombay, too, is one such institution.

CIVIL ENGINEERING DEPARTMENT

Indian Institute of Technology Bombay was established in 1958, and the Department of Civil Engineering has been an integral part of the institute since its inception. The department, with its multifaceted faculties, continues to maintain and cultivate its strong links with the building and construction industry and academic and research institutions, both within and outside the country. Beside high quality teaching and instruction, the department is actively involved in the basic and applied research consultancy, and provides high quality technological advisory support through various research and development projects and consultancies to various organizations.


TRANSPORTATION SYSTEMS ENGINEERING GROUP

Transportation Systems Engineering Group (TSEG) started its post graduate programme in 1988. Although, the transportation as a subject existed all along, marginally for the input required in the combined undergraduate in Civil Engineering, it took off for realistic development in the field only in the second half of eighties. TSEG has Masters and Doctoral programme which are extremely popular.

On the average, there is an intake of twelve students in M.Tech every year, for a twenty four months long programme. Intake for doctoral studies is not fixed one, and at present there are thirty seven doctoral students doing their research. The laboratories are fully equipped with all traditional and modern test facilities. Undergraduate and Post graduate students use the laboratories regularly for their laboratory courses.
FACILITIES

The Traffic Engineering Lab holds many traditional and advanced types of equipment for testing drivers (Driver Testing Units), Fixed-Base Driving simulator and for conducting traffic studies (Radar Speed Meter, VBOX, Sound Meter and GPS receiver). Advanced Pavement Laboratory include advanced instruments like Dynamic Shear Rheometer, Light Weight Deflectometer, Aggregate Image Measurement System, Rotary Evaporator, Dynamic Contact Angle Measuring Device, Force Ductilometer, Automated Marshall Compactor, Rolling Thin Film Oven and Bending Beam Rheometer.

The transportation studio lab features a wide range of tools for transportation planning and traffic simulation (VISSIM, AIMSUN, VISUM, TransCAD, Paramics and CUBE), pavement analysis, design and management (KENPAVE and HDM –IV), Highway geometric design (MX-Road) and GIS tools (ArcGIS).
ORGANIZING COMMITTEE

Chairman : Prof. Gopal R. Patil
IIT Bombay, India

Secretary : Prof. P. Vedagiri
IIT Bombay, India

Members :
Prof. K. V. Krishna Rao
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IIT Bombay, India
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IIT Bombay, India
Prof. Dharamveer Singh
IIT Bombay, India
Prof. Avijit Maji
IIT Bombay, India
Prof. Nagendra R. Velaga
IIT Bombay, India
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The City and Industrial Development Corporation of Maharashtra (CIDCO), India
Mr. K. V. J. Ramana Rao
Egis India Consulting Engineers Pvt. Ltd., India
WORKING COMMITTEE MEMBERS

Aarthi Manoharan
Aditya Kumar Das
Ali Hakimelahi
Amruta Kulkarni
Aniket Kataware
Anna Charly
Aupal Mondal
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Bharat Kumar Pathivada
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Sairam Goud
Sandeepan Roy
Sanu Meena
Sarfaraz Ahmed
Sharath M. N.
Sharmila
Shraddha Shimpi
Siddharth S. M. P.
Sowjanya Dhulipala
Sreekumar M.
Suman Dash
Sushma M. B.
Tushar Choudhari
Vinamra Mishra
### SCIENTIFIC COMMITTEE

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution/Location</th>
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<tbody>
<tr>
<td>Prof. Gopal R. Patil</td>
<td>IIT Bombay, India</td>
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<td>Prof. P. Vedagiri</td>
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<td>Prof. Avijit Maji</td>
<td>IIT Bombay, India</td>
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<tr>
<td>Prof. Sabyasachee Mishra</td>
<td>University of Memphis, USA</td>
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<tr>
<td>Prof. Sushant Sharma</td>
<td>Texas A&amp;M University, USA</td>
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<tr>
<td>Dr. S. Velmurugan</td>
<td>CSIR-Central Road Research Institute (CRRI), India</td>
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<tr>
<td>Prof. Siva Srinivasan</td>
<td>University of Florida, USA</td>
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<tr>
<td>Prof. Animesh Das</td>
<td>IIT Kanpur, India</td>
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<td>Prof. Vinod Vasudevan</td>
<td>IIT Kanpur, India</td>
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<tr>
<td>Prof. Aravind Krishna Swamy</td>
<td>IIT Delhi, India</td>
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<tr>
<td>Prof. Akhilesh Maurya</td>
<td>IIT Guwahati, India</td>
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<tr>
<td>Prof. Bhargab Maitra</td>
<td>IIT Kharagpur, India</td>
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<tr>
<td>Prof. Krishna Prapoorna</td>
<td>IIT Kharagpur, India</td>
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### ADVISORY COMMITTEE

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<tr>
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<tbody>
<tr>
<td>Prof. Kumares Sinha</td>
<td>Purdue University, USA</td>
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<tr>
<td>Prof. Jose Holguin-Veras</td>
<td>Rensselaer Polytechnic Institute, USA</td>
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<tr>
<td>Prof. P. K. Sikdar</td>
<td>Intercontinental Consultants and Technocrats Private Limited, India</td>
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<tr>
<td>Dr. R. K. Jha</td>
<td>Gujarat International Finance Tec-City Co. Ltd.-GIFT, India</td>
</tr>
<tr>
<td>Mr. P. R. K. Murthy</td>
<td>Mumbai Metropolitan Region Development Authority, India</td>
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<tr>
<td>Prof. Chandra R. Bhat</td>
<td>University of Texas, Austin, USA</td>
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<tr>
<td>Prof. Srinivas Peeta</td>
<td>Purdue University, USA</td>
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<tr>
<td>Prof. Ram Pendyala</td>
<td>Arizona State University, USA</td>
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<tr>
<td>Prof. Shashi Nambisan</td>
<td>Iowa State University, USA</td>
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</tbody>
</table>
TRANSPORTATION SYSTEMS ENGINEERING FACULTY

Prof. K. V. Krishna Rao
Professor
Email: kvkrao@civil.iitb.ac.in
Web: https://www.civil.iitb.ac.in/~kvkrao
Phone: +91 22 2576 7305

Prof. Tom V. Mathew
Professor
Email: tvm@civil.iitb.ac.in
Web: https://www.civil.iitb.ac.in/~vmtom
Phone: +91 22 2576 7349

Prof. Gopal R. Patil
Associate Professor
Email: gpatil@civil.iitb.ac.in
Web: https://www.civil.iitb.ac.in/~gpatil
Phone: +91 22 2576 7308

Prof. P. Vedagiri
Associate Professor
Email: vedagiri@civil.iitb.ac.in
Web: https://www.civil.iitb.ac.in/~vedagiri
Phone: +91 22 2576 7307
Prof. Dharamveer Singh  
Assistant Professor  
Email: dvsingh@iitb.ac.in  
Web: https://www.civil.iitb.ac.in/~dvsingh  
Phone: +91 22 2576 7304  

Prof. Avijit Maji  
Assistant Professor  
Email: avimaji@iitb.ac.in  
Web: https://www.civil.iitb.ac.in/~avimaji  
Phone: +91 22 2576 7338  

Prof. Nagendra R. Velaga  
Assistant Professor  
Email: n.r.velaga@iitb.ac.in  
Web: https://www.civil.iitb.ac.in/~velaga  
Phone: +91 22 2576 7341  

LABORATORY STAFF  
Mr. M. T. Shinde  
Md. Azharuddin G. D.  
Mrs. Shraddha Shrimpi  
Mr. Nagesh Narwade  

CONTACT ADDRESS  
Transportation Systems Engineering Group  
Department of Civil Engineering  
Indian Institute of Technology Bombay  
Powai, Mumbai – 400076, INDIA  
Phone: 91-22-25764322(office)  
Website: www.civil.iitb.ac.in/tse
# OVERALL SCHEDULE

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>8.30-9.00</td>
<td>Breakfast for delegates (Venue: VMCC cafeteria, Ground floor)</td>
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<tr>
<td>9.00-9.30</td>
<td>Registration-VMCC Ground Floor</td>
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<tr>
<td>9.30-10.00</td>
<td>Inauguration-B Nag Auditorium, VMCC Ground Floor</td>
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<tr>
<td>10.00-10.30</td>
<td>High Tea (Venue: VMCC cafeteria, Ground floor)</td>
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<tr>
<td>10.30-11.00</td>
<td>Keynote session - B Nag Auditorium, VMCC Ground Floor</td>
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<tr>
<td>11.00-13.00</td>
<td>Chair: Prof. Chandra R. Bhat</td>
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<tr>
<td></td>
<td><strong>Keynote 1:</strong> Prof. Yoshitsugu Hayashi</td>
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<td><strong>Keynote 2:</strong> Prof. Sergio Jara-Diaz</td>
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<td><strong>Keynote 3:</strong> Dr. Shomik Mehndiratta</td>
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<tr>
<td>13.00-14.00</td>
<td>Lunch (Venue: VMCC cafeteria, Ground floor)</td>
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<tr>
<td>14.00-15.30</td>
<td>Lectern Sessions - 1A, 1B, 1C, &amp; 1D</td>
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<tr>
<td>14.00-15.30</td>
<td><strong>TRAFFIC</strong></td>
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<tr>
<td></td>
<td>Chair: Rajat Rastogi</td>
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<td></td>
<td>Invited: Praveen Edara</td>
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<tr>
<td></td>
<td>(TPs: 32, 41, 48, 66)</td>
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<tr>
<td>14.00-15.30</td>
<td><strong>PLANNING</strong></td>
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<tr>
<td></td>
<td>Chair: Aseem Kinra</td>
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<td></td>
<td>Invited: Eric Fitzsimmons</td>
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<tr>
<td></td>
<td>(TPs: 150, 152, 331, 332, 335)</td>
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<tr>
<td>14.00-15.30</td>
<td><strong>NMT+SAFETY</strong></td>
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<tr>
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<td>Chair: M. Parida</td>
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<td>Invited: Eric Fitzsimmons</td>
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<tr>
<td></td>
<td>(TPs: 165, 33, 88, 113)</td>
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<tr>
<td>15.30-16.00</td>
<td>Tea break (Venue: VMCC Ground floor foyer)</td>
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<tr>
<td>16.00-18.00</td>
<td>Lectern Session - 2A, 2B, 2C, &amp; 2D</td>
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<td>16.00-18.00</td>
<td><strong>TRAFFIC</strong></td>
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<td>Chair: S L Dhinatra</td>
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<td>Invited: Velmurugan</td>
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<td></td>
<td>(TPs: 8, 109, 129, 130, 141, 1336)</td>
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<tr>
<td>16.00-18.00</td>
<td><strong>PAVEMENT</strong></td>
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<tr>
<td></td>
<td>Chair: W. K. Mampearachchi</td>
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<td></td>
<td>Invited: Feipeng Xiao</td>
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<td></td>
<td>(TPs: 95, 151, 181, 191, 281, 323)</td>
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<td>16.00-18.00</td>
<td><strong>PLANNING</strong></td>
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<td>Chair: Garuag Joshi</td>
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<td>Invited: Haixiao Pan</td>
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<td></td>
<td>(TPs: 28, 42, 128, 153, 211, 212)</td>
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<tr>
<td>16.00-18.00</td>
<td><strong>NMT+SAFETY</strong></td>
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<td>Chair: Abdul R. Pinjari</td>
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<td></td>
<td>Invited: Kandukuri Raju</td>
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<tr>
<td></td>
<td>(TPs: 15, 247, 258, 16, 69, 220)</td>
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<tr>
<td>18.00-18.30</td>
<td>Tea break (Venue: VMCC Ground floor foyer)</td>
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<tr>
<td>18.30-20.15</td>
<td>Cultural Programme (Venue: PC Saxena Auditorium, IIT Bombay)</td>
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<tr>
<td>20.15 -</td>
<td>Dinner (Venue: VMCC cafeteria, Ground floor)</td>
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<tr>
<td>Time</td>
<td>Day 2 [20 Dec 2016]</td>
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<tr>
<td>8.30-9.00</td>
<td>Breakfast for delegates (Venue: VMCC cafeteria, Ground floor)</td>
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<td>Keynote session - B Nag Auditorium, VMCC Ground Floor</td>
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<td>9.00-9.30</td>
<td><strong>Chair:</strong> Prof. Yoshitsugu Hayashi</td>
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<td><strong>Keynote 1:</strong> Prof. Partha Chakroborty</td>
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<td><strong>Keynote 2:</strong> Prof. Chandra R. Bhat</td>
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<td><strong>Keynote 3:</strong> Shri. P. R. K. Murthy</td>
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<tr>
<td>9.30-10.00</td>
<td>Tea break (Venue: VMCC Ground floor foyer)</td>
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<tr>
<td>10.00-10.30</td>
<td><strong>Lectern Sessions - 3A, 3B, 3C, &amp; 3D</strong></td>
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<td></td>
<td><strong>3A:</strong> Lecture Hall-22</td>
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<td><strong>3B:</strong> Seminar Room-11</td>
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<td><strong>3D:</strong> Seminar Room-12</td>
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<td><strong>Chair:</strong> Praveen Edara</td>
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<td></td>
<td><strong>Invited:</strong> Soma Vijayakumar</td>
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<td></td>
<td>(TPs:155,158,186,193,222,232)</td>
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<td><strong>Chair:</strong> Feipeng Xiao</td>
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<td><strong>Invited:</strong> Animesh Das</td>
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<tr>
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<td>(TPs:34,35,93,108,110,329,296)</td>
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<td><strong>PLANNING</strong></td>
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<td></td>
<td><strong>Chair:</strong> Sanjay Gupta</td>
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<td><strong>Invited:</strong> Aseem Kinra</td>
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<td></td>
<td>(TPs:143,168,172,227,271,298,338)</td>
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<tr>
<td>11.00-13.00</td>
<td><strong>Lunch (Venue: VMCC cafeteria, Ground floor)</strong></td>
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<tr>
<td>13.00-14.00</td>
<td><strong>Poster Session - P1, P2, P3, &amp; P4</strong></td>
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<tr>
<td></td>
<td><strong>Venue:</strong> Canopy Area, 2nd floor, VMCC</td>
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<td><strong>TRAFFIC</strong></td>
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<td></td>
<td><strong>Chair:</strong> Akhilesh Kumar</td>
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<td>(TPs:46,83,216,61,62,65,107,114,119,120,128,131,187,213,276,282,9,21,87,173)</td>
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<td><strong>Chair:</strong> Vishal Thombare</td>
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<td>(TPs:17,52,78,217,241,242,287,233,23,25,53,75,100,133,170,175,194,208,237,244,318,50)</td>
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<td><strong>Chair:</strong> H. R. Varia</td>
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<td>(TPs:132,202,226,60,219,140,319,12,49,160)</td>
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<td>15.30-16.00</td>
<td><strong>Tea break (Venue: VMCC Ground floor foyer)</strong></td>
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<td><strong>Lectern Sessions - 4A, 4B, 4C, &amp; 4D</strong></td>
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<td><strong>4A:</strong> Lecture Hall-22</td>
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<td><strong>Chair:</strong> Animesh Das</td>
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<td>(TPs:124,171,25,627,294,328,334,337)</td>
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<td><strong>Chair:</strong> Haixiao Pan</td>
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<td><strong>Invited:</strong> Bhargab Maitra</td>
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<td></td>
<td><strong>Chair:</strong> Partha Chakroborty</td>
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<td>(TPs:218,221,239,255,286,300)</td>
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<tr>
<td>18.00-19.30</td>
<td><strong>Gala Dinner (Venue: Hotel Ramada, Powai)</strong></td>
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<td>19.30-20.15</td>
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<tr>
<td>Time</td>
<td>Day 3 [21 Dec 2016]</td>
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<td>Breakfast for delegates (Venue: VMCC cafeteria, Ground floor)</td>
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<td>10.30-11.00</td>
<td><strong>Keynote 3:</strong> S. K. Gupta</td>
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<td><strong>Tea break (Venue: VMCC Ground floor foyer)</strong></td>
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<tr>
<td>11.00-12.30</td>
<td><strong>Technical Session - 5A, 5B, 5C, &amp; 5D</strong></td>
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<tr>
<td>5A: Lecture Hall-22</td>
<td><strong>TRAFFIC</strong></td>
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<tr>
<td>11.00-12.30</td>
<td>Chair: Kandukuri Raju</td>
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<tr>
<td></td>
<td>Invited: Pushkin Kachroo</td>
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<tr>
<td></td>
<td>(TPs: 68,270, 303,326,180)</td>
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<td>5B: Seminar Room-11</td>
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<td>Chair: Satish Chandra</td>
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<td></td>
<td>Invited: Meor Othman Hamzah</td>
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<tr>
<td></td>
<td>(TPs: 22,26,27, 29,51, 215)</td>
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<tr>
<td>5C: Lecture Hall-23</td>
<td><strong>PLANNING</strong></td>
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<td>Chair: B. Maitra</td>
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<tr>
<td></td>
<td>Invited: K.V.J. Ramana Rao</td>
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<tr>
<td></td>
<td>(TPs: 262, 308,147,185,295)</td>
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<tr>
<td>5D: Seminar Room-12</td>
<td><strong>NMT+SAFETY</strong></td>
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<td></td>
<td>Chair: M. Kumar</td>
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<tr>
<td></td>
<td>(TPs: 223,251, 268,273,292, 315,330)</td>
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<tr>
<td>12.30-13.00</td>
<td>Valedictory and Prize Distribution (B Nag Auditorium, VMCC Ground Floor)</td>
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<tr>
<td>13.00-14.00</td>
<td>Lunch (Venue: VMCC cafeteria, Ground floor)</td>
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<tr>
<td>14.00-17.30</td>
<td>Travel Behavior Modelling Workshop (15 min tea break in between)</td>
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<tr>
<td>17.30-18.30</td>
<td>Technical Tour (Mumbai Metro Control Room)</td>
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**Abbreviations:**
- NMT-Non-motorized Transport, TP-Technical papers
# SESSION SCHEDULE

## DAY-1

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<td><strong>Chair:</strong> Chandra R. Bhat</td>
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<td><strong>Keynote-1</strong></td>
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<tr>
<td>Policy Making based on Quality of Life performance against Infrastructure Cost, Better for Everyone</td>
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<tr>
<td><strong>Yoshitsugu Hayashi</strong></td>
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<tr>
<td>WCTRS (World Conference on Transport Research Society)</td>
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<td><strong>Keynote-2</strong></td>
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<tr>
<td>Optimal Public Transport Design: The interrelations with pricing and subsidies</td>
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<tr>
<td><strong>Sergio R. Jara-Diaz</strong></td>
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<tr>
<td>Universidad de Chile, Chile</td>
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<td><strong>Keynote-3</strong></td>
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<tr>
<td><strong>Shomik Mehndiratta</strong></td>
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<tr>
<td>World Bank, Washington DC, USA</td>
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<tr>
<td>ABCs of Alternative Intersection and Interchange Designs</td>
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<td><strong>Praveen Edara</strong></td>
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<tr>
<td>University of Missouri, Columbia</td>
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<td><strong>32</strong> Analysis and Modeling of Lateral Placement and Movement of Vehicles on Urban Undivided Roads in Mixed Traffic</td>
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<td>Punith B. Kotagi, Pooja Raj, <strong>Gowri Asaithambi</strong>*</td>
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<tr>
<td>National Institute of Technology Karnataka, Mangalore, India</td>
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<td><strong>41</strong> Modeling of Individual Vehicle Speed on Urban Arterials using Artificial Neural Network</td>
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<td><strong>Subhadip Biswas</strong>*, Shivendra Maurya, Indrajit Ghosh, Satish Chandra</td>
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<tr>
<td>Indian Institute of Technology Roorkee, Uttarakhand, India</td>
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<tr>
<td><strong>48</strong> Study on Travel Time Reliability Parameters in Srinagar City</td>
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<td><strong>Vivek Kumar</strong>*, Mohammad Shafi Mir, Ashok Kumar Singh</td>
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<tr>
<td>National Institute of Technology Srinagar, J&amp;K, India</td>
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<tr>
<td><strong>66</strong> Effect of Road Geometry and Roughness on Free- Flow Speeds and Roadway Capacity for Indian Multilane Interurban Highways</td>
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<tr>
<td><strong>Ashutosh Arun</strong>*, S. Velmurugan, Sh. S. Kannan, Sandip Chakraborty, Sudip K. Roy, CSIR-Central Road Research Institute, New Delhi, India</td>
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* Corresponding author, (Affiliation belongs to corresponding author)
### Lectern Session 1B - Traffic

**Chair:** S. Velmurugan  
**Seminar Room-11**  
**14:00 to 15.30**  

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| **Prasad Mahajan**  
Joint Transport Commissioner, Maharashtra, India  
31 Tangible Service Level Assessment of Urban Streets using Point System to Support Improvement Issues for Private Mode of Transport |         |
| **Suprava Jena***, Sambit Kumar Beura, Prasanta Kumar Bhuyan  
Natl Institute of Technology Rourkela, India  
111 Development of Level of Service Criteria for Urban Corridors based on Speed Variation Characteristics |         |
| **Drisya M.***, Aswathy K. V., K. Krishnamurthy  
National Institute of Technology Calicut, Kerala, India  
285 Study of Interaction of Motorised Two-Wheelers on ‘Rurban’ Highways under Mixed Traffic Condition |         |
| **P. A. Godse***, V. S. Hokam, V. S. Landge  
Priyadarshini Indira Gandhi College of Engineering Nagpur, India  
184 Factors influencing User Perception of LOS at Signalized Intersection under Mixed Traffic Condition |         |
| **O. Darshana***, K. V. Krishna Rao  
Indian Institute of Technology Bombay, Mumbai, India  
250 Evaluating Service Criteria of Urban Streets in Developing Countries based on Road Users’ Perception |         |
| **Suprava Jena**, Priyanka Atmakuri, Prasanta Kumar Bhuyan  
NIT Rourkela, India  
66                                                                                                                                          |         |

### Lectern Session 1C - Planning

**Chair:** Aseem Kinra  
**Lecture Hall-23**  
**14:00 to 15.30**  

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<th>Working Paper</th>
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| **150 Effects of ICT Usage on Students’ Travel Behaviour**  
Alaa Moosa Koya***, Harikrishna M., Anjaneyulu M. V. L. R.  
National Institute of Technology, Calicut, India  
152 Working Paper on Planning of Bus-Based Transit Systems through ‘Network Planning Approach’- Case of BEST, Mumbai |         |
| **Ritesh Ramesh Patil***  
Mumbai Metropolitan Region Development Authority, Mumbai, India  
331 Household Daily Non-Mandatory Activity Participation and Duration Modeling Accounting for Person Level Budget Constraints |         |
| **Rajesh Paleti***, Abdul R. Pinjari  
Old Dominion University, Norfolk, Virginia, USA  
315 Effects of ICT on Students’ Travel Behaviour  
Alaa Moosa Koya***, Harikrishna M., Anjaneyulu M. V. L. R.  
National Institute of Technology, Calicut, India |         |

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<td>Developing a Planning Support System for Mumbai: Lessons in research challenges and opportunities</td>
<td>Arnab Chakraborty*, Bev Wilson University of Illinois at Urbana Champaign, USA</td>
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<td>Using Real Time Traffic Data and Satellite Imagery to understand the relationship between Land Use and Congestion: A framework for Indian cities</td>
<td>Arnab Chakraborty*, Bev Wilson University of Illinois at Urbana Champaign, USA</td>
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<td>Lectern Session 1D - NMT + Safety</td>
<td>Demonstration and Implementation Recommendations to Integrate the United States Road Assessment Program (usRAP) for Rural Roadways in Kansas</td>
<td>Eric Fitzsimmons Kansas State University, USA</td>
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<td>Modelling Bicycle Activity on Multi-Lane Urban Road Segments in Indian Context and Prioritizing Bicycle Lane to Enhance the Operational Efficiency</td>
<td>Haritha Chellapilla*, Sambit Kumar Beura, P. K. Bhuyan VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India</td>
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<td></td>
<td>Analysis and Modelling of Pedestrian Road Crossing Pattern on Urban Undivided Roads in Mixed Traffic</td>
<td>Manu O Kuttan, Surjith Babu, Gowri Asaithambi* National Institute of Technology Karnataka, Mangalore, India</td>
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<tr>
<td></td>
<td>Assessment of Appropriate Methods of Critical Gap Estimation for Pedestrians Under Heterogeneous Traffic Conditions</td>
<td>Udit Jain*, Rajat Rastogi Indian Institute of Technology (IIT) Roorkee, Uttarakhand, India</td>
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<td></td>
<td>Level of Service for Bicycle through Movement at Signalized Intersections Under Heterogeneous Traffic Flow Conditions</td>
<td>Sambit Kumar Beura*, N. Kiran Kumar, P. K. Bhuyan NIT Rourkela, India</td>
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<tr>
<td>Lectern Session 2A - Traffic</td>
<td>Development of Road User Cost Models for High Speed Corridors</td>
<td>S. Velmurugan CSIR - Central Road Research Institute, New Delhi, India</td>
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* Corresponding author, (Affiliation belongs to corresponding author)
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<tr>
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<td>Modelling of Operating Speeds for Urban Roads Under Heterogeneous Traffic Conditions</td>
<td>Sathishkumar S, A. Mohan Rao*, Velmurugan S, Gowri A CSIR-Central Road Research Institute, New Delhi, India</td>
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<td>43</td>
<td>An Investigation of Lane Flow Distribution on Multi-Lane Highways Under Mixed Traffic Condition</td>
<td>Sudipa Chatterjee*, Debashish Roy, Sandip Chakraborty, Ashutosh Arun, Sudip Kumar Roy Indian Institute of Engineering Science and Technology, Shibpur, India</td>
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<td>49</td>
<td>Traffic Data Extraction using Matlab® based Tooltechnique</td>
<td>Mohit Kumar Singh, Harikrishna Gaddam, Lakshmi Devi Vanumu, K. Ramachandra Rao* Transportation Research and Injury Prevention Programme (TRIPP), IIT Delhi, New Delhi, India</td>
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<td>52</td>
<td>Study on Speed Breakers and Its Effect on Speed and Vehicle Operating Cost</td>
<td>Korra Ravi Kiran*, M. Kumar College of Engineering, Osmania University, Hyderabad, India</td>
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<td>108</td>
<td>Smart City Plan for CIDCO Navi Mumbai (South)</td>
<td>Avinash Shabade* CIDCO, Mumbai, India</td>
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**Lectern Session 2B - Pavement**

**Chair:** W. K. Mampearachchi  
**Seminar Room-11**  
**16:00 to 18:00**

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<td>Functional Layer Material Designations and Case Studies of Combined Chip Seal and Micro-Surfacing/Slurry Seal in Airport Pavement</td>
<td>Feipeng Xiao Tongji University, China</td>
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<td>40</td>
<td>Development of Deterioration Model from Functional Characteristics and Evaluation of Structural Performance on Selected Corridor of Hyderabad City – A Case Study</td>
<td>A. Ramesh*, M. Kumar VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana, India</td>
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* Corresponding author, (Affiliation belongs to corresponding author)
### Analysis of Bonded Concrete Pavements using 3D FEM

**Swarna Surya Teja***, K. Sridhar Reddy, M. Amaranatha Reddy, B. B. Pandey  
Indian Institute of Technology Kharagpur, West Bengal, India

### Service Life Prediction for Bridge Structures Exposed to Aggressive Marine Environment

Athira G., Mahima S., **Bahirudeen A.***, Jayachandran K., Moorthy P.  
Birla Institute of Technology and Science, Pilani, India

### Finite Element Analysis of Geotextile Reinforced Highway Embankment using Plaxis D

**Athulya G.K.***, Ankita Kumar, S. P. Guleria, J. N. Mandal  
Indian Institute of Technology Bombay, Mumbai, India

### Program Level Analysis using Highway Development and Management Model (HDM): A Case Study

**Pavan R. Vyas***, Anjaneyappa, B. Ravi  
R. V. College of Engineering, Bengaluru, India

### Sensitivity of Axle Load Spectra on Rutting Performance of a Flexible Pavement using Mechanistic Empirical Pavement Design Guide

**Nur Hossain***, Dharamveer Singh, Musharraf Zaman  
Kleinfelder, Inc., Norman, USA

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**Lectern Session 2C - Planning**  
Chair: Gaurang Joshi  
Lecture Hall-23  
16:00 to 18:00

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| **5D Land Use/Transport Model Building a Balanced Multi-Modal Green Transport System**  
Pan Haixiao  
Tongji University, China | 7 |
| **Willingness to use Non-Motorized Vehicles for Trips in Urban Areas**  
**Anshu Bamney***, Rajat Rastogi  
Indian Institute of Technology Roorkee, India | 22 |
| **Analyzing the Demand for Public Transport through Behavioral Mode Choice Models for Work Trips in Tiruchirappalli City**  
**Sumetha R.***, Samson Mathew  
SSN College of Engineering, Chennai, India | 26 |
| **Impact of Mode Choice in Estimating the Social Travel Demand of Senior Citizens – A Case Study of Tiruchirappalli City**  
**G. Nantha Priya***, G. Subbaiyan, Samson Mathew  
National Institute of Technology, Tiruchirappalli, India | 48 |

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<td>153</td>
<td>Travel Time Dynamics – A Study of Travel Time Budgets in an Indian City</td>
<td>Supraja Krishnan*&lt;br&gt;Urban Mass Transit Company, Hyderabad, India</td>
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<td>211</td>
<td>Modelling the Route Choice Behaviour under Stop-&amp;-Go Traffic for Different Car Driver Segments</td>
<td>Saxena N.*, Rashidi T. H., Dixit V. V., Waller S. T.&lt;br&gt;UNSW, Sydney, Australia</td>
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<td>212</td>
<td>On-Street Parking Demand Estimation Model: A Case Study of Kolkata</td>
<td>Debasisch Das*, M. Ali Ahmed, Saptarshi Sen&lt;br&gt;National Institute of Technology Silchar, Assam, India</td>
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**Lectern Session 2D - NMT + Safety**<br>**Chair: Abdul R. Pinjari**<br>**Seminar Room-12**<br>16:00 to 18:00

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| Kandukuri Raju | Tata Consultancy Services, India |
| 15 | Qualitative Evaluation of Sidewalks in Delhi |
| 18 | Bivina G. R., Diwakar Gupta, Purnima Parida, Manoranjan Parida*<br>Indian Institute of Technology Roorkee, India |
| 247 | Study of Pedestrian Behaviour on Walkway and Sidewalk Facilities for a Commercial Area in Gangtok, Sikkim |
| 85 | Arunabha Banerjee*, Akhilesh Kumar Maurya<br>Indian Institute of Technology, Guwahati, India |
| 258 | Evaluation of Crossing Behaviour of Pedestrian at Mid-Blocks in India |
| 89 | Chaudhari Avinash, Shah Jiten, Arkatkar Shriniwas*, Joshi Gaurang, Parida Manoranjan<br>SVNIT, Surat, Gujarat, India |
| 16 | Commuters' Exposure to PM2.5 : A Case Study of Delhi |
| 18 | Rajeev Kumar Mishra*, Amrit Kumar, Ankita Shukla<br>Delhi Technological University, Delhi, India |
| 69 | Study on the Coping Behaviour Under Stress Condition as related to the Crash Frequency among Indian Drivers |
| 34 | Neelima Chakrabarty*, Kamini Gupta, S. Velmurugan<br>CSIR-Central Road Research Institute, New Delhi, India |
| 220 | Development of Urban Road Safety Audit Tool Kit |
| 76 | S. M. Hassan Mahdavi M., G. Tiwari, K. Ramachandra Rao*<br>Indian Institute of Technology Delhi, New Delhi, India |

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**DAY-2**

### Keynote Session 9:00 to 10:30

**Chair: Yoshitsugu Hayashi**

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<th>Aggregate Batch Mixing in a Stochastic World with Limited Resources</th>
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<td><strong>Partha Chakroborty</strong></td>
<td>Indian Institute of Technology Kanpur, India</td>
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<th>Transportation Analytics in a New Data Landscape</th>
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<td><strong>Chandra R. Bhat</strong></td>
<td>The University of Texas at Austin, USA</td>
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<th>Planning and Implementation of Metro Systems in India</th>
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<td><strong>P. R. K. Murthy</strong></td>
<td>Metro Projects Implementation Unit, MMRDA, India</td>
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### Lectern Session 3A - Traffic 11:00 to 13:00

**Chair: Praveen Edara**

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<td><strong>Vijayakumar Soma</strong></td>
<td>City and Industrial Development Corporation (CIDCO) Ltd., Mumbai, India</td>
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<th>A Comparison of Delay at Signal Controlled Intersections based on Different Methods</th>
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<td><strong>Arpita Saha</strong>*, Satish Chandra, Indrajit Ghosh</td>
<td>Indian Institute of Technology Roorkee, Uttarakhand, India</td>
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<th>Performance Evaluation of Urban Transport Facilities</th>
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<td><strong>Swathy S.</strong>*, Harikrishna M., Anjaneyulu M. V. L. R.</td>
<td>National Institute of Technology Calicut, India</td>
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<th>Assessment of Functional Characteristics of a Signalized Intersection: A Review</th>
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<td><strong>Satyajit Mondal, Ankit Gupta</strong>*</td>
<td>Indian Institute of Technology (BHU) Varanasi, Varanasi, India</td>
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<th>Key factors affecting Capacity and Travel Time Reliability of Freight Transportation at Post Disaster Phase</th>
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<td><strong>Tanmay Das</strong>*</td>
<td>Bangladesh University of Engineering and Technology, Dhaka, Bangladesh</td>
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<td>222 Comparative Study of PCU Estimation Methods on Multi-Lane Urban Road in India</td>
<td>Pallav Kumar, Joyjeet Chakraborty, Ayush Mishra, <strong>Shriniwas Arkatkar</strong>*, Gaurang Joshi, Ashish Bhaskar, Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India</td>
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<td>80</td>
<td>232 Performance of Predictive Spatio-Temporal Query Processor for Predicting Traffic Congestion</td>
<td><strong>Pankaj Mukheja</strong>*&lt;br&gt;Indian Institute of Technology Bombay, Mumbai, India</td>
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**Lectern Session 3B - Pavement**<br>**Chair: Feipeng Xiao**<br>**Seminar Room-11**<br>**11:00 to 13:00**

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<td>Invited Talk</td>
<td><strong>Animesh Das</strong>&lt;br&gt;Indian Institute of Technology Kanpur, India</td>
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<td>34 Laboratory Study on Use of Rap Material in WMA Pavements using Rejuvenator</td>
<td><strong>Mohammad Adnan Farooq</strong>*, Mohammad Shafi Mir, Ankit Sharma&lt;br&gt;National Institute of Technology Srinagar, J&amp;K, India</td>
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<td>25</td>
<td>35 Laboratory Performance Evaluation of Warm Mix Asphalt Additives for Cold Regions</td>
<td><strong>Ankit Sharma</strong>*, Mohammad Shafi Mir, Mohammad Adnan Farooq&lt;br&gt;National Institute of Technology Srinagar, J&amp;K, India</td>
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* Corresponding author, (Affiliation belongs to corresponding author)
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The University of Oklahoma, Norman, USA

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* Corresponding author, (Affiliation belongs to corresponding author)
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**Chair:** Sabyasachee Mishra  
**Seminar Room-12**  
**11:00 to 13:00**

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**Chair:** Akhilesh Kumar  
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**Chair: Vishal Thombre**  
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**Chair: H. R. Varia**

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<td>Crowd Behaviour Analysis through Video Surveillance</td>
<td>P. Yugendar*, K. V. R. Ravishankar National Institute of Technology, Warangal, Telangana, India</td>
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<td>Bicycle Use in Indian Cities: Understanding the Opportunities and Threats</td>
<td>Premjeet Das Gupta*, Kshama Puntambekar School of Planning and Architecture, Bhopal, India</td>
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<td>Open Source Toolkit for Pedestrian Evacuations</td>
<td>Abhay Kumar Chaturvedi, Ankit Gupta* Indian Institute of Technology (BHU) Varanasi, Varanasi, India</td>
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<td>A Critical Review of Regression Models for Analysing Highway Crash Data</td>
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### Lectern Session 4A – Traffic

**Chair:** Kalaga Ramachandra Rao  
**Lecture Hall-22**  
**Time:** 16:00 to 18:00  

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<td>Vehicle Trajectory Correction using Empirical Mode Decomposition</td>
<td>Dibyendu Pal*, C. Mallikarjuna NERIST, Nirjuli, Arunachal Pradesh, India</td>
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<td>Study of Different Vehicles’ Lateral Placement and Speed on Indian Roads</td>
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<td>Shankara S, Kalaanidhi S, Karthiga K, Gunasekaran K* Anna University, Chennai, India</td>
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<td>Development of Truck Route Choice Models using Large Streams of GPS Data</td>
<td>Trang Luong, Abdul R. Pinjari* University of South Florida, USA</td>
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### Lectern Session 4B - Pavement

**Chair:** Animesh Das  
**Seminar Room-11**  
**Time:** 16:00 to 18:00  

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### Influence of Cement-Aggregate Interface on Evaluation of Ultrasonic Pulse Velocity Test for Rigid Pavement

Subair M., Moorthi P. V. P., Aniruddha T., Sanket R., **Bahurudeen A.*
Birla Institute of Technology and Science, Pilani, India

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### Evaluation of the Effect of Geometry of Recycled Pet Fibre on the Properties of Concrete for Rigid Pavement

Abhishekh Kumar, **S. K. Suman*  
National Institute of Technology Patna, Bihar, India

---

### Evaluation of Properties of Reclaimed Polyethylene Terephthalate Modified Bituminous Concrete Mixes

**Rajan Choudhary**, Kishori Murkute, Abhinay Kumar, Ashok Julaganti  
Indian Institute of Technology Guwahati, India

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### Evaluation of the Effect of Geometry of Recycled Pet Fibre on the Properties of Concrete for Rigid Pavement

Abhishekh Kumar, **S. K. Suman**
National Institute of Technology Patna, Bihar, India

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### Effect of Natural Asphalt on Performance Characteristics of Bitumen and Its Mixes

**Ambika Behl**, Gajendra Kumar  
CSIR-Central Road Research Institute, New Delhi, India

---

### Evaluation of Laboratory and Field Compaction of Dense Graded Aggregate Bases

**W. K. Mampearachchi**  
University of Moratuwa, Sri Lanka

---

### Shifting of Utilities during construction of Concrete Pavement

**Vishal R. Thombre**  
MCGM, Mumbai, India

---

### Lectern Session 4C - Planning

**Chair**: Haixiao Pan  
**Lecture Hall-23**  
**16:00 to 18:00**  
**Page No**

**Invited Talk**
Measures for Encouraging Usage of Shared Modes for School Trips

**Bhargab Maitra**  
Indian Institute of Technology Kharagpur, India

---

### Understanding Travel Behaviour of Employees of an Industrial Area- Aurangabad case study

**Sumeet Jaiswal***, Janvi Mohurle, Prajakta Kulkarni, Aishwarya Raje, Diksha Karanjikar, Shivani Dhotre, Mrunal Ghumare  
MIT, Aurangabad, India

---

### Effects of Socioeconomic and Trip Characteristics on Commuters’ perceived importance towards transfer facilities at Metro stations

**Shubhajit Sadhukhan***, Uttam K. Banerjee, Bhargab Maitra  
Indian Institute of Technology Kharagpur, West Bengal, India

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* Corresponding author, (Affiliation belongs to corresponding author)
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<td>Indian Institute of Science Bangalore, India</td>
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<td>Sandip C. Rathod*, H. R. Varia</td>
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<td>Agnivesh Pani, Prasanta K. Sahu*, Ashoke K. Sarkar, Gopal R. Patil</td>
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**Lectern Session 4D - Traffic**  
Chair: Partha Chakroborty  
Seminar Room-12  
16:00 to 18:00

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<td>Indian Institute of Technology Hyderabad, Kandi, Sangareddy, India</td>
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#### Keynote Session

**Chair**: Sergio Jara-Diaz  
**Time**: 9:00 to 10:30

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<td>CSIR-CRRI, New Delhi, India</td>
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#### Lectern secession 5A- Traffic

**Chair**: Kandukuri Raju  
**Time**: 11:00 to 12:30

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* Corresponding author, (Affiliation belongs to corresponding author)
| 180 An Assessment on Network Coding Structure in Vissim for Simulation of a Far-Side Bus Stop in Non-Lane based Traffic System | Bhaskar Paul*, Bhargab Maitra, Sudeshna Mitra
Civil Engineering Department, Indian Institute of Technology Kharagpur, India |

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<td>Institute of Technology, Nirma University, Ahmedabad, Gujarat, India</td>
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<td>Department of Civil Engineering, IIT Kharagpur, India</td>
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* Corresponding author, (Affiliation belongs to corresponding author)
KEYNOTE SPEAKERS

Prof. Sergio Jara-Diaz
Universidad de Chile, Chile

Dr. Sergio Jara-Diaz is a Professor of Transport Economics at Universidad de Chile. Ph.D. and M.Sc. from the Massachusetts Institute of Technology, M.Sc. in Urban Planning from U. Católica de Chile and Civil Engineer from U. de Chile. He is the founding member of the Transport Division at U. de Chile. Is author of Transport Economic Theory (Elsevier, 2007) and more than 100 research articles on users’ behaviour, value and use of time, industry structure on transport networks, public transport, optimal pricing and transport project appraisal. He runs a weekly radio show for 26 years now and has published three books of chronicles. He resides in Santiago, Chile, with his only wife with whom he shares two sons and four grandchildren.

Prof. Ram M. Pendyala
Arizona State University, USA

Dr. Ram M. Pendyala is a Professor in the School of Sustainable Engineering and the Built Environment at Arizona State University (ASU). Dr. Pendyala served on the faculty at ASU during 2006-2014 and rejoined the institution effective Fall 2016. Between 2014 and 2016, Dr. Pendyala served as the Frederick R. Dickerson Chair Professor of Transportation at Georgia Tech. Dr. Pendyala specializes in multimodal transportation systems planning, activity-travel behavior modeling, freight and passenger travel demand forecasting. He is Chair of the Transportation Research Board’s Planning and Environment Group and Associate Editor for Transportation Research Part D. He has his PhD and Master’s degrees from the University of California at Davis and his undergraduate degree from the Indian Institute of Technology-Madras in India.
Dr. Partha Chakroborty is a Professor in the Department of Civil Engineering at IIT Kanpur since 1993. He has received his B.Tech. (with honours) in Civil Engineering from IIT Kharagpur and Masters and Doctoral degrees from University of Delaware, USA. He also serves on various national level committees of CSIR-CRRI, DST, NDMA, etc. as an expert in Transportation Engineering and on the editorial board of Transportation Research Procedia published by Elsevier. He is also the founding editor-in-chief of the international journal Transportation in Developing Economies published by Springer. His research interests include Traffic Flow Theory, Traffic Facilities' Design, Optimal Routing and Scheduling, and Uncertainty Modelling.

Mr. P. R. K. Murthy is the Director (Projects), Metro Projects Implementation Unit, MMRDA. He served as the Chief of Transport and Communications Division at MMRDA. He has 25 years of experience in the field of engineering, administration and project implementation relating to mega transportation infrastructure projects in MMR. He serves on the Board of Mumbai Metro One Pvt. Ltd and Mumbai Railway Vikas Corp., Ltd. as Director.

Dr. Shomik Mehndiratta leads the World Bank’s Transport practice’s efforts related to climate change. He has earlier served as the technical lead of the Bank’s urban mobility practice. He has been at the World Bank since 2002 and in the period 2007-2010 he lived and worked in China. Most of his work in the Bank has been working on urban mobility issues with clients in East Asia, South Africa and Latin America. He is co-editor and author of an edited book on Low Carbon Urban Development in China. Prior to the World Bank he worked at CRA International, a business and economics consulting firm, based out of Boston MA. Shomik is an Indian national, and holds a PhD from the University of California at Berkeley and a eMBA jointly from INSEAD and China’s Tsinghua University.
Prof. Yoshitsugu Hayashi graduated from the Department of Civil Engineering, Graduate School of Engineering, University of Tokyo and was awarded a Dr.-Eng in 1979. In Nagoya University, he served as an Advisor to President, Dean of Graduate School of Environmental Studies, and also as a Director of Education and Research Center for Sustainable Co-Development. His research interests include transport financing (particularly of rail transit) and methods of value capture, diagnosing urbanization and environmental impacts of sprawling land-use and motorization and compact city and smart-shrink based on Quality of Life (QOL) analysis. Since 1999, he has lead WCTRS - Special Interest Group on Transport and the Environment. He has also chaired the Project CUTE (Comparative Study on Urban Transport and the Environment) jointly organized by WCTRS and Institute for Transport Policy Studies (ITPS) Tokyo, co-Editor of the WCTRS official journal “Transport Policy” and Associate Editor of Transportation Research D: Environment, both published by Elsevier and now serving as President of WCTRS consisting of members from 67 countries.

Prof. Chandra R. Bhat is the Director of the Center for Transportation Research (CTR) and the Adnan Abou-Ayyash Centennial Professor in Transportation Engineering at The University of Texas at Austin, where he has a joint appointment between the Department of Civil, Architectural and Environmental Engineering (CAEE) and the Department of Economics. Bhat is a world-renowned expert in the area of transportation and urban policy design, with far reaching implications for public health, energy dependence, greenhouse gas emissions, and societal quality of life. Methodologically, he has been a pioneer in the formulation and use of statistical and econometric methods to analyze human choice behavior. His current research includes the social and environmental aspects of transportation, planning implications of connected and automated smart transportation systems (CASTS), and data science and predictive analytics.
Dr. Satish Chandra has received his undergraduate, masters and doctorate from the University of Roorkee. He joined University of Roorkee (now IIT Roorkee) as Lecturer in 1985, and served as Professor between May 2006-2015. He is now serving as Director, Central Road Research Institute (CRRI), New Delhi since January 2016. He introduced the original concept of Dynamic Passenger Car Unit for converting heterogeneous traffic stream into a homogeneous stream of passenger cars, while retaining the impact of individual vehicle type in the flow analysis, widely accepted and popular concept in use by researchers in India and other developing counties like Egypt, Vietnam, Cambodia, China and Thailand. He is presently the nodal officer for preparing the Indian Highway Capacity Manual, project sponsored by CSIR, New Delhi. He has contributed immensely in the development of different codes and specifications as a member of the Traffic Engineering Committee of the Indian Roads Congress. He has received many awards of repute in his field and coauthored various books and publications in transportation engineering.

Mr. S. K. Gupta graduated with a degree in Civil Engineering from Aligarh Muslim University and was recipient of the 'University Medal' for standing first in all branches of Engineering. He did Masters in Structural Dynamics from IIT/Roorkee (formerly Univ. of Roorkee). He is an ex. IRSE officer with 27 years of experience, out of which 17 years have been at senior positions in the prestigious Delhi Metro Rail Corp. Ltd., New Delhi. He was amongst the first officers joining DMRC. He comes with extensive experience of conceptualizing, planning, contracting and implementation of underground as well as elevated modern metro rail networks. He has worked as an Expat on an international metro consultancy project. He is widely travelled within India and abroad. He has been responsible for execution of some of the signature works of Delhi Metro. In his career span he has been awarded with MD's medal and various other awards/certificates in DMRC as well as in Railways.
INVITED SPEAKERS

Prof. Aseem Kinra
Copenhagen Business School, Denmark

Dr. S. Velmurugan
CSIR-Central Road Research Institute (CRRI), New Delhi, India

Prof. Eric Fitzsimmons
Kansas State University, USA

Mr. Soma Vijayakumar
CIDCO, Mumbai, India

Prof. Pan Haixiao
Tongji University, China

Mr. K.V.J. Ramana Rao
Egis India Consulting Engineers Pvt. Ltd., India

Prof. Feipeng Xiao
Tongji University, China

Prof. Bhargab Maitra
IIT Kharagpur, India

Prof. Meor Othman Hamzah
Universiti Sains Malaysia (USM), Malaysia

Dr. Kandukuri Raju
Tata Consultancy Services, India
Prof. Praveen Edara
University of Missouri, Columbia

Mr. Prasad Mahajan
Joint Transport Commissioner, Maharashtra, India

Prof. Animesh Das
IIT Kanpur, India

Prof. Pushkin Kachroo
University of Nevada, Las Vegas, USA

Prof. Manoranjan Parida
IIT Roorkee, India
KEYNOTE LECTURES

POLICY MAKING BASED ON QUALITY OF LIFE PERFORMANCE AGAINST INFRASTRUCTURE COST, BETTER FOR EVERYONE

Prof. Yoshitsugu Hayashi
WCTRS (World Conference on Transport Research Society)
Email: y-hayashi@isc.chubu.ac.jp

Abstract
In transport planning we do need consider different clients who are citizens of young/old, men/women/ rich/poor, etc. This lecture proposes a new method to define Quality of Life and measure it for differently attributed people, which are used for selection of policy options of a) infrastructure improvement, b) compact city, and c) relocation of service facilities. In the lecture, examples of QOL analysis in Japan, Singapore and China are demonstrated.

OPTIMAL PUBLIC TRANSPORT DESIGN: THE INTERRELATIONS WITH PRICING AND SUBSIDIES

Prof. Sergio R. Jara-Diaz
Universidad de Chile, Chile
Email: jradiaz@ing.uchile.cl

Abstract
Strategic design of public transport includes lines structures (network), frequencies and vehicle sizes. In this presentation the relations between these elements and the financial conditions (prices, subsidies) are established, reviewing our main findings in fourteen years of research in this area. This is motivated by the ill-conceived re-design of the Santiago transit system in 2007, and covers analyses of single line models (intermodal comparisons, operating strategies, sub-optimal prices, simultaneous car pricing), of travel cards, and of the spatial structure of transit lines, where the role of patronage, spatial distribution of demand, representation of the city and perception of transfer disruption is particularly emphasized.

AVOID SHIFT AND IMPROVE : THE ROAD TO LOW CARBON TRANSPORT

Dr. Shomik Raj Mehndiratta
World Bank, Washington DC, USA
Email: smehndiratta@worldbank.org

Abstract
This talk will present an evolving analysis of the underlying rationale, key characteristics and potential aggregate impact of the World Bank's strategy to support climate mitigation efforts that are also consistent with the Bank's broader mission to eliminate extreme poverty and boost shared prosperity.
Abstract
The aggregate batch mixing problem is one in which aggregate batches with different size gradations are blended to obtain a mix that satisfies some specified size limits. The quantities of interest are the mixing proportions. Traditionally, this problem has been posed as a deterministic optimization problem with no restrictions on the resources. In reality the aggregate batch mixing problem works with variables that are stochastic in nature. Ideally one should seek proportions that give a mix that satisfies prescribed size limits with high reliability. Further, with increase in use of reclaimed aggregates there is a present need to specify resource constraints on certain aggregate batches. This talk will focus on the batch mixing problem and development of an appropriate optimization formulation.

TRANSPORTATION ANALYTICS IN A NEW DATA LANDSCAPE
Prof. Chandra R. Bhat
The University of Texas at Austin, USA
Email: bhat@mail.utexas.edu

Abstract
This keynote presentation will focus on a new data landscape in which a whole host of equipment can act as sensors — legacy roadway systems, smart phones and GPS systems, and smart cars themselves. The key issue is how to deal with such voluminous and diverse amounts of incoming data per unit of time, and translate them into usable information for near-real time operations purposes or for longer-term planning purposes. This is a challenge, given the low latency and data reliability required to translate data into actionable intelligence, especially for such safety applications as collision avoidance. In addition, predictive analytics to translate data into information requires the ability to deal with data that may be from multiple sources, highly noisy, heterogeneous, and high-dimensional with complex interdependencies. On the last of these, the joint modeling of data with mixed types of dependent variables (including ordered-response or ordinal variables, unordered-response or nominal variables, count variables, and continuous variables) is a tricky problem. The presentation will discuss the exciting possibilities, some enquiry and predictive analytics pathways forward in terms of methods, and the research challenges in the emerging landscape of data science applications for the transportation field. This will include a discussion of the activities being undertaken as part of the U.S.DOT-funded Tier 1 Center at UT-Austin on “Data-Supported Transportation Planning and Operations” (D-STOP).
PLANNING AND IMPLEMENTATION OF METRO SYSTEM IN INDIA

Mr. P. R. K. Murthy
Metro Projects Implementation Unit, MMRDA, India
Email: prkmurthy1960@yahoo.com

Abstract
There has been a growing interest among policymakers about the relevance of rail-based systems in India, to address the mobility needs of the expanding population in the cities. While evaluating different mass transit options for Indian cities, metro systems are often given preference due to the fact that road-based bus systems cannot cater to capacity requirements as much as metro systems. In addition to this, metro rails are perceived to have higher levels of comfort, speed and efficiency, than bus systems, making them more attractive to both policymakers and potential users of the system. Currently in India metro projects are under different stages of implementation in Delhi, Kolkata, Mumbai, Bangalore, Chennai, Hyderabad, Pune, Ahmedabad to mention a few. The talk will highlight details on planning system selection and project implementation aspects of the metro system in India.

BEHAVIORAL IMPLICATIONS OF TRANSFORMATIVE DISRUPTIONS IN TRANSPORTATION

Prof. Ram M. Pendyala
Arizona State University, USA
Email: Ram.Pendyala@asu.edu

Abstract
Rapid developments in vehicle automation and connectivity have spurred considerable debate on the extent to which these technologies may affect traveler behavior and transform the transportation system in terms of its performance, character, and energy and environmental impacts. Advanced vehicular technologies such as connected and automated/autonomous vehicle systems, and new ride-sharing and ride-hailing services, represent a new generation of disruptive forces that continue to evolve (thus rendering real-world experimentation difficult), with considerable speculation regarding their market penetration and adoption, impacts, and behavioral implications. This presentation offers a comprehensive conceptual framework for characterizing the types of behavioral responses that may be realized as a result of the increasing market penetration and adoption of these disruptive technologies. Following the presentation of a conceptual framework, this research aims to address this topic by providing an overview of a number of research studies undertaken by the authors aimed at understanding, modeling, and predicting consumer preferences for the adoption and use of alternative technology options and mobility services. Research results suggest that there is considerable variance in consumer preferences for various smart technology options and mobility services, and this variance has important implications for transportation planning and operations in the future. The presentation concludes with a discussion of these implications.
MEASUREMENT OF DENSITY UNDER MIXED TRAFFIC CONDITIONS
Prof. Satish Chandra
CSIR-Central Road Research Institute, New Delhi, India
Email: satishce@gmail.com

Abstract
Density is one of the fundamental macroscopic characteristics of the traffic stream. It is used as the measure of effectiveness for road network performance and as a means of judging Level of Service (LOS) of the road. In practice, density is usually calculated as the ratio of the flow and speed (fundamental traffic equation). Fundamental traffic equation assumes stationary traffic conditions, which is not valid in complex and dynamic real situations. This necessitates developing other methods to measure density which can be used under heterogeneous traffic situation as prevalent in India. This research presents a critical evaluation of four methods of estimating density, namely n-t method, highway capacity manual (HCM) method, time and area occupancy method and also proposes a new method termed as ‘Multi Snap’. Analysis of field data using n-t method establishes the validity of fundamental equation even in mixed traffic flow. This method gives the accurate value of density and is quite simple and quick. Results of HCM method are highly misleading under mixed traffic situations. Area occupancy gives better results as compared to time occupancy but both of these methods are less accurate than n-t method. The proposed method is a modification of HCM method and it shows that as the number of observations is increased during study period, the error in density measurement reduces rapidly.

MUMBAI METRO LINE-3: CHALLENGES IN IMPLEMENTING THE FIRST UNDERGROUND METRO CORRIDOR IN MUMBAI

Mr. S. K. Gupta
Mumbai Metro Rail Corporation Ltd., Maharashtra, India
Email: subodh.gupta@mmrcl.com

Abstract
Mumbai Metro Line-3 is the first underground metro project in Mumbai city. The line spanning 33.5 km between Colaba to SEEPZ connects important transport hubs, business centers and other places of interest. It passes through close vicinity of high rise building and other infrastructure. The project poses number of challenges of administrative, geological, technical and logistic nature. This presentation would be covering some of these aspects as to how we would meet with these challenges to successfully implement this project.
INVITED LECTURES

ABCS OF ALTERNATIVE INTERSECTION AND INTERCHANGE DESIGNS

Prof. Praveen Edara
University of Missouri, Columbia
Email: www.praveenedara.org

Abstract
Alternative geometric designs offer creative low-cost solutions to enhance safety and mobility of roadway junctions. Examples of such designs are: diverging diamond interchange (DDI), J-turns, continuous flow intersection, and parallel flow intersection. Recent research, in the past decade, has documented the benefits of these designs; thereby leading to increased implementations across the United States. This talk will provide an overview of alternative intersection and interchange designs and their safety performance. Transferability of some of the designs to Indian roadways and the associated challenges of adapting to mixed traffic conditions will also be discussed.

DEMONSTRATION AND IMPLEMENTATION RECOMMENDATIONS TO INTEGRATE THE UNITED STATES ROAD ASSESSMENT PROGRAM (usRAP) FOR RURAL ROADWAYS IN KANSAS

Prof. Eric Fitzsimmons
Kansas State University, USA
Email: fitzsimmons@ksu.edu

Abstract
Vehicle crashes on rural roadways in Kansas continues to be a serious safety concern. Many state agencies are utilizing systemic safety tools to identify, prioritize, and implement countermeasures based on numerous data sources. This study will present current systematic tools and the resolution of detailed needed to complete a safety analysis. The United States Road Assessment Program is one such systemic tool which relies on determining areas of risk along a roadway without the need of localized crash or geometric data which can sometimes be hard to obtain depending on the roadway. Three rural two-lane corridors were selected including a US highway, Kansas highway, and a rural secondary. Data collection for the usRAP software including manual speed data collection, system-wide centerline miles and crashes, crash costs, countermeasure costs, and manual roadway coding data every 100 m. The usRAP software evaluated each corridor and developed a star-rating for each 100 m segment indicating areas of potential risk to vehicles, motorcycles, pedestrians and bicyclists. Safer Roads Investment Plans were developed for each corridor based on the coded information. These plans included recommended countermeasures which mainly targeted run-off-the-road crashes included removing fixed objects in the clear zone, enhancing horizontal curves through delineation, and side slope improvements. Additionally, a benefit-cost ratio was provided for each countermeasure and also a program benefit-cost ratio. usRAP output for the rural secondary corridor was compared to a traditional road safety audit which was recently completed and the results were similar for issues that could be identified from the roadway point of view.
DEVELOPMENT OF ROAD USER COST MODELS FOR HIGH SPEED CORRIDORS

Dr. S. Velmurugan
CSIR - Central Road Research Institute, New Delhi, India
Email: vmssathya@gmail.com

Abstract
During the last decade, the liberalization of the Indian economy aimed at the pace of augmentation of various infrastructure projects which began in the early 1990s has been continued as an evolutionary process by the successive governments. In this regard, the growth trends registered in the road transport sector is indeed exemplary which can be attributed to the following:

- Globalisation of business
- Deregulation of transport and a changing governmental infrastructure
- Organisational changes in business environs
- Rapidly changing technology

This has resulted in the entry of a large number of vehicles possessing state of the technologies like variants of passenger vehicles spread across small cars i.e. engine size up to 1400 cc and big cars / vans / Sport Utility Vehicles (SUVs) i.e. 1400 cc engine size. In addition to this, many national and international companies have introduced new and improved models of motorized two wheelers, buses and goods vehicles (for instance Volvo) into the Indian motor vehicle segment. These radical changes have transformed the Indian road traffic scene completely as the registered vehicular population has grown from 53 million in 2000 to 159 million by the end of 2014. It is observed that the length of multilane divided carriageways i.e. four-lane / six lane / eight lane and even expressways (which are fully access controlled facility) is around 27000 Kms which are managed by Ministry of Road Transport and Highways (MoRT&H), National Highways Authority of India (NHAI) and many State Governments under the umbrella of Special purpose Vehicle (SPV) in the form of Design Build, Finance, Operate and Transfer (DBFOT) or simply Build Operate and Transfer (BOT) model. However, these upgradation measures are being carried out without taking on board the need for the capacity augmentation of many such candidate highways segments by carrying out a scientific assessment except for referring to the arbitrary values given in the Indian Road Congress (IRC) document titled, IRC:SP-84 (2015) i.e. Manual and Specifications for Four Laning Projects under Public - Private Partnership and IRC:SP-87 (2014) i.e. Manual and Specifications for Six Laning Projects under Public - Private Partnership. Obviously, the above transformation in the automobile and road sector development coupled with changing traffic mix due to the above have necessitated the research on road user cost to be revisited periodically and develop Road User Cost (RUC) equations exclusively covering varying widths of multi-lane divided inter-urban carriageways which is referred as high speed corridors in this paper.

Considering the above, a study entitled, 'Development of Road User Cost Models for High Speed Corridors' was taken up under the umbrella of the main study titled, “Development of Maintenance Management Strategies for High Speed Corridors”, funded by Council of Scientific and Industrial Research (CSIR) under 11th Five Year Plan by CSIR - CRRI. In this study / talk, maiden attempt to develop Road User Cost (RUC) equations for varying widths of multi-lane divided inter-urban carriageways including four lane / six lane / eight lane divided carriageways as well as expressways coupled with updating the existing RUC equations for the two lane, intermediate and single lane carriageways by incorporating changes in road quality, vehicle and fuel technology, economic aspects of users would be discussed.
FUNCTIONAL LAYER MATERIAL DESIGNATIONS AND CASE STUDIES OF COMBINED CHIP SEAL AND MICRO-SURFACING/SLURRY SEAL IN AIRPORT PAVEMENT

Prof. Feipeng Xiao
Tongji University, China
Email: fpxiao@tongji.edu.cn

Abstract

With the increasing attention to preventive maintenance and rehabilitation of asphalt pavement, asphalt emulsions have gained popularity. Synchronous chip seal and micro-surfacing slurry seal are widely used in pavement preservation due to their low cost and efficiency, but not prevalent in new pavement construction, especially for airport pavement. The objective of this study was to characterize the functional layers of combined with chip seal and slurry seal through conventional test methods for asphalt emulsions, asphalt binders, and chip and slurry seals including setting time, residual amount on sieve of 16-mesh, Engler viscosity, standard viscosity, residue content, penetration, ductility, failure temperature, wet track abrasion test, and load wheel test for two airport pavements. Differential scanning calorimetry (DSC) was also conducted to explore the energy differences amongst various emulsions. In addition, cases studies at laboratory and field were also tested to evaluate the waterproof performances of the functional layers. The results of material tests showed that the laboratory waterproof test on trial pavement met the requirement of standards and the trial airport pavement was emphasized the importance of compaction during the construction. In addition, the good quality control and the pneumatic tire roller compaction are indispensable to achieve a great performance of functional layer.

5D LAND USE/TRANSPORT MODEL
BUILDING A BALANCED MULTI-MODAL GREEN TRANSPORT SYSTEM

Prof. Pan Haixiao
Tongji University, China
Email: hxpank@online.sh.cn

Abstract

In view of our city’s different condition in high density and mixture in land use between other western industry country, the article proposes the new model of urban transportation and land use——5D. That is put walking and cycling transport at the top priority in urban planning to reverse the current planning practice of car traffic first. Because the urban transport and the land use in China have the characteristic of synchronization and intergrowth, the establishment of the urban multi-modal green transport system should place itself at its urban development condition. So it points out that specially maintaining the high proportion bicycle travel in city is an important contribution to world environment problem.

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INTEGRATED PUBLIC GRIEVANCE REDRESSAL SYSTEM (iPGRS)

Dr. Kandukuri Raju
Tata Consultancy Services, India
Email: kandukuri.raju@tcs.com

Abstract

With increasing awareness and option of multiple channels passengers today are more vocal about their grievances and what dissatisfy them in their whole journey experience. Indian Railways (IR) receives lakhs of service related complaints and grievances from the passengers annually through various channels (viz. web based, mobile app, social media, phone or paper based etc.). These channels are disparate, work in silos and follow different processing (mostly manual). There is no uniform business process or single platform visibility to IR to address these grievances. This results in increased response time due to complexity (different channels, different processes etc.) in addressing these grievances.

IR started to semi automate their process for twitter complaints but the process is not capable enough to survive large volumes expected in future. IR today employ a small Grievance cell (aka twitter cell) with 20 people working in shifts 24*7 and manually handling 5,000 complaints through twitter daily. An estimate suggest that the increase in popularity of such service and penetration of smartphones can increase volumes of tweets by 6 times in next one year leading to additional requirement of 100 persons. This will put cost pressure and reduced revenues due to dissatisfied passenger.

iPGRS is an Omni channel (web & mobile) solution to help IR in overcoming the above said challenges. iPGRS integrates grievances from multiple channels onto a single platform, and creates service request (SR) based workflow which enables monitoring of grievances resolution. Concerned stakeholders will receive these SRs as an action item in their workflow and it becomes their responsibility to properly address and close. After that, feedback would be taken from the passenger related to their grievances. This way, system would be able to handle large volumes of grievances with transparency and accountability. System includes many automation techniques like rule based engine, text analytics etc. to speed up the whole process. iPGRS offers a 360 degree integrated dashboard for further analysis and service improvement

Following are the 5 major components envisaged for the iPGRS system

Consolidation: Register and consolidate grievances from various channels into a single platform or database.

Dissemination: System converts grievances into unique SR numbers for individual identity. Based on business rules, it would sanitize the grievances by de-duplication, prioritization and elimination of fake SRs. Subsequently it routes SRs to respective stakeholders based on workflow mechanism. This gives real time visibility of action/events happening to an individual grievance/SR at any stage.

Implementation: Service Level Agreement (SLA) based response and monitoring enables the stakeholders to respond to a grievance in time.

Feedback: Customer feedback to close the grievance process. Unaddressed grievances based on the customer feedback will be re-routed as per the business rule.

Analytics: Advance Analytics will enable big picture view in form of management dashboard for the business managers such as Top 5 problems, worst performing trains and stations, etc. iPGRS offers a system which is digital, innovative, automated, transparent, and efficient to handle volumes of grievances with accuracy.
DEVELOPMENT OF GREENFIELD AIRPORT IN INDIAN CONTEXT: CASE STUDY OF NAVI MUMBAI INTERNATIONAL AIRPORT (NMIA) PROJECT

Mr. Soma Vijayakumar
City and Industrial Development Corporation (CIDCO) Ltd., Mumbai, India
Email: cidcocgmta@gmail.com

Abstract
Mumbai, being the financial and commercial Capital of India, requires aviation facilities of the highest order. Presently Mumbai airport is handling about 41.67 MPPA (Million Passengers Per Annum) and is experiencing severe constraints in augmenting the air, land and city side facilities to meet the future growth. Air Travel Demand for Mumbai Metropolitan Region is growing rapidly and the forecasted air traffic is expected to be around 100 MPPA by 2034. To meet this anticipated air travel demand, the Ministry of Civil Aviation (MoCA) granted approval for the development of a Greenfield airport at Navi Mumbai. The Navi Mumbai Airport is proposed to be developed through Public-Private Participation (PPP) by setting-up a Special Purpose Vehicle (SPV) with equity contribution from CIDCO. The proposed Airport is situated near Ulwe in the geographical centre of Navi Mumbai and at a distance of approx. 35 km from the existing airport in Mumbai. The National Highway 4B abutting the boundary of the proposed Airport and Aamra Marg (NH-348) running along the western boundary of the Airport provide the main access to the airport. The Navi Mumbai International Airport is located in a core area of 1160 Ha. and is proposed to have two parallel and independent runways for simultaneous and independent operations along with full length taxiways on either side of runways. The airfield is designed to accommodate new large aircraft like A380/B747-8 and complies with ICAO Aerodrome Code 4F. The proposed airport, expected to be developed in 4 phases, is expected to cater to 10 million passengers per annum (MPPA) in the first operations year and in the ultimate phase, 60 MPPA. The basic cost of airport project is estimated to be around Rs. 16,704 Crores (FY 2015) spread over four phases, including the cost of pre development works at the airport currently estimated at Rs 3,144 cr. The Navi Mumbai Airport would act as a powerful engine for the overall growth of our country, Maharashtra and particularly Mumbai, Nashik, Pune & Ahmednagar belt. The project after obtaining various approvals is in advanced stage of bidding and selection of Concessionaire on PPP basis is presently under process. Availability of excellent aviation facilities would bring large volumes of business and investment to MMR.

STRESSES IN CONCRETE PAVEMENT

Prof. Animesh Das
Indian Institute of Technology Kanpur, India
Email: adas@iitk.ac.in

Abstract
The basic formulation for estimation of stresses (due to load and temperature) in concrete pavement will be reviewed in this talk. Few simple foundation models will be considered. Finally, the challenges involved in obtaining analytical solutions will be discussed.
Abstract
With almost 30 per cent of the global foreign direct investment (FDI) inflows in 2013 channeled to Asia the region is world leading in attracting FDI. Yet, on a sub-regional level South Asia is the weakest region among all Asian sub-regions. This gives rise to the question what separates South Asian countries from their more successful East and South East neighbouring countries. In this talk we underline the importance of performance in national transportation and logistics systems in developing and emerging countries.

The general question why certain countries manage to attract FDI while others fail has been frequently addressed in literature. Moreover, research in logistics and transportation now claims on a host of determinants that explains the location considerations of MNEs based on host country logistics performance. By implementing these determinants into more traditional FDI and trade models our objective is to shed more light on the importance of the individual aspects of national transportation systems on the FDI and trade patterns in the (South) Asian region. Moreover, we analyze the costs of distance for trade and FDI as well as the potential of national transportation systems to overcome these costs. Our findings show that the elements of national transportation systems positively influence both trade and FDI. Additionally, more developed national transportation systems are able to overcome the costs of distance to some degree. We also find support for the notion that the nature of the costs of geographic distance (e.g. transportation costs) differ between trade and FDI. While the former is related to international transportation and port infrastructure, the latter is based on within-country transportation and is moderated by land-based transportation infrastructure. Finally, our approach and results enable us to compare and rank the different national transportation systems in the (South) Asian region that can be beneficial to policy makers as a benchmarking tool.

UNDERSTANDING URBAN MOBILITY STRATEGIES FOR SMART CITIES

Prof. Manoranjan Parida
Indian Institute of Technology Roorkee, India
Email: mparida@gmail.com

Abstract
Smart City makes efficient use of physical infrastructure through artificial intelligence and data analytics to support a strong and healthy economic, social, cultural development. Ministry of Urban Development (Govt of India) has identified 100 cities to be developed into smart cities so as to drive economic growth and improve the quality of life of people by enabling local area development and harnessing technology. The Habitat III conference, held recently in Quito, also recognized the importance of developing smart cities and decided to commits towards adopting a smart city approach, which makes use of opportunities from digitalization, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery.

Smart mobility deals with providing safe and accessible transportation options that operate efficiently through innovative solutions. This mainly focusses on developing solutions with respect
to smart parking, intelligent traffic management, integrating multi-modal transport etc. The unprecedented growth of road traffic has put pedestrian and cyclists at high risk, with a considerable increase in the rate of accidents and cost of travel. The National Urban Transport Policy (2014) was coined with the objective of planning plan for the people rather than vehicles by providing sustainable mobility and accessibility to all citizens to jobs, education, social services and recreation at affordable cost and within reasonable time. It is worth noting that the objective of this policy is in line with that of the mobility alternative of smart cities. Smart mobility aims to achieve efficient road networks, promoting pedestrian and bicycle facilities, efficient traffic management, integrated public transportation systems, development and management of parking systems, and to develop a unified transportation authority for overall management at the network level and at the entity level.

Smart mobility options across the globe could be used as a reference in further enhancing the transportation solutions. The use of non-cash payment for public transportation, bicycle sharing networks, use of electric vehicles and development of charging points across the road network, smart traffic managements solutions and use of intelligent transportation system, seamless movement across multi-modal transportation, etc are some of the smart mobility solution adopted at different parts of the world. However, adopting any of these options to an existing city, should be materialized only after due consideration of its immediate impact and long term benefits that it will have on converting it into a smart city.

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**MEASURES FOR ENCOURAGING USAGE OF SHARED MODES FOR SCHOOL TRIPS**

Prof. Bhargab Maitra  
Indian Institute of Technology Kharagpur, India  
Email: bhargab@civil.iitkgp.ernet.in

**Abstract**

The vehicular volume in urban India is growing steadily due to rapid urbanization and consequent growth of private vehicle ownership and usage. However, the augmentation of road capacity in urban India is often restricted by physical constraints. The imbalance between demand and supply has aggravated traffic congestion and pollution in urban India. Over years, a large number of schools which were established in open areas with low traffic intensity have gradually become parts of dense urban development and alongside busy traffic corridors.

The three most significant modes used in the transfer of school children are school bus, pool-cars and private vehicles. Among the three modes, a significant portion of school trips are now made using private vehicles. Due to increasing use of private vehicles, the roads in the influence zone of the schools are severely affected during the school opening and closing hours. Consequently, this is aggravating the traffic congestion, emission and safety problems around schools. It is necessary to formulate appropriate measures to encourage the use of shared modes (e.g. school buses and pool cars) for school trips and thereby improve the traffic situation around schools in urban areas. The present works aims to investigate the concerns of parents regarding usage of shared modes for school trips and suggest appropriate technological and management interventions for necessary improvement. The work is demonstrated with reference to a few schools in the Kolkata metro city.
TRAVEL TIME DYNAMICS: HAMILTON-JACOBI EQUATION

Prof. Pushkin Kachroo  
University of Nevada, USA  
Email: pushkin.kachroo@gmail.com

Abstract

The talk will show why traditional travel time models are not appropriate for real time traffic dynamics, and hence should not be used for dynamic traffic problems. The talk presents a new mathematical model for travel time dynamics developed by the author. The derivation of the model will be presented, and then most important details about its mathematical structure will be explained. The model is a coupling between conservation law (a hyperbolic PDE, the LWR model) and a Hamilton-Jacobi PDE with mixed boundary conditions. Open problems in this topic will be presented including possible numerical schemes.

QUANTIFICATION OF COMPACTABILITY AND RESISTANCE TO MOISTURE DAMAGE OF WARM MIX ASPHALT

Prof. Meor Othman Hamzah  
Universiti Sains Malaysia (USM), Malaysia  
Email: cemeor@yahoo.com

Abstract

Warm mix asphalt (WMA) was developed to address rising concerns over adverse environmental impacts, energy prices and global warming. WMA enables asphalt mixtures to be produced at lower temperatures. Being adhesion promoter, surfactants-based warm mix asphalt appear not to exhibit significant effect on binder rheological properties. Its temperature reduction mechanism can be ascertained from an evaluation of mixture compactability or workability. Unlike concrete, there is no established method to quantify mix compactability. For asphalt, ease of compaction is measured based on its Compaction Energy Index (CEI) obtained from the relationship between degree of compaction versus the number of gyration curves. The CEI is the accumulated area under the curve between gyration number 8 to 92%Gmm. Lower CEI is more desirable because less energy is needed to achieve the required density. Compactability can also be determined from the linear relationship between accumulated compaction energy versus number of gyrations curves. The higher the slope indicates higher workability. Studies on ease of compaction at the Universiti Sains Malaysia (USM) showed that many categories of WMA exhibit lower CEI and higher slope despite the lowered mixing and compaction temperatures. This explains the mechanism behind its reduced production temperature capability, especially for surfactant-based warm additive. Unfortunately, lowering production temperature results in the presence of trapped moisture in the aggregate that can hasten moisture damage which serves as the building block for many pavement surface distresses. To investigate this phenomenon at micro level, many novel laboratory innovative simulative tests have been developed at the USM to quantify moisture damage on WMA. For instance, the accelerated laboratory vacuum saturator (ALVS) is an innovative equipment that not only subject mixtures to the damaging effects of water and vacuum, but also temperature. The pneumatic asphalt tensile testing (PATTI) device was adapted as the enabler to realistically quantify adhesive failure of pure binder and mastics on aggregate substrates. A method was also developed to input a known quantity of moisture in asphalt mixtures to precisely ascertain the disastrous effects of known moisture percentage in asphalt mixtures. Imaging technique has been used to precisely quantify moisture damage attributed to cohesive failure, adhesive failure and broken aggregate.
TRAFFIC DIVERSION DURING CONSTRUCTION OF MUMBAI METRO LINE 3

Mr. K. V. J. Ramana Rao
Egis India Consulting Engineers Pvt. Ltd., India
Email: kjvr.rao@maplegc.in

Abstract
Diversion of traffic is the most important activity of any urban infrastructure project which affects the traffic movement due to the construction activity (partly or fully on the road). Mumbai Metro Line 3, though the alignment is proposed to be underground, most of the stations are proposed to be constructed using cut and cover methodology. Traffic Diversion plans to minimize inconvenience to road users for 26 stations locations affecting the traffic movement will be presented.
CONFERENCE ABSTRACTS
**EVALUATION OF PEDESTRIAN SPEEDS ON SIDEWALKS: A COMPARATIVE STUDY AT THE COMMERCIAL HUBS IN THE TWIN CITIES OF KOLKATA AND HOWRAH**

Deotima Mukherjee¹, Soumyadip Das¹, Pritam Saha¹*, Sudip Kumar Roy¹

¹ Indian Institute of Engineering Science and Technology, Shibpur, Howrah, West Bengal, India

* E-mail: saha.pritam@gmail.com

**Abstract**

The present paper focuses on describing walking speeds of pedestrians on sidewalks and the parameters governing them. On the basis of field data, obtained from two study sites at the commercial hubs of the twin cities of Kolkata and Howrah, it has been observed that pedestrian characteristics such as age, gender and carrying of luggage significantly affect walking speeds. The appropriate models of speed distributions were selected using a methodology based on K-S test and the normal distribution was found to exhibit its aptness in describing the speed data. Then, impacts of pedestrian characteristics on their speeds were studied accordingly.

**Keywords:** Pedestrians; sidewalks; land-use; walking speeds

**ANALYSIS OF TIME HEADWAYS UNDER HEAVY TRAFFIC FLOW CONDITIONS ON TWO-LANE ROADS: CASE STUDY FROM NORTH-EAST INDIA**

Rupali Roy¹*, Nabanita Roy¹, Pritam Saha¹, Ashoke Kumar Sarkar²

¹ Indian Institute of Engineering Science and Technology, Shibpur, Howrah, India

² Birla Institute of Technology and Science Pilani, Rajasthan, India

* E-mail: rupaliroy.nit@gmail.com

**Abstract**

This paper presents an investigation on headway distributions under heavy flow when the traffic is heterogeneous in character, based on field data collected on a two-lane highway in India. Contestant headway distribution models were evaluated and three distribution functions namely, log-logistic, Pearson 5 and Pearson 6 were considered while modelling. The appropriate models were selected using a methodology based on K-S test. Log-logistic distribution was found appropriate at moderate flow whereas, at congested state of flow it was Pearson 5. However, at unstable flow nearing capacity, both following and non-following components of headways were observed to follow different distributional characteristics.

**Key Words:** Two-lane roads; mixed traffic; time headway; distributions; goodness-of-fit
MODELLING OF OPERATING SPEEDS FOR URBAN ROADS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

Sathishkumar S.1, A. Mohan Rao1*, Velmurugan S.1, Gowri A.2
1 CSIR-Central Road Research Institute, New Delhi, India
2 National Institute of Technology, Surathkal, India
* Email: amrao_crri@yahoo.co.in

Abstract

Operating speed of vehicle measured on roadways is a critical component for a host of analysis in the transportation field including transportation safety, roadway geometric design, etc. Operating Speed has also been used for the road engineers for the measurement of roads quality, performance and service. The main objective of this study is to develop the model for the estimation of operating speed based on the high influencing factors. In this study total of 24 locations are selected from Delhi, Mumbai, Nagpur, Kolkata, Roorkee to examine the factors that influence the operating speed of vehicles. The properties like width of the road, frictional points, land use type, traffic volume and speed where collected, traffic volume, speed. Frictional points, Width of the road, median opening have influence on operating speed of the vehicle. The study observed that the parameters such as composition of vehicles, Land use, and Friction type seems to have much influence on the operating speed.

Keywords: Operating speed, modelling, traffic composition, friction points, and urban roads

BASE CAPACITY ESTIMATION OF FOUR LANE DIVIDED URBAN CARRIAGeways UNDER MIXED TRAFFIC CONDITIONS

Sathishkumar S1, A. Mohan Rao1*, Velmurugan S.1
1 Central Road Research Institute, New Delhi, India
* Email: amrao_crri@yahoo.co.in

Abstract

In India, the rapid boom in industrial and economic development in the urban areas has led to increased mobility in urban areas. Due to the above, there is an exponential growth in the number of vehicles plying on the roads. In urban areas the magnitude and nature of traffic flow will be different from rural areas. In this regard, knowledge of the roadway capacity is an important parameter for planning, analysis and operation of roadway systems. Passenger car unit is the factor used for the conversion of mixed traffic into a common unit by keeping the passenger car as reference vehicle. It may be noted that the lane capacity provided in IRC (1990) is obsolete due to the fact rapid strides has been witnessed during the last decade in the road engineering and vehicle technology on the urban roads of India. The above radical changes can be attributed as the primary reason for the increase in the roadway capacity as compared to the values reported in IRC: 106 (1990). Highway capacity manuals (HCM) from developed countries may lead to serious prediction errors of traffic performance if applied directly in developing countries like India, due to homogeneity condition and lane following behaviour in developed countries. In this paper, four lane divided road sections located in different urban cities in India are considered and the basic traffic parameters like speed, density and flow are estimated and related.

Keywords: Capacity, Passenger car unit, Operating Speed and Urban Roads
METHODOLOGIES FOR EVALUATING PEDESTRIAN LEVEL OF SERVICE

Kamal Singh*

1 Maulana Azad National Institute of Technology, Bhopal, India
* Email: singhk@manit.ac.in

Abstract
Walking is the oldest mode of transportation for the humans. Pedestrians constitute a large proportion of trip makers but exclusive pedestrian facilities are generally missing in most of the cities of the developing countries. Wherever facilities are provided, they are occupied either by hawkers, vendors or shopkeepers. Pedestrians are compelled to use some space of the carriageway thus increasing their frictions and making them vulnerable. Therefore it is important to plan and provide pedestrian facilities in accordance to the observed pedestrian behavior and needs rather than relying on the set norms or specifications and the findings from the cities with dissimilar characteristics. To know how well roadways accommodate pedestrian travel or how they are pedestrian friendly or how safe is crossing the road, it becomes necessary to assess the walking conditions. Evaluation of Pedestrian Level of Service (PLOS) is the most common approach to assess the quality of operations of pedestrian facilities.

A methodology has been proposed to evaluate pedestrian level of service. One case study has been taken to compare the results of the proposed methodology with the results of eight other methods. According to the results obtained, it is observed that the estimated pedestrian LOS varies significantly depending on the selected method, as some take into consideration mainly qualitative parameters where others use only quantitative ones. Out of eight methods applied, results of four methods match with the result of proposed methodology and other four give different results. However the results obtained by pedestrian satisfaction rating were found very close to the results obtained by using the proposed methodology.

Key words: Pedestrians, Pedestrian level of service, Pedestrian facilities, walking conditions

COMPUTATION OF LINE CHOICE PROBABILITY ASSUMING COUNTDOWN INFORMATION AT TRANSIT STOPS - CASE STUDY FOR A SECTION OF DELHI BUS TRANSIT NETWORK

Padma Seetharaman*, Nataraju Jakkula1, Madhu Errampalli1, Satish Chandra1
1 CSIR-Central Road Research Institute, New Delhi, India
* Email: padmaseetharaman5@gmail.com

Abstract
The influence of information dissemination through 'countdown signs', on passenger line choice is dealt with in the current paper. 'Countdown signs' show the arrival of transit services at transit stops via a LED display board. A section of Delhi bus transit network is modelled wherein the frequency of the lines are ascertained from the Delhi Transport Corporation (DTC) website assuming erlang interarrival distribution. Poisson rate of passenger arrivals is chosen such that it reflects the uncongested conditions of the section. The line choice probability for the chosen section with and without information and for varying shape factors of erlang distribution is tabulated.
QUALITATIVE EVALUATION OF SIDEWALKS IN DELHI

Bivina G R¹, Diwakar Gupta¹, Purnima Parida², Manoranjan Parida¹*
¹ Indian Institute of Technology Roorkee, India
² CSIR-Central Road Research Institute, New Delhi, India
* Email: mparida@gmail.com

Abstract
Qualitative assessment of walking on sidewalks is crucial for the evaluation and design of sidewalks. The objective of this research is to identify the degree of importance of various qualitative factors associated with walking on sidewalks and degree of satisfaction of pedestrians using existing sidewalks from various land uses. A questionnaire survey was conducted at 29 selected locations that includes different land uses in Delhi, India. The findings of the research helps urban activist and planners to take cognizance of the perceptions and importance for the sidewalk attributes that provides serviceability for pedestrians.

Keywords: Qualitative evaluation, sidewalks, land use

COMMUTERS’ EXPOSURE TO PM2.5: A CASE STUDY OF DELHI

Rajeev Kumar Mishra¹*, Amrit Kumar¹, Ankita Shukla²
¹ Delhi Technological University, Delhi, India
² JK Infraprojects Limited, Delhi, India
* Email: rajeevkumarmishra@dce.edu

Abstract
This study is an effort to assess the exposure of particulate matter (PM2.5) to commuters, travelling in different modes of transport (AC Bus, Non-AC Bus, AC Car, Non-AC Car and Auto-rickshaw) along major transport corridor in Delhi. The study was conducted during morning peak hours, evening peak hours and off-peak hours of the day. Among all considered modes of transport, the maximum concentration was found in Auto-rickshaw (102 μg/m³), while the minimum was observed in AC car (43 μg/m³) and AC bus (50 μg/m³), which indicates that the public transport may be used by commuters to reduce their personal exposure to particulate matter.

Keywords: Commuter, Exposure, NAAQS, PM2.5, Vehicles

MECHANISTIC APPROACH FOR STABILISED FLEXIBLE PAVEMENTS

Prashant P. Nagrale¹, Atulya P. Patil¹*
¹ Sardar Patel College of Engineering, Andheri, Mumbai, India
* Email: atulyapatil69@gmail.com

Abstract
Most of the time flexible pavements in India need to be constructed on problematic subgrade soil. Such subgrades have low California Bearing Ratio which leads to more pavement thickness. Decrease in availability of suitable subbase and base course materials for highway construction leads to a search for economic method of converting locally available troublesome soil to suitable one for highway construction. An experimental program was undertaken to study the effect of...
lime and fiber on Clay type of subgrade soil. California bearing ratio (CBR) tests were conducted on unstabilized and stabilized soil with varying percentage of stabilizers and optimum quantity of stabilizers required for maximum benefits is estimated. Pavement sections were modeled as a 2 – D axisymmetric finite element pavement section using commercial software ANSYS. The values of vertical compressive strains at the top of unstabilized and stabilized subgrade were further used to estimate layer thickness reduction or extension in service life of the pavement due to stabilization. The study shows that the service life of the pavement increases by 6.49 and 3.26 times due to lime and fibre stabilization.

**Keywords:** subgrade stabilization; California bearing ratio; compressive strain; layer thickness reduction; traffic benefit ratio

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**DETERMINING CAPACITY FOR URBAN ARTERIAL ROADS OF RAJKOT CITY USING TWO-WHEELER EQUIVALENT UNITS**

Jay K. Kalaria*, Yogesh U. Shah¹, Ravindra V. Solanki¹, Monica M. Vala¹

¹ Marwadi Education Foundation, Rajkot, India

* Email: Jay.kalaria@gmail.com

**Abstract**

In this study, the fundamental parameters of the traffic stream viz. speed, flow and density have been analyzed for multilane divided roads in Rajkot city. Three urban arterial road sections of Rajkot city were selected for data collection. All the three road sections selected were of 4 lane divided. The traffic data were collected on each section during peak hours for two working days. The traffic flow composed of multi-axle vehicles, trucks, buses, LCV, cars, three-wheelers, two-wheelers, and non-motorized vehicles; however the two-wheelers contributed to about 65% of the traffic stream. Different Speed - Density connections have been built up in this study, resulting in the estimation of the roadway capacity. The capacity of the selected sections was presented in terms of dynamic Two-Wheeler Equivalent Units (2WEUs) values. The range of 2WEUs observed in the present study for 2W, 3W, Car, LCV, Bus, Truck and MAV are 1, 3.63 to 6.07, 3.52 to 5.46, 7.83 to 14.28, 21.78 to 41.41, 14.21 to 28.30 and 23.84 to 37.65 respectively. The capacity values observed by using Static PCUs for all the three road section in upward direction were 4723, 3234 and 5712 respectively whereas in downward direction it is 4218, 5222 and 3823 respectively. The capacity values observed by using 2WEUs for all the three road section in upward direction were 15578, 9083 and 13459 respectively whereas in downward direction it is 12591, 14473 and 16528 respectively.

**Key Words**: Traffic Capacity, Mixed traffic flow, Two-wheeler Equivalent units(2WEUs)

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**LABORATORY STUDIES ON EFFECT OF ZYCOTHERM ADDITIVE ON BITUMINOUS CONCRETE MIX**

Bheemashankar*, Amarnath M. S.¹

¹ UVCE, Bangalore University, Bangalore, India

* Email: bheemashankar92@gmail.com

**Abstract**

The application of traffic load on pavement leads to the development of tensile stresses in the pavement. The lack of tensile strength properties in bituminous layer leads to the development of cracks in pavement. Indirect Tensile Strength (ITS) test is conducted on Bituminous Concrete
(BC) mix specimens, to evaluate the tensile strength of BC mix. The tensile strength properties of BC mixes can be enhanced by addition of materials like chemical additives (Zycotherm) and mineral fillers (Cement and Lime). To know the effect of temperature on BC mix, ITS test is conducted at different temperatures viz. 10°C, 20°C, 30°C and 40°C for BC mix specimens prepared with and without zycotherm for mix with each filler. To evaluate the effect of moisture on Indirect Tensile Strength the Tensile Strength Ratio (TSR) test is conducted. It is observed that the BC mixes with Zycotherm shows higher ITS and TSR values compared to the BC mixes without Zycotherm.

**Keywords:** Bituminous Concrete, Indirect Tensile Strength, Zycotherm, Fillers, Tensile Strength

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**EFFECT OF CURING PERIOD ON STRENGTH, PLASTICITY AND DURABILITY CHARACTERISTICS OF TERRAZYMЕ TREATED SOILS**

Pavitra Deshanur¹, Manjunath C.¹*, Amarnath M. S.¹

¹ UVCE, Bangalore University, Bangalore, India
* Email: pavitra.e501@gmail.com

**Abstract**

Soil stabilization is a technique to improve the properties of weak soils and making them suitable for use in specific engineering projects. In the present study an attempt is made to study the effect of curing period on bio-enzyme treated soils. A bio-enzyme named Terrazyme, when mixed with soil alters its engineering properties. Since it is a concentrated liquid, it should be diluted with water. For the purpose of study two different soils viz., red soil and black cotton soils were tested. The properties of the soils were determined in the laboratory. The soils were treated with fixed amount of Terrazyme as given by manufacturer based on percent passing 75 micron sieve, plasticity index and density of soil. The prepared soil samples were cured for 0, 3, 7, 14 and 28 days and subjected to laboratory testing. The results of the studies show that there is increase in California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) of soil and decrease in Plasticity Index (PI) with increase in curing period. Also the durability test was conducted on Terrazyme treated soil samples cured for 28 days.

**Keywords:** Bio-enzyme, Terrazyme, California bearing ratio, Unconfined compressive strength, Plasticity index, Durability

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**A STUDY ON EFFECT OF DOSAGE OF BIO-ENZYME ON STRENGTH AND PLASTICITY CHARACTERISTICS OF SOILS**

Manjunath C.¹*, Pavitra Deshanur¹, Amarnath M. S.¹

¹ UVCE, Bangalore University, Bangalore, India
* Email: manjuc007@gmail.com

**Abstract**

Road construction on soils with poor engineering properties necessitates adoption of Stabilization techniques. Bioenzymes are found to improve the soil properties and thus performance of roads. Effect of bio-enzymes on soils depends on type, dosage of bio-enzyme, its curing period and amount of fines. To evaluate the effect of bio-enzyme, two soils were treated with varying dosages of Terrazyme, a commercial Bio-enzyme and the effect of Terrazyme dosage on plasticity characteristics and unconfined compressive strength of soils were evaluated. It was found that with increase in Bio-enzyme dosage, the plasticity index of the soils decreases up to certain
limit and then the reduction was not substantial. Studies further revealed that the increase in Unconfined Compressive strength is dependent on fines content.

**Keywords:** Stabilization, Bio-enzyme, Terrazyme, Plasticity index, Unconfined Compressive Strength

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**STUDY ON RECOVERY BEHAVIOR OF CRUMB RUBBER MODIFIED ASPHALT BINDERS**

Veena Venudharan\(^1\)*, Krishna Prapoorna Biligiri\(^1\)

\(^1\) Indian Institute of Technology Kharagpur, West Bengal, India

* Email: veenavenudharan@iitkgp.ac.in

**Abstract**

The objective of the paper was to investigate recovery behavior of CRM binders at various stress levels to understand the recovery performance under linear and non-linear viscoelastic regimes. The scope of the study included six CRM binders. The recovery performance was evaluated by conducting multiple stress creep and recovery test. The recovery data was modeled using Weibull function to understand the change in various viscoelastic components of recovery at linear and non-linear viscoelastic regions. The study is envisioned to provide an essential understanding towards the variations in the elastic behavior of CRM binders in linear and non-linear viscoelastic regions.

**Keywords:** Crumb rubber, Asphalt binder, Creep and recovery, Rheological modeling, Non-linear viscoelasticity

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**INVESTIGATION OF FRACTURE CHARACTERISTICS OF ASPHALT MIXTURES WITH VARYING MATERIALS PROPERTIES: SEMI-CIRCULAR BENDING TEST**

Gourab Saha\(^1\)*, Krishna Prapoorna Biligiri\(^1\)

\(^1\) Indian Institute of Technology Kharagpur, West Bengal, India

* Email: gourabsaha@iitkgp.ac.in

**Abstract**

The study evaluated the fracture performance of six polymer modified gap-graded asphalt mixes, and investigated the associated fracture mechanism using Semi-Circular Bending (SCB) test. A total of 76 SCB specimens were tested, and a mix-level factorial design was performed at 95% confidence interval to evaluate the fracture characteristics. Statistical analyses revealed that fracture toughness (\(K_{IC}\)) reduced with increasing air voids and temperature. Though \(K_{IC}\) reduced initially with increasing asphalt content, it remained insensitive with further asphalt binder addition. Overall, the study analyzed the fracture characteristics of gap-graded asphalt mixtures based on fundamental material properties and macroscopic fracture pattern.

**Keywords:** Asphalt mixture, gap gradation, fracture properties, fracture toughness, statistical analysis
WILLINGNESS TO USE NON-MOTORIZED VEHICLES FOR TRIPS IN URBAN AREAS

Anshu Bamney*, Rajat Rastogi1
1 Indian Institute of Technology Roorkee, India
* Email: anshubamne19@gmail.com

Abstract
This paper examines the potential of using non-motorized vehicles (NMVs, walk and bicycle), as a sustainable mode of transport in Bhopal city (tier 2 city), India. Revealed Preference (RP) and Stated Preference (SP) data was collected using a paper questionnaire. Promotional policies for NMVs and restrictive policies for motorized vehicle use were presented to the respondents. The share of NMVS for work and education trips was found to be 19% and 8%, respectively. Around, 17-18% of work and educational trip makers were found willing to shift to NMVs. Logistic regression models were developed, to estimate the probability of willingness to use NMVs. The models showed an accuracy of more than 85 % in the prediction of willingness level. The willingness to use NMVs was found increasing with an increase in bicycle ownership and decrease in trip length, educational level, age and socio-economic level of the commuter. The study made it possible to understand the infrastructural and policy needs to improve the share of NMVs, as well as, attributes affecting their use.

Keywords: Non-motorized vehicles (NMVs), willingness, logistic regression, India

CHARACTERIZATION OF FUNDAMENTAL PROPERTIES OF PERVERSIOUS CONCRETE PAVING MIXTURES

Anush K. Chandrappa*, Krishna Prapoorna Biligiri1
1 Institute of Technology Kharagpur, West Bengal, India
* Email: anushkcindian@gmail.com

Abstract
Pervious concrete is a sustainable pavement material, which is gaining importance for its low impact development abilities. In this study, the relations between mixture variables and fundamental properties of pervious concrete paving materials were investigated that led to the development of predictive models for unconfined compressive strength (UCS) and permeability parameters. Further, the potential characteristics of pervious concrete materials to function as filter beds and future replacement for sand filters were investigated. The UCS and permeability magnitudes were in the range of 5-25 MPa and 0.07-3.5 cm/s, respectively. The predictive models were developed based on the robust criteria and were found to be highly accurate with low bias.

Keywords: Pervious concrete, Pavements, Unconfined compressive strength, Permeability, Filter beds
TANGIBLE SERVICE LEVEL ASSESSMENT OF URBAN STREETS USING POINT SYSTEM TO SUPPORT IMPROVEMENT ISSUES FOR PRIVATE MODE OF TRANSPORT

Suprava Jena¹*, Sambit Kumar Beura¹, Prasanta Kumar Bhuyan¹
¹ National Institute of Technology Rourkela, India
* Email: suprava728@gmail.com

Abstract
This study proposes automobile users’ response pattern to assess service quality provided by transportation infrastructure under mixed traffic flow condition. To determine the tangible Level of service (LOS) scores for urban streets, this study has explicitly considered some point indicators (PI) which reflect the automobile driver’s requirement on various road facilities. Specific weight coefficients (Ci) were determined for each PI based on their degree of importance on the comfort level of drivers. Lastly, the %LOS score was calculated for street segments and classified into six different LOS categories (A-F) with the help of GA Fuzzy clustering technique.

Keywords: Point indicators, Level of service, Automobile drivers, GA Fuzzy clustering technique

ANALYSIS AND MODELING OF LATERAL PLACEMENT AND MOVEMENT OF VEHICLES ON URBAN UNDIVIDED ROADS IN MIXED TRAFFIC

Punith B. Kotagi¹, Pooja Raj¹, Gowri Asaithambi¹*
¹ National Institute of Technology Karnataka, Mangalore, India
* Email: gowri@nitk.ac.in

Abstract
In India, majority of urban roads are undivided where the behavior of flows in a particular direction is predominantly influenced by the opposing traffic. Due to lack of lane segregation, the vehicles in ongoing direction occupy the opposing lane which increases the lateral interactions between vehicles. These lateral interactions are influenced by various parameters such as vehicle types, driver behavior and vehicular speeds. Study of such interactions through analytical methods is again a complex process. Simulation models play a significant role to evaluate such complex traffic situations, where it is necessary to study the lateral characteristics of vehicles such as, placement, separation and movement. Present study mainly focuses on the analysis of lateral characteristics of vehicles on two-lane urban undivided roads. Traffic data was collected from an urban undivided mid-block section in Bangalore city, India using video graphic technique. Multiple linear regression model was developed for predicting the lateral placement of subject vehicle and it was found that lateral placement of subject vehicle is influenced by types and speeds of subject and opposing vehicles. Lateral separation for different types of ongoing (subject)-opposite pairs were also obtained. The results of pairwise analysis shows that both the ongoing and opposing vehicles have less freedom to move laterally when the size of either vehicle increases and hence, lateral separation decreases. The lateral shifts of vehicles on urban undivided roads were modeled using multinomial logistic regression. Lateral shift of a vehicle is influenced by speeds of subject vehicle and leader in current path, speed of leader in target path, and lateral gap between leaders in current path and target path. Further research can be carried out considering other types of lateral movements such as passing and overtaking behavior of vehicles.

Keywords: Lateral Placement, Lateral Separation, Lateral Shift, Lateral Movement, Urban Undivided Roads, Mixed Traffic
ANALYSIS AND MODELLING OF PEDESTRIAN ROAD CROSSING PATTERN ON URBAN UNDIVIDED ROADS IN MIXED TRAFFIC

Manu O. Kuttan¹, Surjith Babu¹, Gowri Asaithambi¹*
¹ National Institute of Technology Karnataka, Mangalore, India
* Email: gowri@nitk.ac.in

Abstract
In India, traffic is mixed in nature with insufficient or absence of proper pedestrian facilities, insufficient carriageway width, absence of lane discipline, illegal on-street parking and high frequency of intersections. Among all these frictions, pedestrians constitute a major role. Due to improper road geometry and insufficient designated crossing points on road, pedestrians are sometimes forced to cross the road and they create confusion and risk to themselves, as well as to the drivers. This jaywalking behavior of pedestrians leads to severe conflicts and accidents. There are no proper improvement measures implemented for the safe movement of pedestrians and hence, there is a special need to study the road crossing behavior of pedestrians to ensure their safety on roads. This paper aims to study the different crossing patterns at an undesignated mid-block cross walk at two urban undivided stretches located in India. For this purpose, traffic video data were collected on two road stretches in Kerala, India. A total of 1100 pedestrian data were collected through video graphic survey and the various crossing patterns followed by pedestrians observed in the study locations are one-stage perpendicular, one-stage oblique, one-stage mixed, two-stage perpendicular, two-stage oblique and two-stage mixed. Parameters like pedestrian demographic characteristics and vehicular characteristics were also extracted from the video. A multinomial logistic regression model was developed to model the choice of crossing pattern of pedestrians. The variables like waiting time at the curb, pedestrian crossing speed, gap size and group size has significant effect on the pedestrian crossing pattern. This model can be implemented in pedestrian simulation model to incorporate the behavioral aspects of pedestrians. The study findings will be useful for the traffic planners and designers to understand the influence of pedestrian road crossing on traffic flow characteristics. The study will also be helpful to improve the existing pedestrian facilities and also, to provide pedestrian safety measures.

LABORATORY STUDY ON USE OF RAP MATERIAL IN WMA PAVEMENTS USING REJUVENATOR

Mohammad Adnan Farooq¹*, Mohammad Shafi Mir¹, Ankit Sharma¹
¹ National Institute of Technology Srinagar, J&K, India
* Email: adnannit@yahoo.com

Abstract
The use of Rejuvenator has shown improved workability of Recycled Asphalt Pavement material (RAP) Incorporated Hot Mix Asphalt (HMA) mixes by rejuvenating the stiff binder of RAP. In this study effect of varying proportions (Viz. 10%, 15% & 20%) of Used-Mobile Engine Oil (Rejuvenator), used in conjunction with 0.5% Evotherm (WMA additive) was studied with different proportions of RAP. The study determines Optimum dosage of Rejuvenator for 20%, 40% and 60% RAP material used to prepare Warm Mix Asphalt (WMA) mixes. Without Rejuvenator, only upto 20% RAP can be used to prepare RAP- WMA mixes. With 20%, 40%
and 60% RAP material at their respective optimum dosage of Rejuvenator, all the properties of RAP-WMA mixes were within specified limits (MORTH) as required for Dense Bituminous Macadam.

**Keywords:** Recycled Asphalt Pavement Material, Warm Mix Asphalt, RAP, WMA, Used mobile engine oil, Rejuvenator, Evotherm

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**LABORATORY PERFORMANCE EVALUATION OF WARM MIX ASPHALT ADDITIVES FOR COLD REGIONS**

Ankit Sharma*, Mohammad Shafi Mir†, Mohammad Adnan Farooq†

† National Institute of Technology Srinagar, J&K, India

* Email: sharmaankit.sharma65@gmail.com

**Abstract**

Warm Mix Asphalt (WMA) is a new energy-saving and environmental-friendly technology with a broad prospect for application in highway construction. When compared with Hot Mix Asphalt (HMA), WMA reduces the mixing and compaction temperatures (by 30°C), energy consumption and emissions of harmful gases, while maintaining the workability of HMA. In this study three different additives viz. "Sasobit" (Organic Wax Additive), "Evotherm" (Emulsion Based Chemical Additive) and Zycotherm (Antistripping Chemical Additive) are being evaluated for their performance in cold weathering conditions. To study the cold weathering performance, laboratory specimens of all tests were subjected to Freeze-Thaw cycles (2, 4, 6 and 8 in numbers) and testing was done after alternative Freeze-Thaw cycles. A comparative study was performed to analyse the trend of variation in strength and properties of WMA after different freeze-thaw cycles for different WMA additives. Tests and properties for the evaluation of performance were Marshall Stability (M.S.), Indirect Tensile Strength (ITS), Tensile Strength Ratio (TSR), Percent Aggregate Coating, Compactibility and Marshall Quotient (M.Q.).

**Keywords:** Warm Mix Asphalt, Sasobit, Evotherm, Zycotherm, Freeze-Thaw cycles, Moisture Susceptibility, Weathering

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**MODELING OF INDIVIDUAL VEHICLE SPEED ON URBAN ARTERIALS USING ARTIFICIAL NEURAL NETWORK**

Subhadip Biswas*, Shivendra Maurya†, Indrajit Ghosh†, Satish Chandra‡

† Indian Institute of Technology Roorkee, Uttarakhand, India

‡ CSIR-Central Road Research Institute, Delhi, India

* Email: subhadipbiswas.in@gmail.com

**Abstract**

Developing speed model is a challenging task particularly under mixed traffic condition where the traffic composition plays a significant role in determining vehicular speed. The present research has been conducted to model individual vehicular speed in the context of mixed traffic on an urban arterial. Based on the field data, speed prediction model for individual vehicle category has been developed adopting the methodology of Artificial Neural Network. Validation results show a great deal of agreement between the predicted and the observed speeds. The proposed models have been utilized to evaluate the effects of traffic volume and its composition on speed.

**Keywords:** Speed model, Artificial Neural Network, Urban arterial, Mixed traffic
ANALYZING THE DEMAND FOR PUBLIC TRANSPORT THROUGH BEHAVIORAL MODE CHOICE MODELS FOR WORK TRIPS IN TIRUCHIRAPPALLI CITY

Sumetha R.1*, Samson Mathew2
1 SSN College of Engineering, Chennai, India
2 National Institute of Technology Tiruchirappalli, India
* Email: sumetha.pdy@gmail.com

Abstract
An efficient public transport system is essential for meeting the mobility needs of the population and in ensuring access to basic services like education and health. Several factors affect the demand for public transport service. In addition to characteristics of the journey, the traveller and the transport network; commuters’ perception of the transport service also affects the demand for public transport. In this study, the various factors affecting the demand for public transport are identified and analyzed including an analysis of user perceptions of the public transport system like attribute rating and perceived satisfaction of public transport service in addition to the demographic, socio-economic and trip characteristics. The demand for public transport for work trips in Tiruchirappalli city is modeled using a disaggregate behavioral model approach based on logit formulation. From the binomial logit model and the multinomial logit model, the direct and cross elasticities for the various factors affecting the demand for public transport are determined. These elasticity values help in improving the understanding of the behaviour of public transport users and the factors influencing their migration to private modes of transport especially for work commutes.

Keywords: Behavioral modeling; Public transport; Mode choice analysis; Demand analysis; Logit model

MICROSCOPIC ANALYSIS OF LATERAL AND LONGITUDINAL GAPS IN MIXED TRAFFIC CONDITIONS WITH WEAK LANE DISCIPLINE

Krishna Murthy Gurumurthy1, Vikrant Singh1, Gowri Asaithambi1*
1 National Institute of Technology Karnataka, Mangalore, India
* Email: gowri_iitm@yahoo.co.in

Abstract
Traffic conditions in developing countries such as India, is of a mixed nature, characterized by weak lane discipline or the lack of it, as compared to developed countries which have traffic of a homogenous nature with strict lane discipline. A wide range of vehicle types can be seen in mixed traffic of which, a large proportion comprises of two wheelers and three wheelers. These vehicle types have smaller vehicular widths and higher lateral maneuverability, making traffic under these conditions very unpredictable. Macroscopic estimates like flow, density and average speed can be used to simulate these conditions to an acceptable degree, but a microscopic analysis is necessary to predict vehicle behavior accurately. This study uses rich mixed traffic trajectory data to determine the effect of type, speed, lateral position and flow of a vehicle in a stream on the lateral and longitudinal gap maintaining behavior. It is a step towards the development of comprehensive simulation software which can accurately describe the motion of vehicles under mixed traffic conditions. It was found that the lateral and longitudinal gaps were found to maintain a broadly distinctive distribution when grouped under pairs of interacting
vehicle types. It was also found that individual vehicle types did not behave similarly with changing macroscopic and microscopic characteristics.

**Keywords:** Lateral gaps; Longitudinal gaps; Mixed traffic trajectory; Weak lane discipline; Microscopic analysis

**STUDY ON TRAVEL TIME RELIABILITY PARAMETERS IN SRINAGAR CITY**

Vivek Kumar, Mohammad Shafi Mir, Ashok Kumar Singh

1 National Institute of Technology Srinagar, J&K, India

* Email: vivekkumar.140792@gmail.com

**Abstract**

Study focused on arterial roads of Srinagar with four road sections taken into account for calculation of travel time reliability parameter using vehicle License plate matching method. FHWA travel time reliability parameters and statistical parameter such as standard deviation and variance will be determined. Planning time index for section 1-2, known as NIT to Gurudwara section, is comparatively less than the other sections and it ranges from 1.66 to 2.91 during morning peak hours. Where maximum PTI occurred for section 2-3, known as Gurudwaa to Shiraz chowk section is 3.27. Standard deviation for section 3-4 known as Shiraz Chowk to Dal Gate is less and it range from 12 to 17. This study gives the reliability parameter for working days only.

**Keywords:** Federal Highway Authority, Planning time index, Reliability parameter, Buffer time index, Travel time index

**DEVELOPING A PUBLIC TRANSPORT ACCESSIBILITY MODEL (PTAM) TO ASSESS WORKPLACE ACCESSIBILITY IN KOLHAPUR CITY, MAHARASHTRA, INDIA**

Sangram K. Nirmale, Vidya V. Ghuge

1 National Institute of Technology Nagpur, India

* Email: sangramknirmale@gmail.com

**Abstract**

The goal of public transport is to ease the accessibility of localities, where passengers are able to perform certain activities. Amongst all activity, work trips are certainly unavoidable and routine ones. The lack of level of accessibility is the root cause for the transport related problems. The present study attempts to assess the level of accessibility within Kolhapur city. Focusing on the working population origin-destination survey is conducted and accessibility indices are calculated. Public Transport Accessibility Model (PTAM) is formulated to evaluate level of accessibility by public transport. PTAM values can help policy makers for public transport improvement.

**Keywords:** Public transport, workplace accessibility, Relative Accessibility Index (RAI), Public transport Accessibility Model (PTAM)
WATER HARVESTING USING NOISE ABSORBING POROUS PAVEMENT

Siksha Swaroopa Kar¹*, Ravinder Solanki¹, P. K. Jain¹
¹CSIR-Central Road Research Institute, New Delhi
*Email: sikshaswaroopa@gmail.com

Abstract
Water is a scarce resource in developing country and the conservation and re-use of storm water runoff is often important to supplement the need. The quality of the runoff is also important to ensure that it can be reused, or discharged to a location where it will not have negative impacts. Pavements are ubiquitous in our environment and consequently they have become an intrinsic and seldom thought-about part of life. However, for developers and local authorities who have to address storm water flooding and water quality issues, they are very much at the forefront of the planning process. This is because impervious surfaces such as pavements have such a major impact on water quality and on the health of natural ecosystems. In response to these issue permeable and porous pavements have been developed to reduce the environmental footprint of new growth. Porous and permeable pavements are becoming more prevalent as a storm water management tool.

Impervious surfaces of roadways, roof tops and parking lots resulting storm water runoff and deliver dirt and debris directly into the stream. In turn, the existing impervious surfaces caused ponding water which translates few hours of heavy rain into flash floods. Since the 19th century, most cities of the developed country rely on traditional pipe and open drain network system to mitigate storm water runoff. The captured storm water runoff afterwards distributed to nearby water course and sewer system.

Porous asphalt is an innovative road surfacing technology which allows water to percolate into the pavement. The inter-connected voids inside the porous asphalt allowed water to infiltrate through the pavement. Researcher described porous parking lot system as a system that consists of porous asphalt over an aggregate base, function as reservoir structure for temporary storm water detention which infiltrate into the existing ground. porous asphalt parking lot system proved that the pavement certainly provides green solution to manage storm water runoff. In the present study, porous asphalt mixes have been evaluated in terms of air voids, permeability, abrasion loss and indirect tensile strength. Different gradations were considered to evaluate the optimum gradation having the best permeability and strength. This paper highlights the determination of the design for porous asphalt slab having high permeability, high skid resistance and high noise resistance along with desirable strength for harvesting of water in residential areas in developing country.

A COMPARATIVE STUDY ON PFC MIXES

Satish Chandra¹, Rajiv Kumar²*
¹ CSIR-Central Road Research Institute, New Delhi, India
² Indian Institute of Technology Roorkee, India
* Email: ranjitrajiv@gmail.com

Abstract
The present study summarizes the results of laboratory investigation on the effect of different aggregate gradation on the performance of Porous Friction Course (PFC) mixes. Three different aggregate gradations prevalent in India, Germany and US were investigated with polymer modified bitumen as a binder. Optimum binder content was decided based on stone to stone contact...
condition, air voids and drain down criteria, and it was found to be 5.7% of the total mixture. The performance was evaluated in terms of moisture susceptibility, rutting, permeability and stiffness of PFC mixes. Findings of this study provide a better understanding of the effect of aggregate gradation on the performance of PFC mixes.

**Keywords:** Porous Friction Course, Stone Mastic Asphalt, Drain down, Polymer Modified Bitumen, Cellulose fibers

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**STUDY OF VEHICLE DAMAGE FACTOR FOR URBAN ROADS IN INDIA**

Ashok Kumar Singh¹, Mohammad Shafi Mir¹*, Vivek Kumar¹

¹ National Institute of Technology Srinagar, J&K, India

* Email: shafi@nitsri.net

**Abstract**

India is one of the fastest growing nations in the world. India’s economy has grown manifold in the recent past and is likely to grow further as per the present trends¹. The Government of India has specified the legal limit of axle load. Many trucks violate these load limits to reduce unit transportation cost. The damage by overloaded vehicles to pavements is exponential. Overloading vehicles reduce the design pavement life. The analysis of the traffic characteristic and loading was conducted on the basis of the traffic counts survey and axle load survey data. The data includes measurements from 14 stations of urban roads in Srinagar. The objectives of the study are to determine the vehicle damage factor (VDF) for urban roads using data of various locations and statistical grouping of VDF based on traffic volume and class of urban road. The study explains the variation of traffic volume on different road sections and the variation in the percentage of commercial vehicles. It is estimated that 6% commercial vehicles are moving over these roads. The equivalent standard axle load (ESAL) of each vehicle is determined by using the fourth power law. The study found that the loads in urban areas experienced up to ten times more damaging effect because of the heavy axle loads moving over these roads as compared to what would have been caused by standard axle loads. Computed VDF values are 2.2, 1.5 and 1.0 for arterial road, sub-arterial road and collector streets respectively. From the results, it can be concluded that overloaded vehicles on the road are very influential to the reduction in pavement service life.

**Keywords:** Vehicle Damage Factor, Urban Road, Equivalent Standard Axle Load, Commercial Vehicles, Portable Weigh Pad, Equivalency Vehicle Factor

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**LABORATORY EVALUATION OF MODIFIED BITUMINOUS MIX USING LOW DENSITY POLYTHENE**

Imran Ahmed¹*, Mohammad Shafi Mir¹, Ankush Sharma¹

¹ National Institute of Technology Srinagar, J&K, India

* Email: kietimran@gmail.com

**Abstract**

One of the most important reasons of the pre-mature road damage in cold regions is the ill effects of weathering. In this study, an attempt has been made to use reclaimed polyethylene which has been obtained from plastic packets used in packaging of milk in Jammu & Kashmir. The study has been conducted by evaluating the influence on engineering properties of Dense Bituminous macadam (DBM) modified by using LDPE in the mix. The effect of weathering action is also studied
by applying appropriate freeze-thaw cycles (0,2,4,6,8) on polythene -impregnated bituminous mixes. The OBCs have been found to be 4.66%. Addition of Waste Polyethylene to mixes improves several engineering properties like Marshall Stability, Retained Marshall Stability, Unconfined Compressive Strength value and indirect tensile strength etc.

**Keywords:** Low Density polythene (LDPE), Freeze-thaw cycles (FTC), Moisture susceptibility, weathering

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**CAPACITY ANALYSIS OF ESCALATORS: A CASE STUDY OF VIJAYAWADA RAILWAY STATION**

Eswar Sala1*, K. V. R. Ravishankar1
1 National Institute of Technology Warangal, Telangana, India.
* Email: eswar.sala@gmail.com

**Abstract**

Passageways, stairs and escalators acts as means to disperse passengers to various platforms. Efficient dispersal by these means depends on various factors like pedestrian age, gender, luggage and platoon size. Proper location of these facilities plays a major role. Compared to stairways, escalators are potential, easy and fast way to transport passengers. However, practical capacity of escalators is of a question. In this paper an attempt is made to study the practical handling capacity of escalators in a railway station. Flow characteristics of escalators are analyzed and practical observed capacity is estimated and is compared to theoretical capacity.

**Keywords:** Railway station, Pedestrian, Escalator, Capacity

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**EVALUATION OF BUS ROUTE: USING MULTIPLE CRITERIA DECISION – MAKING METHOD BY AHP (ANALYTICAL HIERARCHY PROCESS) – “A CASE STUDY OF VADODARA CITY”**

Monicaba M. Vala1*, Jay K. Kalaria2
1 GTU, Chandkheda, Ahmedabad, India
2 Marwadi Education Foundation, Rajkot, India
* Email: Monica.vala@yahoo.com

**Abstract**

Transport affects the economic and social life of everyone. Public Transportation is the backbone of the development of urban areas. Bus is a very crucial and critical component of the mass transportation system in a country. Buses carry majority of the public transport passengers in Indian cities. Better public bus services in our towns and cities contribute towards the regeneration of both the business community and our living areas. An efficient, reliable bus service can be an attractive alternative to those who have access to a car.

But, now a day’s Bus services in particular have deteriorated, and their relative output has been further reduced as passengers have turned to personalized modes and intermediate public transport. Improved public transports services are necessary to ameliorate these problems. The public agencies operating public transport systems often fail to restructure service types to meet with the changing demand pattern. As a result public transport becomes financially less viable, speeds reduce, and congestion levels increase and the transportation becomes a source of environmental problem.
Bus routes evaluation is one of the important aspects of transit planning system. It provides valuable information based on which important operating decisions can be taken. The evaluation identifies the operating conditions and existing problems so as to provide an objective basis for requisite decision for regulating routes, such as withdrawing a route, or combining routes or establishing new routes, and improving service and efficiency of routes. One of the important aspects that affect the performance of the bus transportation is the performance of the routes.

This paper presents the development of bus route evaluation system, for a public bus transportation system in Vadodara city of Gujarat. It is necessary to regulate existing bus routes and reallocate transit resources for sustainable operation. At present there is no system for bus route evaluation for Vadodara city. This paper discusses the development of a comprehensive bus route evaluation system using various performance indicators. Hence it is proposed to develop a model to evaluate the performance of routes. The performance of route depends on several criteria. Some of these criteria are quantitative (on time performance, bus stop spacing, fuel consumption, etc.) in nature and some are qualitative (road condition, safety, comfort). So, it is proposed to use a Multi Criteria Decision Making (MCDM) tool to evaluate the routes. The MCDM tool which can deal with both qualitative and quantitative factors is Analytical Hierarchy Process (AHP), which integrates quantitative and qualitative attributes of the routes.

**Keywords:** Analytic Hierarchy Process, Route Evaluation, Performance Indicator

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**DETERMINATION OF DYNAMIC PCUS OF DIFFERENT TYPES OF PASSENGER VEHICLES ON URBAN ROAD: A CASE STUDY OF RAJKOT CITY**

Bindiya N. Patel¹, Mayursinh B. Jadeja¹, Monica M. Vala²*

¹ Marwadi Education Foundation, Rajkot, India

²* Email: monicaba.vala@marwadieducation.edu.in

**Abstract**

This paper presents a concept of ‘dynamic passenger car unit’ ('dynamic PCU'), appropriate for the heterogeneous traffic on Indian roads, and shows that the PCU factor for a vehicle type is not a static factor as is usually assumed. This PCU factor is the ratio of the projected rectangular area of the vehicle type, as a proportion of that of a car, to the velocity of the vehicle type, as a proportion of car velocity. Field data for present study were collected at three urban roads in Rajkot City. Midblock section of 30 m selected on four lane divided road with no gradient and curvature. The basic considerations in selection of a section were it should be free from the effect of intersection, bus stop, curvature, gradient and other side friction. Dynamic Passengers Car unit (DPCU) value obtained by Chandra’s method, Multiple linear Regression method, Homogenization coefficient approach based on comprehensive field traffic data (traffic volume and speed) collected by video camera technique on midblock section during morning peak hour (9 am to 12 pm) and evening peak hour (5 pm to 8 pm). DPCU value obtained by Chandra’s method for 2w, 3w, LCV, Bus, Truck and MAV are 0.23, 1.07, 2.42, 8.06, 4.75, 8.35. DPCU value obtained by homogenization coefficient method for 2w, 3w, lcv, bus, truck and MAV are 0.51, 1.11, 1.74, 4.47, 2.73 and 4.81. Also compare Dynamic Passengers Car unit (DPCU) value obtained by above methods, suggest reliable method and describe DPCU-composition relationship.

**Keywords:** Dynamic Passenger Car Unit, Heterogeneous Traffic, Traffic Volume, Urban Road
**TRAFFIC BEHAVIOUR AT TOLL PLAZA IN BENGALURU**

Sambhavi S.¹, Vivek R. Das¹*, P. Prakash¹

¹ Dayananda Sagar College of Engineering, Bangalore, India

* Email: vivekdurgadath@gmail.com

**Abstract**

The traffic in metropolitan cities, especially in India is very complex. In India, due to heterogeneous traffic conditions, road safety and congestion has become a major issue to both vehicle users and pedestrians followed by lots of delay to moving vehicles. A toll road is a public or private roadway for which a charge is assessed for passage. It is a form of road pricing typically implemented to help recoup the cost of road construction and maintenance, which amounts to a form of taxation. This research is intended to highlight the major problems faced at toll roads. At toll plaza’s the delay caused to vehicle users is of prime concern since this delay causes loss of productive time and fuel. Hence 3 typical toll plazas in Bengaluru on three major roads Tumkur – Bengaluru road (NHAI Toll Plaza), NICE road – Veerbhadra Nagar to Electronic city (NICE Toll Plaza) and BEHL toll plaza in electronic city were considered for the present study. Data was collected by manual observation of parameters. Traffic behaviour in these toll plazas was analyzed through traffic distribution survey, descriptive and parametric analysis on service time delay. Based on the study it was found that truck traffic consume more service time than other category of vehicles. Separate probability distribution function is recommended for service time delay of cars, buses and trucks. Finally a level of service criteria was developed for a toll plaza with service time delay.

**Keywords:** Traffic, Toll Plaza, Service time delay

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**ANALYSIS OF DRIVING PATTERN AND FUEL CONSUMPTION AT SIGNALISED INTERSECTION**

Ronak Bhudhrani¹, P. V. Pradeep Kumar²*, Niraj Sharma², Ch. Ravisekhar², Rajni Dhyani²

¹ Parul Institute of Engineering and Technology, Vadodara, India

² CSIR-Central Road Research Institute, New Delhi, India

* Email: pvpradeep1964@rediffmail.com

**Abstract**

Signalised intersections are critical points of any road network, where various operating modes such as acceleration, deceleration and idling are observed leading to increased rate of fuel consumption. In the present study, an attempt has been made to analyse various driving patterns and the corresponding fuel consumption rate for a typical vehicle. Field studies were undertaken on the test vehicle equipped with GPS based data acquisition system and online fuel flow detector. The study covered three signalised intersections in Delhi. The driving characteristics and the corresponding fuel consumption of the test vehicle in terms of deceleration, acceleration, approach speed on the upstream and downstream of the conflict area for straight movement were analysed for understanding the range of fuel consumption rate. It has been observed that the fuel consumption rate during acceleration at signalised intersection increases by 4.5 times to that of idling fuel consumption rate whereas the fuel consumption rate increases by 1.5 times to that of idling during deceleration.

**Keywords:** Driving pattern, Signalised intersection, Fuel consumption rate, Acceleration, Deceleration
EFFECT OF ROAD GEOMETRY AND ROUGHNESS ON FREE-FLOW SPEEDS AND ROADWAY CAPACITY FOR INDIAN MULTILANE INTERURBAN HIGHWAYS

Ashutosh Arun1*, S. Velmurugan1, S. Kannan1, Sandip Chakraborty2, Sudip K. Roy2
1 CSIR-Central Road Research Institute, New Delhi, India
2 Indian Institute of Engineering Science and Technology Shibpur, West Bengal, India
*Email: ashutosharun.87@gmail.com, ashutosharun.crri@nic.in

Abstract
The objective of this study is to estimate the effect of road geometrics and pavement roughness on free-flow speeds (FFS) and capacities of multilane interurban highway segments. Traffic data, geometric and pavement condition details were collected on 43 sections located on National Highways spread all across India. The segment capacity was determined using the Greenshields' speed-density relationship. Thereafter, a relationship was established between the FFS and base capacities of the highway segments. Finally, the effect of various adjustment factors was estimated through linear regression.

Keywords: Indo-HCM, multilane interurban highways, FFS, Base Capacity, Adjustment Factors

A STUDY ON THE SATURATION FLOW AND ITS INFLUENCING FACTORS FOR SIGNALIZED INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

Savitha B. G.1*, R. Satya Murthy2, H. S. Jagadeesh2, H. S. Sathish2, T. SundarRajan3
1 K S School of Engineering & Management, Bangalore, India
2 BMS Engineering College, Bangalore, India
3 Pondicherry Engineering College, Pondicherry, India
* Email: bg_savitha@yahoo.com

Abstract
The intersections on urban roads in India generally cater to heterogeneous motorised traffic, along with slow-moving traffic including pedestrians. It is therefore necessary to consider saturation flow for mixed traffic conditions to evaluate the overall operation of signalized intersections. A proper traffic model must consider the varying characteristics of all the road users to effectively design and efficiently manage the signalized intersections. This paper presents the results of the study on analyses of saturation flow rate conducted at signalized intersections with mixed traffic condition in the city of Bangalore, India. Studies were carried out at 30 signalized intersections at Bangalore with varying conditions. Saturation flow computed as per IRC SP-41 (1) was compared to the observed field saturation flow. Analysis of saturation flow by linear regression method for each intersection separately, had interesting findings of various factors on the saturation flow. The various influencing factors affecting the saturation flow were found to be width of the road, percentage of right and left turning movements, gradient, composition of the traffic and right turning radius. In this paper, 30 signalized junctions in Bangalore urban area, with varying traffic parameters were studied. Saturation flow rates were computed by IRC SP 41 method \( S = 525 \times W \), \( W \) is the width of the road in m, and a new saturation model has been proposed namely, \( S = S_0 \times f_{rt} \) PCU/hg, by taking base saturation flow value as \( S_0 = 515 \times W \), \( W \) is the width of road in m and \( f_{rt} = 1 + 0.17 \times P_{rt} \), \( P_{rt} \) is the percentage of right turning vehicles. By introduction of \( f_{rt} \) into the saturation flow model, there is a slight increase in the \( R^2 \) value compared to Saturation flow by IRC SP-41 method. This shows that by the introduction of the suggested influencing factors in this
paper with the base saturation flow can give better picture of the field conditions, especially under heterogeneous traffic conditions of an urban area.

Paper ID: 69

**STUDY ON THE COPING BEHAVIOUR UNDER STRESS CONDITION AS RELATED TO THE CRASH FREQUENCY AMONG INDIAN DRIVERS**

Neelima Chakrabarty¹*, Kamini Gupta¹, S.Velmurugan¹

¹ CSIR-Central Road Research Institute, New Delhi, India

* Email: neelima.chakrabarty@gmail.com

**Abstract**

Road Safety is a multi-sectoral and multidimensional issue. It incorporates the development and management of road infrastructure, provision of safer vehicles, legislation and law enforcement, mobility planning, provision of health and hospital services, child safety, urban land use planning etc. The situation in India is worsening and road traffic injuries (RTI) have been increasing over the past twenty years. According to official statistics 141,526 persons were killed and 477,731 injured in road traffic crashes in India in 2014 (NCRB, 2015). This may be partly due to the increase in number of vehicles on the road but mainly due to the absence of coordinated evidence-based policy to control the problem.

As a driver plays a vital role in road safety so, through this study attempts had been made to understand how a driver copes with a stress situation by their ability to react correctly to more stimuli as quickly and accurately as possible. In this study the driving simulator installed at CSIR-CRRI and Vienna Test System have been used. In this study driver stress has been defined as the set of responses associated with the perception and evaluation of driving as being demanding or dangerous relative to the individual’s driving capabilities.

**Objective:** The objective of the present study was to observe the relationship between the coping behaviour of drivers under stress situation and correlating with the number of crashes results performed on Driving Simulator.

**Methodology:** In this study 35 drivers as sample were administered for the Tolerance Test for Stress Conditions (the Vienna Test System). Simultaneously, the crash records of these drivers were also collected by administering driving test from the Driving Simulator installed at CSIR-CRRI. From the test results, number of correct, incorrect, omitted and delayed responses of the drivers were segregated and tabulated. Then the data pertaining to different categories of drivers as related to crashes were compared and analysed with their performance in the car driving simulator.

**Findings:** The findings of the data highlight that Greater the number of crashes lesser was the percentage of drivers who could cope with the stress. In other words, the numbers of crashes and the driver’s inability to cope with a situation have a direct relation. Higher the number of crashes made, higher was their inability to cope with a stress situation.

**Keywords:** Coping Behaviour, Road Crash, Correct Response, Car Driving Simulator, Road Safety, Crash Frequency, Stress Situation, National Road Safety Policy, Driver Behaviour, Determination Test
A STUDY ON FWD DEFLECTION BOWL PARAMETER TO ASSESS STRUCTURAL CONDITION OF FLEXIBLE PAVEMENT

Ujjval J. Solanki1, P.J. Gundaliya2, M.D. Barasara3
1 R.K. University, Rajkot. Gujarat. India
2 L.D. College of Engineering, Ahmedabad. Gujarat, India
3 Darshan Institute of Engg. and Technology, Rajkot. Gujarat, India
* Email: ujjvalsolanki@rediffmail.com

Abstract
The Falling weight deflectometer (FWD) is used for structural evaluation of flexible pavement layers. The magnitude of the load, duration and area of loading is so adjusted that it corresponds to the effect of loading due to standard axle on in-service pavement. The FWD study outcomes is deflections at radial distance about 0,300,600,900,1200,1500 and 1800. The objectives of the study are condition assessment of in service pavement using FWD deflections without backcalculation for modulus value of different layer. Varying age and different location within country the flexible pavement is evaluated using FWD. Based on deflections different deflection bowl parameters are calculated, three significant divisions for preliminary structural maintenance is classified as need overlay, need to observe and no need of overlay.

Keywords: Structural Evaluation, Back calculation, Falling Weight Deflectometer FWD

AUTOMATIC ALCOHOL DETECTION CIRCUIT BREAKER DEPLOYED IN THE IGNITION LINE TOWARDS SAFE DRIVING HABITS OF FOUR WHEELER CARS

Ashok G. Matani1*, Akhil Palliwar1, Rohit Nayab1, Pooja Bhonde1
1 Government College of Engineering, Amravati (M.S.) India
*Email: ashokgm333@rediffmail.com

Abstract
Driving while intoxicated or drunk is dangerous and drivers with high blood alcohol content (BAC) are at high risk of road accidents, highway injuries and vehicular deaths. According to the community against drunken driving (CADD), 70% of road accidents in India are due to drunken driving. Alcohol mixed with blood reduces the ability to produce and transmit electrical impulses from the brain to other parts of the body. India spends 3% of its GDP on dealing with road traffic & medical treatment. In spite of strict laws imposed on the general public the cases of drinking driving still remain at the brink. Hence there is an urgent need to reduce and stop drunken driving in our society. Detection of drunkenness is very important so as to impose a deterrent by way of fines and penalties and in extreme cases even suspend the driving licenses. Thus, we decided to design an 'Alcohol Sensing Device' which would not only intimate our relatives of the malice but also prevent the ignition of the vehicle in case the driver is drunk.

Keywords: Alcohol Sensor MQ3, Thermistors, Humidity Sensor, Temperature variation along tube, BAC levels
FACTORs AFFECTING THE RIDING QUALITY OF THE ROAD (A CASE STUDY OF URBAN ARTERIAL ROAD IN TUMKUR CITY)

Sumati Dongre1, K. M. Mallesh1*
1 Siddaganga Institute of Technology, Tumkur, Karnataka, India
*Email: malleshkm@rediffmail.com

Abstract
Pavement roughness is the presence of irregularities on the pavement surface that adversely affect the riding quality of the pavement. Poor riding quality depends upon the presence of pavement undulations which results in increase in discomfort and fatigue to road users, increase in fuel consumption and vehicle maintenance cost, reduction in vehicle operating speed and increase in accident rate. The evaluation of pavement using various indicators like roughness index (RI) have been commonly used to assign a maintenance strategy for the existing pavements.

The study area consists of urban arterial road section with a road length of 7.2Km. The methodology includes identification of pavement distress data collection, development of individual distress density and finally developing a combined PCI for the section. The performance indices viz. Pavement Condition Index, Pavement Roughness Index are developed individually. The proposed index is expected to be a good indicative of pavement condition and performance. The developed PCI was used to select the maintenance strategy for the pavement section (overlay design by Benkelman Beam Deflection method).

Cores are extracted for evaluating the material property and construction quality. The obtained results are used for modeling using multilinear regression analysis.

CALIBRATION OF PERFORMANCE OF ROUNDABOUNTS BASED ON GAP ACCEPTANCE PARAMETERS USING SIMULATION FOR INDIAN SCENARIO

Shweta Rao1*, Yadu Krishna2, Atmakuri Priyanka3, Prasanta Kumar Bhuyan4
1 VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
2 Kottayam Institute of Technology and Science, Kottayam, India
3 Indian Institute of Technology Chennai, India
4 National Institute of Technology Rourkela, India
* Email: shwetarao.272@gmail.com

Abstract
Indian traffic is characterized by wide range of variations and heterogeneous composition. This makes the driver behaviour a prominent feature for developing traffic models and simulations. In this study, detailed analysis is carried out to simulate a traffic model for roundabouts using the entry and the circulating flow values to calculate the gap acceptance parameters like critical gap and follow-up time. To measure the critical gap of entry of roundabouts incorporating distribution of headways, statistical techniques like equilibrium of probabilities and cumulative probability density function are used. The equilibrium of probabilities method was found to overcome few assumptions relating to homogeneity used by several methods. The simulation was carried out using VISSIM software taking the vehicle dimensions and flow values as input parameters. Deceleration and minimum headway were used
as calibrating parameters to simulate the model. The values of critical gap and follow-up headway showed less variation with those obtained using equilibrium of probabilities method.

**Keywords:** Gap Acceptance parameters, simulation, roundabouts, VISSIM

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**USE OF MULTINOMIAL LOGIT MODEL IN EVALUATION OF SERVICE LEVELS OF PEDESTRIAN FACILITIES**

Rima Sahani1*, Dudi Praveena1, P. K. Bhuyan1

1 National Institute of Technology Rourkela, India

* Email: luckyrima44@gmail.com

**Abstract**

Main aim of this study is to provide service measures for walking facilities such as sidewalk, signalized intersection and un-signalized intersection using pedestrian perception data sets. Based on factors which are mainly affecting the pedestrian’s satisfaction level like traffic, safety, comfort, maintenance and aesthetics proper questionnaire has been prepared for these three facilities. Multinomial logit modeling concept has been applied to estimate probability and category of satisfaction levels of different facilities. Analysis shows that 38.4% of total pedestrians were having problems while walking due to illegal on-street parking and vending encroachment as they covers maximum space of the sidewalks.

**Keywords:** Pedestrian Perception, Walking Facilities, Service levels

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**MODELLING ENTRY CAPACITY REDUCTION FACTOR OF ROUNDABOUTS UNDER THE INFLUENCE OF PEDESTRIANS IN DEVELOPING COUNTRIES**

Ashish Kumar Patnaik1, Rima Sahani1, Kalpana Sahoo1, Prasanta Kumar Bhuyan1*

1 National Institute of Technology Rourkela, India

* Email: pkbtrans@gmail.com

**Abstract**

Objective of this study is to develop an entry capacity reduction factor model of roundabout under the influence of circulating flow, pedestrian flow and diameter of Central Island. Multivariate regression analysis is carried out with R-Square value observed to be 0.946 and 0.965 in the development and validation of this model. Capacity reduction factor increased by (15%, 30% & 35%), (10%, 15% & 20%) and (25%, 35% & 45%) respectively with increase in circulating flow, pedestrian flow and diameter of Central Island by (50, 100 & 150) PCU/h, (50, 100 & 150) Ped/h and (10, 20 & 30) m respectively.

**Keywords:** Roundabout, Circulating Flow, Pedestrian Flow, Multivariate Regression, Entry Capacity Reduction Factor
ASSESSMENT OF APPROPRIATE METHODS OF CRITICAL GAP ESTIMATION FOR PEDESTRIANS UNDER HETEROGENEOUS TRAFFIC CONDITIONS

Udit Jain1*, Rajat Rastogi1
1 Indian Institute of Technology (IIT) Roorkee, Uttarakhand, India
* Email: udit.iitr@gmail.com

Abstract
This paper evaluates the different methods of critical gap estimation for pedestrians at uncontrolled mid-block crossings. Data were collected at two marked mid-block crossing locations in Delhi and Chandigarh. Eight most widely used methods of critical gap estimation have been considered in this study. The violations of accepted and rejected gaps with respect to the critical gap have been explored for the evaluation of different methods using “Violation Percentage” and “Violation Ratio”. The paper concludes that the critical gap by Raff’s method and difference minimization method is a logical and fair estimate of the critical gap, followed by maximum likelihood and probability equilibrium method.

Keywords: Pedestrian, Crossing, Critical Gap, Violation Ratio, Violation Percentage, Safety

A CRITICAL REVIEW OF REGRESSION MODELS FOR ANALYSING HIGHWAY CRASH DATA

Sujata Basu1, Pritam Saha1*
1 Indian Institute of Engineering Science and Technology Shibpur, India
* Email: saha.pritam@gmail.com

Abstract
Increasing road traffic over the years has resulted in simultaneous increase in road accidents particularly in most of the developing countries like India. Thus, road accident has become a major concern and analysing accident data has been an important look out to the analysts in order to discern the trends of road crashes. Accordingly, a number of statistical models have been developed over the past few decades for road crash prediction. This paper basically provides a detailed insight of those models and evaluates their compatibility and aptness in predicting crashes on roads if the prevailing traffic is heterogeneous in character.

Keywords: Heterogeneous traffic; road crashes; over-dispersion; regression models

UNDERSTANDING TRAVEL BEHAVIOUR OF EMPLOYEES OF AN INDUSTRIAL AREA-AURANGABAD CASE STUDY

Sumeet Jaiswal1*, Janvi Mohurle1, Prajakta Kulkarni1, Aishwarya Raje1, Diksha Karanjikar1, Shivani Dhotre1, Mrunali Ghumare1
1 MIT, Aurangabad, India
* Email: jaiswalsumeet@gmail.com

Abstract
In this piece of work we conducted a travel survey at Shendra MIDC to understand the travel behavior of people working in a MIDC and to model their mode choice. The travel data was collected by on-site survey. The travel questionnaire consisted of seven questions targeting information such
as age, place of residence, departure time from place of residence, arrival time at work place and monthly expenditure for their home to work journeys. The survey resulted in 753 responses, representing approximately 12% of total expected number employees in Shendra MIDC.

First spatial and exploratory analysis on the survey data was performed. The collected data shows that around 53% of employees live close to Aurangabad city whereas roughly 26% respondents were living in villages near to the study site. Remaining 21% of the respondents were travelling from far-distance villages. Analysis also found that people living in Aurangabad city are captive to either company bus or to their private 2-wheelers due to the lack of any public transport option.

Later, binary logit model was fitted to the data to model mode choice. The model indicated that the travel distance and travel cost are the two most influential factors deciding the mode choice. The key information from the study that local authority and MIDC authorities could use is that there is a strong desire among daily commuters – who faces daily commuting hardships - to have access to public transport system, and they are very much likely to shift to public transport if the service is reliable, cost effective, and speedy.

**Keywords:** Travel survey, MIDC, Logit model, Public Transportation

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**STUDIES ON THREE DIMENSIONAL PEDESTRIAN MOTION ON RAILWAY FOOT OVER BRIDGE**

Ujjal Chattaraj\(^{1,*}\), Manoj Kumar Biswal\(^1\), Jyoti Biraj DasMaurya\(^1\)

\(^1\) National Institute of Technology (NIT) Rourkela, India
\(^*\) Email: chattaraju@nitrkl.ac.in

**Abstract**

With the advancement of civilization and research skills over the years vehicular traffic has been given priority over pedestrian traffic. With the increase of population in cities, pedestrian traffic is increasing day by day. Pedestrian safety has become a matter of concern for the Traffic Engineers. Pedestrian comfort is primary importance for the Engineers who design different pedestrian facilities. Pedestrian comfort and safety can be measured for various facilities in terms of different level of service (LOS). In this study video data on pedestrian movement have been collected from different Railway foot over bridges (FOBS) in India. The level of service of those facilities has been analyzed. A cellular automata based model has been formulated to mimic the route choice behavior of the pedestrians on the foot over bridges.

**Keywords:** Foot over Bridges (FOBS), Level of Service (LOS), Cellular Automata Model
A COMPARATIVE STUDY ON EMPIRICAL AND RHEOLOGICAL PROPERTIES OF MODIFIED BITUMINOUS BINDERS

Kh. Lakshman Singh1*, Praveen Kumar2, H.C. Mehndiratta2
1 Nit Silchar, Assam, India
2 Indian Institute of Technology (IIT) Roorkee, Uttarakhand, India
* Email: lakshman_kh@yahoo.com

Abstract
The empirical tests such as penetration, softening point and ductility have been used for characterization of bitumen in India. The rheological characterization of bituminous binders based on the properties such as penetration, softening point, ductility and absolute viscosity are not satisfactory to characterize the bituminous binders. In the present study, dynamic shear rheometer was used for characterizing the bituminous binders which measures rheological properties directly. The rheological properties of modified binders were analyzed using Dynamic Shear Rheometer (SR5 Asphalt Rheometer) and testing was performed in temperatures from 46°C to 82°C in increments of 6°C at a frequency of 10 rad/s. A comparison has been made between empirical tests results and the rheological properties obtained from Dynamic Shear Rheometer like complex modulus (G*), phase angle (δ) and dynamic viscosity (η') were discussed in this paper. The results from the present study indicate that the rheological properties increase as the modifier concentration increases. It is observed that the complex modulus increases with decrease in penetration values but phase angle increases with increase in penetration values.

Keywords: Complex modulus, Empirical test, Rheological properties, Modified binder

DEVELOPMENT OF DETERIORATION MODEL FROM FUNCTIONAL CHARACTERISTICS AND EVALUATION OF STRUCTURAL PERFORMANCE ON SELECTED CORRIDOR OF HYDERABAD CITY – A CASE STUDY

A. Ramesh1*, M. Kumar2
1 VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana, India
2 University College of Engineering Osmania University, Hyderabad, Telangana, India
* Email: aramesh28@gmail.com

Abstract
Highways shall be maintained and evaluated periodically for improving the service life of pavement structure, predominantly in developing countries like India. In this context an attempt is made in evaluating pavement structure on urban express highway, Nehru Outer Ring Road in Hyderabad city. Functional evaluation is performed through roughness measurements and pavement condition survey. Structural evaluation is through Benkelman Beam Deflection studies. Pavement condition index (PCI) is used as numerical indicator for rating the expressway. PCI, age & roughness are used in developing roughness predication model. The results of deflection studies infer that an additional overlay of 45mm of BC shall be provided in fro direction, APPA junction To Gachibowli.

Keywords: Pavement Condition Index (PCI), International Roughness Index (IRI) and Pavement Deflection
CROWD BEHAVIOUR ANALYSIS THROUGH VIDEO SURVEILLANCE

P.Yugendar*1, K. V. R. Ravishankar1
1 National Institute of Technology, Warangal, Telangana, India
* Email: poojaryugendar1@gmail.com

Abstract
Developing countries are more vulnerable to stampedes during mass gathering events, with higher fatality rate than rest of the world. Crowd behaviour can depend on factors, such as individual behaviour and also the age, gender of the individual. This paper tries to estimate the crowd density using factors which include road width, vehicles presence in the crowd and parked vehicles and tracking of people by using tracker software. It was observed that, crowd size was high and average speed was found to be 0.81 m/s. it was observed that the density was high for category 3 compared to category 1.

Keywords: crowd, tracker, density, stampedes

FREIGHT TRANSPORT MODELING - ISSUES AND CHALLENGES: A CASE STUDY OF KANDLA PORT

Sandip C. Rathod*1, H. R. Varia2
1 R.K. University, Rajkot, Gujarat, India
2 Tatva Institute of Technological Studies, Modasa, Gujarat, India
* Email: scrathod@gmail.com

Abstract
Freight transport is the transport of goods for commercial entities. There has been a significant increase in commodity import and export from ports in last few decades. Freight transport sector is growing rapidly because of increase in production centres and reduction in transport cost. In addition, the growth of freight volume is accelerated due to increasing consumption of commodities, products and services. Research in freight transport is scarce and it is one of the young branches in transportation modeling particularly in India. For the developing countries like India it is very difficult to develop freight transport model because of non-availability of data or available data is not in desired form. So, it is challenging area for researchers in transportation modeling. In this regard, an attempt is made through this study to explore the feasibility of estimating the truck trip generation from the Kandla port. This paper contains category analysis of freight transport data collected from a freight corridor connecting to/fro port and trend equations are also set up. Data is collected through questionnaire survey. Seasonal data like, pre monsoon and post monsoon collected on weekends and intermediate day. Variables for data collection are divided into two categories viz. Based on characteristics of the mode and Based on characteristics of the goods. The purpose of this paper is also to focus on parameters which are essential for developing freight transport model and to find collective suggestions from researchers working in this area.

Key words: Freight transport, goods, commodities, trip generation
LABORATORY INVESTIGATION IN THE IMPROVEMENT OF SUBGRADE CHARACTERISTICS OF EXPANSIVE SOIL STABILIZED WITH NAILING TECHNIQUE

J. Ranjitha¹*, M.R. Rajasekhara¹
¹ Dayanand Sagar College of Engineering, VTU, Karnataka, India
* Email: ranjitha15@gmail.com

Abstract
Subgrade is the lower portion of the road which is constructed in close conformance with the lines, grades and cross-sections indicated on the plans, to receive the base and surface layers. The performance of the pavement structure depends on the strength and stability of the subgrade under adverse loading and climatic conditions. The pavement failure is attributed to the poor performance of subgrade and hence needs proper attention. The subgrade comprising of black cotton soil is highly unpredictable and the behaviour of this soil plays a vital role in design, construction and maintenance operations of the pavement. Improper treatment of this soil leads to failures in the pavement in the form of potholes, cracks, undulation, deformation, fissures or more.

The conventional methods of ground improvement technique have proven costlier. In the present study low cost ground improvement technique is proposed for stabilizing the black cotton soil subgrade. No fines concrete tapered nails in the form of geonails are driven into the subgrade soil. The diameter and height is varied to get geonails of three different dimensions. California Bearing ratio and the load settlement characteristics by miniature plate bearing test is analyzed. The number and spacing of the nails is varied to determine the effect of group efficiency on overall improvement in the strength of the subgrade.

Geonails with large diameter and large tapering angle driven in black cotton soil exhibit high modulus of subgrade reaction. Group efficiency of the nails increases the load carrying capacity of the subgrade.

No fines concrete can be effectively used to improve the stability of the weak subgrade than the conventional concrete and is more economical. The method can be adopted effectively for village roads carrying low traffic.

Keywords: Subgrade; No fines concrete; Geonail; CBR; Plate bearing test

CONGESTION INDICATORS: A MEASURE OF TRAFFIC CONGESTION FOR SIX LANE URBAN ARTERIALS OF KOLKATA

Rudraprasad Roychowdhury¹, Debashish Roy¹*, Sandip Chakraborty¹, Sudip Kumar Roy¹
¹ Indian Institute of Engineering Science and Technology, Shibpur, India
* Email: debashishroy87@gmail.com

Abstract
Road traffic congestion is the major hindrance for the urban mobility. Rapid growth of car ownership and limited road space have resulted poor mobility. Mitigation of urban traffic congestion have been major focus for the urban traffic planners. In this study three sections of six lane divided urban arterial of Kolkata has been selected for data collection. Travel time, classified traffic volume count
has been collected and analyzed. Variation of congestion indices with hourly traffic volumes have been developed for all three selected study sections. It has been observed that the buffer index shows a decreasing pattern with hourly volume for the selected study sections. The planning time index and congestion index shows an increasing trend hourly volume for all the study sections. Only travel time index shows varying results with hourly volume. For two study sections it is found that the trend of travel time index has been increasing with hourly volume. But in one study section it has been observed that this index decreases with an increase in hourly volume. Regression analysis are also developed to correlate between indices and hourly volume. Variation of indices with hourly volume has been observed that the congestion index has a good $R^2$ value for all the three study sections. Buffer index, planning time index does not give a proper $R^2$ value in one study section with hourly volume. Similarly, it has also been observed that travel time index shows a varying pattern for the three study sections with hourly volume. Models for congestion index with hourly volume have been developed. The analysis shows that Buffer Index can be used only as traffic stream reliability indicator while Congestion Index and Travel Time Index can be used to quantify traffic congestion effectively.

**Keywords:** Quantifying Congestion, Indices Measures, Traffic Volume, Travel Time, Regression Analysis

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**FTIR ANALYSIS OF SHORT TERM AGED PMB AND WMA Binders**

Bhupendra Singh*, Praveen Kumar¹, Kartikeya Shukla¹

¹ Indian Institute of Technology (IIT) Roorkee, Uttarakhand, India

* Email ID: bhupendrasingh.iitr@gmail.com

**Abstract**

Short term ageing occurs during the construction stage of the pavement. Short term ageing affects physical chemical and rheological properties of the binder. The present study aims at studying and comparing the ageing characteristics of conventional bitumen with that of the polymer modifies bitumen (PMB) and warm mix asphalt (WMA) by using Fourier Transform Infrared Spectroscopy (FT-IR). Based on the FTIR results ageing index (AI) of all the samples have been worked out. The comparison has been made between the results of different binders to study the effect of modifiers on the ageing characteristics of the binder.

**Keywords:** Fourier Transform Infrared Spectroscopy (FT-IR), polymer modifies bitumen (PMB), warm mix asphalt (WMA), Ageing index (AI)

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**AN INVESTIGATION OF LANE FLOW DISTRIBUTION ON MULTI-LANE HIGHWAYS UNDER MIXED TRAFFIC CONDITION**

Sudipa Chatterjee*, Debashish Roy¹, Sandip Chakraborty¹, Ashutosh Arun², Sudip Kumar Roy¹

¹ Indian Institute of Engineering Science and Technology, Shibpur, India

² CSIR-Central Road Research Institute, New Delhi, India

* Email: sudipachatterjee13@outlook.com

**Abstract**

In a traffic stream of multi-lane interurban highways, the lane choice behaviour of different vehicles contributes the lane flow distribution. In the present study the distribution of flow over lanes on multi
-lane highways under mixed traffic condition is analyzed. Firstly, the general choice of lane by a vehicle category is observed and secondly the influence of various traffic parameters like proportion of heavy vehicles, flow rate and average stream speed on lane flow distribution is evaluated. The lane flow distribution pattern of mixed traffic flow is unique and even vary for different road facility. Finally, analytical models of lane flow distribution for mixed traffic flow are developed under different traffic conditions. The models are statistically validated for other road sections with similar traffic condition.

Keywords: Lane flow distribution, Lane choice, Mixed traffic condition, Multi-lane highways, Regression model

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**SUSTAINABLE APPROACH FOR RIGID PAVEMENT USING RECYCLED CONCRETE AGGREGATES**

Reshma E.K.*, M. R. Rajashekar

1 Dayananda Sagar College of Engineering, Bangalore, India

* Email: reshuk.ek@gmail.com

**Abstract**

Recycling of Construction and Demolition waste as concrete aggregates is an important way to contribute to a sustainable material flow, thus sustainable pavements. A transformation of recycling waste materials into useful products for reapplication in pavements is recommended. In the present paper, laboratory trials were conducted to investigate the possibility of using recycled concrete aggregates as a replacement of both coarse and fine aggregates in rigid pavement slab. Present investigations used recycled aggregates from three different source and important strength tests are conducted on recycled aggregates collected from demolished pavement. The demolished concrete is then broken down using hammer and crushed and sized by screening operations that result in an aggregate product that meets the specified grading requirements. The mix was designed to have a 28 day target compressive strength of 25 MPa. Two sets of mixes were prepared. Initially a control mix is prepared using natural coarse and fine aggregates. The first set of Recycled aggregate concrete mix were derived by replacing only the natural coarse aggregates proportion in the control mix with RCA at 15, 25, and 35 % replacement levels. Second set of Mixes were prepared by replacing only the natural fine aggregates proportion in the control mix with RCA at 15, 25, and 35 % replacement levels. Saturated surface dried aggregates were used for all the mixes. 25% and 35% of recycled fine and coarse aggregates respectively can be replaced.

**Keywords:** Construction and Demolition waste, Rigid pavements, Recycled aggregate concrete
DEVELOPMENT OF LEVEL OF SERVICE CRITERIA FOR URBAN CORRIDORS BASED ON SPEED VARIATION CHARACTERISTICS

Drisya M.1*, Aswathy K. V., K. Krishnamurthy

1 National Institute of Technology Calicut, Kerala, India
* Email: drisya_p140075ce@nitc.ac.in

Abstract

This study incorporated the perception of road users in defining the level of service criteria for undivided urban corridors. For quantifying the quality of travel, the speed variation characteristics of individual vehicles were studied in detail by using in-vehicle GPS. Coefficient of variation of speed is found to be the most influencing parameter that governs automobile LOS. Considerable variation was observed in the criterion values estimated for different vehicle types under the automobile category comparing with HCM 2010. Hence this new methodology can be used as a basis to assess the automobile LOS from the individual drivers’ point of view.

Keywords: level of service (LOS), GPS, coefficient of variation of speed, and HCM 2010

LEVEL OF SERVICE FOR BICYCLE THROUGH MOVEMENT AT SIGNALIZED INTERSECTIONS UNDER HETEROGENEOUS TRAFFIC FLOW CONDITIONS

Sambit Kumar Beura*, N. Kiran Kumar, P. K. Bhuyan

1 NIT Rourkela, India
* Email: sambit.beura@gmail.com

Abstract

Service qualities offered to the bicycle through movement at signalized intersections under heterogeneous traffic conditions have been modeled using attributes collected from 35 intersection approaches. Perceived satisfactions of 160 users were assessed and seven major attributes contributing to bicycle services were identified. A highly reliable model ($R^2 = 0.86$) was developed using step-wise regression analysis. Sensitivity analysis carried out on modelled variables reported that, main-street traffic volume (38%), width of main-street (17.6%), pavement conditions (15.9%) and average stopped time delay (15.2%) are by far the most important variables. Affinity Propagation clustering was used to define ranges of service categories (A-F).

Keywords: Signalized Intersection; Heterogeneous Traffic Flow; Bicycle Level of Service; Perception Survey; Stepwise Regression; Sensitivity analysis; Affinity Propagation Clustering
DESIGNS OF CASCADED SIR BASED BAND PASS FILTER FOR INTELLIGENT TRANSPORT SYSTEM APPLICATION

Shivesh Tripathi†*, N. P. Pathak†, M. Parida†

† Indian Institute of Technology, Roorkee, Roorkee-247667, India
* Email: shiveshtripathi@gmail.com

Abstract

Design and implementation of a hexagonal slot cascaded SIR based band pass filter is presented in this paper. The proposed filter works in the frequency band dedicated to DSRC (Dedicated Short-Range Communication) i.e. 5.85-5.925GHz. In this filter, a cascaded SIR (Stepped Impedance Resonator) on the top and hexagonal slot on the bottom of the microstrip substrate are integrated. The elements together function as a fifth order band pass filter. In order to get the specified filter response with 2.54% 1-dB bandwidth (5.85-6 GHz) and 0.1-dB pass band ripple in this design, we selected linearly coupled SIR structure.

Keywords: Band Pass Filter (BPF), Dedicated Short-Range Communication (DSRC), Intelligent Transport Systems (ITS)

IDENTIFICATION AND ANALYSIS OF ACCIDENT BLACK SPOTS ON NH147 USING GIS

Harsh Naik†, Krina Patel†, Tazeen Pathan†*, Hemang Dalwadi†

† Nirma University, Ahmedabad, Gujarat, India
* Email: 13bcl082@nirmauni.ac.in

Abstract

The increase in motorization accompanied with expansion of road network has brought with it the challenge of addressing the adverse influence of road traffic accidents. Road accidents are a global cataclysm with ever raising trend which pose a public health and development challenge and greatly affect the human capital development of each nation. Recent studies by WHO (World health organization)\[1\] reveals that India has highest number of accidents. Accident Black Spots are location on the road with higher severity of accident either in terms of numbers or injuries. In this paper efforts have been made to identify the location of accident black spots on SarkhejGandhinagar Highway (NH 147). S.G.Highway is the connection link between the business hub of Gujarat, Ahmedabad and the capital city, Gandhinagar. It faces huge traffic demands on daily routine. To carry out Black Spot analysis, IRS P-6 LISS-III data has been used. Mapping and geospatial analysis is done in freely available Quantum GIS (QGIS) software. Primary and secondary data of January 2013 to August 2015 are collected for the study and analyzed. GIS, an ingenious solution to this obstacle in mobility, can manage all attributes geographically and provides a suitable environment for compendious analysis of traffic safety problems. It can synchronize spatial and non-spatial data and can be used for visual analysis, data interpretation and information query. The conclusive goal is to identify and analyze accident black spots using QGIS, compare it with the most vulnerable segments from the method of Prioritization. This paper also discusses some suggestive which can be implemented on that particular segment which has been identified as stretch with maximum accidents. This study will showcase how to carry out black spot identification for urban areas of developing countries using open source GIS software.

Keywords: Accident black spots, Prioritization, Comparison, Geographic information system (GIS)
IMPACT OF ELECTRONIC TOLL COLLECTION (ETC) ON EDUCING DELAY AT TOLL PLAZA

Anibrata Roy1*, Dipanjan Nag1, Arkopal Goswami1
1 Indian Institute of Technology Kharagpur, India
* Email: way2aniroy@gmail.com

Abstract
Electronic toll collection (ETC) can reduce delay through the toll area. Vehicular on-board electronic equipment interacts with fee collection infrastructure at the toll booths to automatically collect toll, thereby reducing the time vehicles otherwise would have spent waiting in queue and at the toll booth itself. However, many factors are involved to ensure that this reduction in delay is achieved. This paper investigates two such factors, (a) the usage and (b) service rate of ETC lane, i.e. the flow of vehicles and corresponding service rate of an ETC lane so as to reduce overall delay at a toll plaza.

Keywords: Toll operations, electronic toll collection, inter-arrival time, arrival rate, service rate, delay

RHEOLOGY OF DOUBLE COATED FULL DEPTH RECLAMATION MATERIALS

Apparao Gandi1*, Alan Carter1, Dharamveer Singh2, Sara Bressi3
1 Ecole de technologie superieure, Montreal, Canada
2 Indian Institute of Technology, Bombay, India
3 Università degli studi di palermo, Palermo, Italy
* E-mail: apparaog.iitg@gmail.com

Abstract
The present study was undertaken to evaluate the mechanical behaviour of four types of full depth reclamation (FDR) mixtures with different binders: emulsified asphalt, foamed asphalt, double coating combining two different emulsions, and double coating combining foam and emulsion. The complex modulus (E*) tests were performed on laboratory compacted FDR specimens at various temperatures and loading frequencies and analyzed with the help of 2S2P1D model. It was concluded that the use of both binders (double coating) can give a mixture higher modulus and better moisture resistance than mixes with only either one of the usual binder.

Keywords: Full Depth Reclamation, double coating, emulsified asphalt, foamed asphalt, and Complex modulus
IMPACT OF RAINFALL ON TRAVEL TIME AND CONGESTION, CASE STUDY GREATER MUMBAI

Arti Roshan Soni1*, Munish Kumar Chandel1
1 Indian Institute of Technology, Bombay, India
* Email: arti.soni14@gmail.com

Abstract
Climate change can severely affect the rainfall pattern of a city and thus impact transport related activities. Travel time is an important transport parameter that may significantly be affected by rainfall. We study the impact of rainfall of different intensities on travel time for three roads in Greater Mumbai. Test vehicle technique was adopted to determine the difference in travel time under different conditions. The result showed a difference in travel time (dry Vs rainfall) for all the routes in the range of 7-70%. The most affected road was Lal Bahadur Shastri Marg followed by Jogeshwari Vikhroli Link Road. Eastern expressway was the least affected from rainfall conditions. The findings of the results can help transport planners in taking future traffic related management decisions and prepare for the conditions arising due to climate change.

Keywords: Greater Mumbai, Travel time, Climate Change, Congestion

IMPACT OF MODE CHOICE IN ESTIMATING THE SOCIAL TRAVEL DEMAND OF SENIOR CITIZENS – A CASE STUDY OF TIRUCHIRAPPALLI CITY

G. Nantha Priya1*, G. Subbaiyan1, Samson Mathew1
1 National Institute of Technology, Tiruchirappalli, India
* Email: gnanthapriya@yahoo.com

Abstract
Mode is an important factor influencing the travel pattern of senior citizen. Their travel pattern is flexible since they have more leisure time. The seniors spend their leisure time for social activities. This paper analyses the mode preference of the seniors for various social activities. The study area is Tiruchirappalli City Corporation. Household questionnaire survey was carried out for data collection. The target population was the senior citizen whose age is 60 and above. SPSS software was used for preliminary data analysis and NLOGIT 5 was used for modelling mode choice of the senior citizen. Nested logit (NL) was used for building the model as it relaxes the IID (Independence of Identically Distributed) and IIA (Independence of Irrelevant Alternatives) property. This property diagnoses the unobserved error component of each alternative which has a role to play in determining a choice outcome. The result indicated that household size and their relationship with their members, gender, age, education, employment type, income, time of travel, travel cost and trip length were the variables influencing the social travel demand. The modes of travel considered for the analysis were auto, bus, two wheeler, cycle, car and walk.

Keywords: Mode choice, Nested Logit, senior citizen, social travel
TRAFFIC CONGESTION MODELLING UNDER MIXED TRAFFIC CONDITIONS THROUGH FUZZY LOGIC APPROACH: AN INDIAN CASE STUDY OF ARTERIAL ROAD

Aathira K Das1, Krishna Saw1, B K Katti1*
1 Sardar Vallabhbhai National Institute of Technology, Surat, India
* Email: bkkatti04@gmail.com

Abstract
Rapid urbanization trends observed in Indian metropolitan cities have resulted in significant growth in travel demands and traffic congestion thereby today. To understand the nature of congestion, and its control. A system for measuring the severity of traffic congestion is needed. The main objective of the present paper is to develop mixed traffic congestion model. Qualitative rating technique has been adopted in five graded linguistic variables. The technique is also adopted for noting down road side disturbances of roadside parking, pedestrian encroachment, land-use impacts and vendors’ areas. The uncertainty environment does prevail in situation perceptions. Therefore fuzzy rule based approach has been adopted in modelling.

Keywords: Traffic Congestion, uncertainty, Fuzzy Rule Base Approach

TRAFFIC DATA EXTRACTION USING MATLAB® BASED TOOL TECHNIQUE

Mohit Kumar Singh1, Harikrishna Gaddam1, Lakshmi Devi Vanumu1, K. Ramachandra Rao1*
1 Transportation Research and Injury Prevention Programme (TRIPP), IIT Delhi, New Delhi, India
* Email: rrkalaga@civil.iitd.ac.in

Abstract
Availability of traffic data is essential for effective design, operation and management of the transportation systems. Obtaining the data using traditional traffic data collection methods for heterogeneous traffic is cumbersome and inaccurate. In addition, difficulty is involved in using these methods for continuous monitoring and collection of data. Video Image Processing Systems (VIPS) are trying to fill the gaps in this regard and few attempts have been made in the Indian context. Out of various methods available to collect data, VIPS are cost effective and easy to adopt. In the present study, we present a new tool developed based on MATLAB® environment.

MATLAB is one of the powerful engineering programming tool used to extract traffic data from videos. Several codes are available at Mathworks web to extract the videos and these can be modified as per the need of the user. In addition, semi-automatic and fully-automatic extraction tools can be constructed on the MATLAB platform. In the present study, a semi-automatic tool for extracting the traffic data from videos is presented. Further, it also includes vehicle trajectories, speeds and classified volume count that can be extracted for any specific interval of time. Moreover, this tool can be used to get pedestrian flows and trajectories. Videos can be moved forward or backward without effecting the results, and final result can be obtained in text or spread sheets. The accuracy of the results depends on the attention of the user.

Keywords: Heterogeneous Traffic, Traffic data extraction, MATLAB, Pedestrian Counts, Trajectories
AN ANALYSIS OF ILLEGAL TRAFFIC MOVEMENTS AT INTERSECTIONS TO IMPROVE SAFETY

Sasanka Bhushan Pulipati*, Aadhar Saxena¹
¹ National Institute of Technology Warangal, Telangana, India
* Email: bushan515@yahoo.com

Abstract
Traditionally, intersection safety is analyzed using historical crash data and conflict techniques. The authors propose that an analysis of illegal traffic movements can be helpful in improving traveller safety at intersections in places where the traffic is not well organized. An illegal traffic movement means a movement that is not allowed according to the prevailing road rules. The authors explain the analysis procedure and demonstrate it with a case study. They show that this analysis shows a path to recommend specific steps to reduce the illegal movements and thereby reduce the crash potential.

Keywords: Illegal traffic movement, intersection safety analysis, crash, conflicts, traffic violation

MODE CHOICE MODELLING OF COMMUTER TRIPS IN TIRUCHIRAPPALI CITY USING MNL

Bush B. Thomas*, G. Nanthapriya¹, V. Sunitha¹, Samson Mathew¹
¹ National Institute of Technology Tiruchirappalli, India
* Email: bushbthomas25@gmail.com

Abstract
Mode choice is one of the most vital stages in the transportation planning process and it has a direct impact on the policy making. It is the process of arriving at a decision about which mode will be chosen under a set of circumstances. The scope of the work is limited to the Tiruchirappalli Corporation area. Work trips are modeled and presented in this paper. The various factors affecting the mode choice of trip makers are identified and analyzed. The household survey data is used to form Multinomial Logit (MNL) model to analyze the mode choice behavior.

Keywords: Mode choice; Commuter trips; Multinomial logit model

ASSESSMENT OF STONE MASTIC ASPHALT PERFORMANCE WITH THE INCLUSION OF FIBER MATERIAL ON RESILIENT CHARACTERISTICS

Teja Tallam*, Katasani Sweta¹, A. Ramesh¹
¹ VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
* Email: tnteja@mail.com

Abstract
SMA is a gap graded mix which is more durable and suitable for heavy trafficked loads, but offers slightly lesser modulus value compared to well graded bituminous mixtures. The main objective of this study is to compare the inclusion of polyester fibers in SMA mix for understanding the behaviour on resilient characteristics. Optimum binder content (OBC) of SMA mix from the laboratory study is obtained as 6.5% and the corresponding optimum fiber content (OFC) was
obtained at 0.4% when performed through drain down test. Polyester fibers have good drain down characteristics and provide good homogeneous mixture compared with conventional SMA. It is observed from test results that resilient modulus increased with the inclusion of polyester fibers by 18% and tensile strength ratio by 1.2%. This indicates that fiber inclusion provides better cracking resistance compared with conventional SMA mix.

**Keywords:** Marshal, Polyester fibers, Cellulose fibers, Drain down characteristics and Resilient Modulus

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**STUDIES ON PEDESTRIAN FUNDAMENTAL DIAGRAM CONSIDERING IMPACTS OF GENDER MIX**

Ujjal Chattaraj¹, Amit Kumar Das¹*, Manoj Kumar Biswal¹

¹ National Institute of Technology Rourkela, Odisha, India
* Email: amit76078@gmail.com

**Abstract**

Pedestrian fundamental diagrams are extremely essential to understand the pedestrian motion. In this contribution an attempt is made to avoid all sorts of disturbing influences on the pedestrian flow. A variation in the subjects (i.e. same gender and a mix of male and female pedestrians in alternate positions) is introduced to see the variation in pedestrian fundamental diagram. A very simple pedestrian flow system is used in which the subjects move in a single file under closed boundary conditions. Fundamental diagrams for same gender pedestrians and mixed gender pedestrians are found to be significantly different.

**Keywords:** Fundamental diagram, pedestrian flow, gender mix condition, single file

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**MODELLING FREIGHT GENERATION AND DISTRIBUTION FOR NATIONWIDE INTERSTATE FREIGHT MOVEMENT**

Middela Mounisai Siddartha¹*, Pulipati Sasanka Bhushan¹, C. S. R. K. Prasad¹

¹ National Institute of Technology Warangal, Telangana, India
* Email: middelasiddartha@gmail.com

**Abstract**

India does not have a formal model for forecasting interstate freight travel demand perhaps because of lack of data or resource constraints. The authors make an attempt in this study to develop freight travel demand models using public sources of data. They use the data on freight productions and attractions of the states, and their distance slab-wise commodity distribution diagram published in the Total Transport System Study Report performed by RITES Ltd. They calibrate multiple regression models for freight generation and gravity models for freight distribution. They use tri-proportional algorithm for gravity model calibration. The results of freight distribution are compared with Preliminary Engineering cum - Traffic study (PETS) for Eastern Dedicated Freight Corridor (DFC) for validating the models.

**Keywords:** Freight demand modelling, econometric model, linear regression model, tri-proportional approach, gravity model
IMPLEMENTATION PLAN BASED ON TOD TYPOLOGY BY SPATIAL ANALYSIS USING GIS FOR DENSE CITIES

Prashanth S. Lokku1*, Suhas T.1, C. S. R. K. Prasad1
1 National Institute of Technology Warangal, Telangana, India
* Email: lps.lokku@gmail.com

Abstract
Transit-Oriented Development (TOD) is one of the most appropriate solutions to make cities sustainable as proved in many foreign countries. This study aims to develop an implementation plan through TOD Typology based on existing site condition. Hyderabad Metropolitan Area (HMA) is considered as study area. Surveys such as landuse survey and stated preference survey are planned to understand the ground realities. A sample size of 1.13% is collected as part of stated preference and it revealed that 71% of people showed willingness towards TOD. Finally, study suggested TOD Typology as Residential TOD, Commercial TOD, Public & semi-public TOD and Mixed TOD.

Keywords: Transit-Oriented Development, TOD, TOD Typology, Spatial Analysis

STUDY ON SPEED BREAKERS AND ITS EFFECT ON SPEED AND VEHICLE OPERATING COST

Korra Ravi Kiran1*, M. Kumar1
1 College of Engineering. Osmania University, Hyderabad, India
* Email: ravikiran1307@gmail.com

Abstract
Speed bumps have a significant effect on Vehicle Operating cost. They cause in delays, reduce the mileage and cause discomfort to the passengers and leads to accidents. This paper focuses on how speed humps affect various factors of the vehicle such as travel time, delays, 85th percentile speed and mileage. In the whole context an attempt is made to study various consequences due to speed humps and bumps by considering two stretches at Chandranyagutta and Shamshabad airport road for the speed breaker stretch because of low traffic density, presence of well-designed speed breakers. Similarly the stretch between Chandranyagutta and Srisailam highway is adopted for studies involving free stretch. This study also presents a graphical model for the determination of loss in mileage as a factor of speed breaker density and average speed of the vehicle. This can be used to estimate the approximate hike in the cost of the journey of a two-wheeler and a four-wheeler due to the loss of fuel.

Keywords: Travel time & Delay studies, Vehicle Mileage, 85th percentile speed
ATTRIBUTE SELECTION FOR PUBLIC TRANSPORT IMPROVEMENT IN INDIAN CITIES

Santanu Ghosh¹, Bhargab Maitra¹
¹ Indian Institute of Technology Kharagpur, India
* Email: reach2santanu@gmail.com

Abstract
The paper reports an investigation on the importance of various bus system attribute in Indian Cities from urban commuters’ point of view. The work is demonstrated with reference to Bhubaneswar and Kolkata. Eight numbers quantitative and twelve numbers qualitative attributes were selected for user intercept survey in a 1 to 10 point numerical rating scale. The data were analyzed using Fuzzy Topsis method in order to compare the importance perception of the commuters of two cities. The work justifies the need for improvement of qualitative and quantitative attributes of bus service to improve the attractiveness of bus system in both the cities.

Keywords: Kolkata, Bhubaneswar, Fuzzy, Topsis, Attribute

PLATOONING ON TWO LANE RURAL HIGHWAYS IN MIXED TRAFFIC CONDITION

Sangeetha M.¹*, Gaurav Kumar Jain¹, Anjaneyulu M. V. L. R¹, Harikrishna M.¹
¹ National Institute of Technology Calicut, India
* Email: sangeethamadambi@yahoo.co.in

Abstract
Platooning is an important phenomenon on two lane highways which adversely affect the capacity and Level of Service of the road facility. 400 platoons of different sizes were analysed to obtain threshold headway of 3.25 seconds and 9472 platoons from two sites of a National Highway section at Kozhikode were analysed in detail. The average platoon size; number of followers and percent following were plotted against traffic flow to study the trend in platoon behavior with increase in flow. It is observed that the average platoon headway and the average platoon speed decreases with increase in the platoon size.

Keywords: platoon, threshold headway, average platoon headway, average platoon speed, number of followers, percent following, two lane rural highways

ROAD CRASH PREDICTION MODELING FOR CYBERABAD AREA- HYDERABAD-INDIA

Chetlapally Anukesh¹*, M. Kumar¹
¹ College of Engineering, Osmania University, Hyderabad, India
* Email: krk1307@gmail.com

Abstract
Accidents have been a major social problem in the developing countries of world for over fifty years. It is strongly felt that most of the accidents being a multi factor event, are not merely due to drivers fault on account of driver’s negligence or ignorance of traffic rules and regulations, but also due to many other related factors such as abrupt changes in road conditions, flow characteristics, road user’s behavior, climatic conditions, visibility and absence of traffic guidance, control and management devices. In the above context an attempt is made to study various types of accidents
including causative factors and black spot identification in Cyberabad area of Hyderabad city. The study involves collection of accident data from various police stations for the period of four years. Based on the collected data various models were developed. A fuzzy logic, Sensitivity Analysis, SPSS techniques used for development of accident prediction models. A comparison was made among various models and found that a fuzzy logic model gives the best prediction model. Further, black spots identification has done by quantum of accident method.

**Keywords:** Accidents, Black spot, fuzzy logic

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**ASSESSMENT OF ROBUSTNESS OF ROAD NETWORK**

Goutam Pattnaik\(^1\)*, Harikrishna M.\(^1\), Anjaneyulu M. V. L. R.\(^1\)

\(^1\) National Institute of Technology, Calicut, India

* Email: goutampattnaik.vky@gmail.com

**Abstract**

Robustness of a road network is its ability to continue performing well when it is subjected to failures or attacks. To decide if a given network is robust, a quantitative measure to assess network robustness is needed. Robustness measures will help in identifying critical links or nodes whose non-functioning will cause a greater effect on the whole network. In this work, the various factors that influence the performance of a network are identified and the robustness indices are computed based on these factors. Seven different network patterns: tree, hexagonal, circular, star, grid, star-grid and star-hexagonal were used as test networks to evaluate the efficiency of the method proposed. Grid-star pattern is identified to be most robust among the seven different network patterns based on the indices calculated. Road networks of Calicut and Bangalore city were analysed for robustness and the results indicated that Calicut network is more robust in terms of connectivity, whereas Bangalore road network is superior in terms of settlements and accessibility.

**Keywords:** Robustness, indices, network performance, disturbances, nodes, links, traffic flow, network patterns

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**PRIORITIZATION OF STREETS FOR IMPROVEMENT OF NON-MOTORIZED TRANSPORT FACILITIES IN SMART CITY DEVELOPMENT**

Nitin Tiruttani\(^*\)*, Pulipati Sasanka Bhushan\(^1\), C. S. R. K. Prasad\(^1\)

\(^1\) National Institute of Technology Warangal, Telangana, India

* Email: nitintiruttani@gmail.com

**Abstract**

Efficient urban mobility is one of the core infrastructure elements of smart city. Non-Motorized Transport (NMT) is as a part of it. For improvement of NMT facilities in an area, prioritization of streets is required for their improvement in the order of poor facilities to good facilities. The authors demonstrate a methodology to prioritize urban streets for improving their suitability for walking and cycling. Using the data collected through field observation and user surveys, they evaluate streets in different neighbourhoods on criteria such as safety, connectivity, attractiveness and comfort with regards to walking and cycling. They score the streets using a
quantitative or qualitative scale, whichever is suitable, and calculate an overall weighted score using simple additive method. The ascending order of this score gives the order of priority. The method is easily transferable to other cities.

**Keywords:** Smart city, non-motorized transport, pedestrian and bicyclist, user perception survey, prioritization of streets

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**EFFECTS OF ICT USAGE ON STUDENTS’ TRAVEL BEHAVIOUR**

Alaa Moosa Koya*, Harikrishna M.¹, Anjaneyulu M. V. L. R.¹

¹ National Institute of Technology, Calicut, India

* Email: alaa4ameen@gmail.com

**Abstract**

The potential of Information and Communication Technologies (ICT) to change our society, including mobility is evident. Both empirical and statistical research on the relation between ICTs and the amount of travel requires continuous attention because of the rapid innovations related to both spectrums of that relation. Quantitative research that considers personal ICTs like high speed mobile Internet (4G) or Smartphones and tablets in relation to mobility is limited. In this research an attempt is made to contribute to the understanding of the relation between personal ICTs and activity travel behaviour of students. The effect of ICT usage on travel has been less studied in Indian context and hence such a study will offer a more realistic picture to transport planners and policy makers to develop strategies that can reduce traffic congestion, air pollution and energy consumption. The sample population includes students from higher secondary section, senior secondary section, arts colleges and professional colleges of Calicut. Preliminary analysis of data collected (1435 samples) is carried out to know the general trends and characteristics of the study area in the context of ICT. Data collected also involves ratings of various motives behind choosing ICT. Attitudinal survey is also included in the questionnaire to bring out the personality trait of the respondents and thereby examine the possibility of a relationship between personality trait, ICT use and travel behaviour among students. The test results show that ICT use and travel are positively correlated. Furthermore, assuming that interrelations between ICT and travel exist, structural equation models were developed for various e-activities taking them as endogenous variables.

**Keywords:** ICT; e-activities; virtual activity; structural equation model; endogenous variable; extroversion; neuroticism

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**ANALYSIS OF BONDED CONCRETE PAVEMENTS USING 3D FEM**

Swarna Surya Teja*, K. Sridhar Reddy¹, M. Amaranatha Reddy¹, B. B. Pandey¹

¹ Indian Institute of Technology Kharagpur, West Bengal, India

* Email: ssurya.547@gmail.com

**Abstract**

A concrete pavement may consist of two layers of bonded concrete panel with the top layer being made up of premium quality aggregates while the lower layer concrete can have lower grade aggregates such as recycled concrete and marginal aggregates. The monolithic action of the two layers of concrete slabs results in decreased thickness of pavements resulting in a saving of the natural resources. The paper presents an analysis of stresses in bonded concrete pavements.
considering axle load and temperature gradients acting simultaneously so that an appropriate pavement thickness can be selected for a given traffic using the approach of IRC: 58-2015.

Keywords: 3D FEM, Two-Lift Concrete Pavements, Monolithic behavior, Pavement quality concrete, Lean Concrete, axle loads, temperature gradient

WORKING PAPER ON PLANNING OF BUS-BASED TRANSIT SYSTEMS THROUGH ‘NETWORK PLANNING APPROACH’- CASE OF BEST, MUMBAI

Ritesh Ramesh Patil*

1 Mumbai Metropolitan Region Development Authority, Mumbai, India
* Email: riteshrpatil@gmail.com

Abstract
The paper starts with a review of existing planning process of BEST bus services in the city of Mumbai through available documentations, interviewing concerned planning officials and public perception in general. This concluded on the existing process being incremental in nature and ad hoc as it is very problem specific planning, neglecting the impacts on the network as a whole, very frequent (every 4 months) changes in schedules & routes, lacks in communicating it to the users. Simultaneously, the literature review concluded that planning the network using the network planning principles and supply-oriented approach makes the Network efficient and attracts riders acts as underlying hypothesis of this paper. The paper then focuses on these principles and lays down a methodology to assess the existing network, propose changes in the route structure and lay an evaluation framework to evaluate scenarios. The paper concludes justifying that by simplifying route structure, having an hierarchy in routes, stable frequencies, and convenient transfers leads in reduced wait times and increase the total travel time savings.

Keywords: Public Transport Network, Public Transport System, BEST-Mumbai, network planning principles, network design, simple route structure, route hierarchy

TRAVEL TIME DYNAMICS – A STUDY OF TRAVEL TIME BUDGETS IN AN INDIAN CITY

Supraja Krishnan*

1 Urban Mass Transit Company, Hyderabad, India
* Email: krishnansupraja@gmail.com

Abstract
The theory of travel-time budget put forth by Yacov Zahavi in the 1970s, deems that individuals have a stable, predictable average daily travel time whether in an urban or a rural area. The concept of stable/constant travel time budget is quite appealing. However, it is more of a rule of thumb as most scientific evidences refute it. This research attempts to test these theoretical propositions based on a case from India. The observed relationships between socioeconomic variables and TTB only support the hypothesis of “regularity” and not “stability”. The research further confirms that travel time budget is not only determined by the activity at the destination or the mode of transport but also by personal beliefs and the perception of travel time. The findings
of this research would help transport policy adopt a more subjective notion than simple monetary cost.

**Keywords:** Travel time budgets, Survival Analysis

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**Abstract**

Delay at signalized intersection refers to the time loss of a traveler while crossing an intersection. The efficiency of traffic operation at signalized intersections is assessed in terms of delay caused to an individual vehicle. Highway Capacity Manual method and Webster's method are most widely used in India for delay estimation purpose. But in India, traffic is highly heterogeneous in nature with extremely poor lane discipline. Therefore, to explore best delay estimation technique for Indian condition a comparison was done. It was observed that direct estimation of delay using field measured data is more accurate than existing conventional and modified methods.

**Keywords:** Delay Estimation Technique, Heterogeneous Traffic, Signalized Intersection

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**Abstract**

In any robust pavement management system requires reliable inputs from a periodic pavement condition evaluation survey. Strategic maintenance decisions and planning are dependent on these inputs. Non-destructive testing (NDT) methods provide ideal means for pavement evaluation. A Light Weight Deflectometer (LWD) is one such newly developed NDT method that provides a quick, portable and convenient evaluation solution. This paper presents two case studies utilizing the LWD method. The in-situ modulus of pavement layers is first estimated from the measured surface deflection data using LWD. These estimates for different layers are then compared with the relevant corresponding estimates obtained from: case (i) DCP testing for flexible pavement section, and case (ii) Rebound hammer testing for rigid pavement section. The flexible pavement was chosen to be a Pradhan Mantri Gram Sadak Yojana (PMGSY) road, to check the applicability of these low cost methods, to low volume roads. Regression analysis is performed for both the case studies and the goodness-of-fit between the respective sets of estimates is examined. For flexible pavement case, a good fit was found. However, from the present study, no conclusive correlation was found for the rigid pavement case.

**Keywords:** LWD, in-situ modulus, DCP, DPI, Rebound hammer
PERFORMANCE EVALUATION OF URBAN TRANSPORT FACILITIES

Swathy S. *, Harikrishna M., Anjaneyulu M. V. L. R.

* National Institute of Technology Calicut, India
* Email: s4swathys@gmail.com

Abstract

Urban transport, a complex form of transportation that transfers people and cargo within the territory of a city and the immediate suburban zones, caters to the demand for travel within a city. However, in many cities, the urban transport system is found to perform poorly, causing hardship to the people. Hence, a performance measurement and evaluation of urban transport facilities becomes essential as it would aid in the management of existing transport plans and programmes and contribute to the identification and assessment of successful alternative programmes and projects. The Ministry of Urban Development (MoUD), GOI, has identified certain criteria for assessing the service level performance of urban transport. This work aims at identifying the performance indicators that influence the user’s perception of urban transport facilities and to have a qualitative assessment of urban transport facilities based on the identified indicators. Public transport facility is considered for the study, as they cater to a major share of the urban travel demand. In this study, the public transport facility at two cities in Kerala, Kozhikode and Thiruvananthapuram, is evaluated.

To evaluate the performance of transportation system, two types of questionnaire survey, namely, preference survey and rating survey were conducted. Preference survey was done to determine the preference of users to the identified performance indicators for the three facilities and rating survey was done to rate the existing facilities. Direct Interview method was used for data collection. Performance index can be an efficient means to determine the performance of urban transport system. Based on the rating survey results, the Performance index for each of the facility for the two cities was formulated. A criterion for estimation of Level of Service (LOS) provided by the facilities was developed and based on this, the performance of transportation system was evaluated and the aspects that require improvement were identified.

Keywords: Public transport, Preference survey, Rating survey, Factor analysis, Performance Index, Level of service

PERFORMANCE EVALUATION OF BRT BUSES WITH PASSENGER CARS - A CASE STUDY OF INDORE BRT CORRIDOR

Pritesh Bhana *, Tejas Parmar, S. M. Narulkar

* S.P.C.E. Mumbai, India
* S.G.S.I.T.S. Indore, India
* Email: snarulkar@gmail.com

Abstract

This paper illustrates the analysis conducted on traffic data collected along the Indore BRT corridor with cars in dedicated BRT lane and without cars in the BRT lane. The BRT system in Indore was implemented with full technical specifications and details in May, 2013. The main objective of the project study was to investigate the impact of passenger cars on performance of BRT corridor after passenger cars and other emergency vehicles were allowed in BRT lane for a shorter period of one year on the order of the Indore Bench of the Honorable High Court of the State of Madhya Pradesh after a Public Interest Litigation. The performance evaluation was carried out along the BRT corridor
on selected intersections and sections under two main scenarios in viz. the cars in the BRT lane and only buses in BRT lane with five traffic parameters which includes traffic flow, passenger flow, occupancy level, speed and delay and queue length. The study reveals that both the scenarios have some merits and demerits. The study suggested that, the cars can be allowed in the BRT lanes in selected sections to reduce traffic congestions in Mixed Vehicle (MV) traffic lane and to utilize the capacity of the BRT lane. Also, alternative parallel routes for personal vehicles are needed to be identified.

Keywords: BRT Buses, BRT lane, MV lane, Performance Evaluation, Traffic Flow, Passenger Flow

EFFECTS OF SOCIOECONOMIC AND TRIP CHARACTERISTICS ON COMMUTERS’ PERCEIVED IMPORTANCE TOWARDS TRANSFER FACILITIES AT METRO STATIONS

Shubhajit Sadhukhan¹*, Uttam K. Banerjee¹, Bhargab Maitra¹
¹ Indian Institute of Technology Kharagpur, West Bengal, India
* Email: shubhajit.iitkgp@gmail.com

Abstract
Transfer facilities provide the last mile connectivity for metro commuters to make their trips using metro. There is a need for improvement of transfer facilities at metro stations in emerging countries such as India. For rational improvement planning of transfer facilities, it is necessary to understand the commuters’ perceptions towards these facilities. As there is substantial variation in socioeconomic and trip characteristics of commuters in megacities, the present study investigates the effects of socioeconomic and trip characteristics on commuters’ perceived importance of transfer facilities. The findings could help to make improvement strategies considering the requirements of different groups of commuters.

Keywords: Metro station; Transfer facilities, Rating data, perceived importance, heterogeneity, Non-parametric tests, TOPSIS

MODELLING BICYCLE ACTIVITY ON MULTI-LANE URBAN ROAD SEGMENTS IN INDIAN CONTEXT AND PRIORITIZING BICYCLE LANE TO ENHANCE THE OPERATIONAL EFFICIENCY

Haritha Chellapilla¹*, Sambit Kumar Beura², P. K. Bhuyan²
¹ VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India
² National Institute of Technology Rourkela, Odisha, India
*Email: ch.haritha11@gmail.com

Abstract
This study has investigated the bicycle activity on 44 multi-lane urban road segments under heterogeneous traffic flow conditions and subsequently, developed a highly reliable ($R^2 = 0.74$) Bicycle Level of Service (BLOS) model. A sensitivity analysis carried out on modeled parameters has reported that traffic volume has the highest influence on BLOS. Thus the provision of bicycle lane is highly expected. The effect caused on motor-vehicle users due to shrinkage in existing carriageway width while providing a bicycle lane is studied using the VISSIM tool. For majority of segments, such a provision did not greatly hamper satisfactions of motor-vehicle users.
Keywords: Urban road segment; Heterogeneous Traffic Flow; Operational Efficiency; Bicycle Level of Service; Simulation; VISSIM; Sensitivity Analysis

Paper ID: 166

**PASSENGER CAR UNIT BASED ON INFLUENCE AREA**

Chandrapatla Achyuta Ramalinga Swamy1*, Caleb Ronald Munigety1 and Anjaneyulu M. V. L. R.1

1 National Institute of Technology, Calicut, India

* Email: achyuthchandrapatla@gmail.com

Abstract

Passenger Car Equivalent (PCE) or Passenger Car Unit (PCU) for different classes of vehicles is very important in study of traffic in heterogeneous traffic conditions. PCU values are used to convert traffic stream which consist of different vehicle types into an equivalent traffic stream composed of exclusively cars. This process of conversion of different vehicles to equivalent of cars can be called as Homogenisation of traffic stream. Several researchers have proposed several methods for the estimation of PCU values for different classes of vehicle. And there is a wide variability in the PCU values estimated by different classes of vehicles at different flow conditions. In this study, PCU were estimated based on influence area which is found to be more logical compared to other methods when estimated at different flow conditions.

Keywords: Heterogeneous traffic flow, Non-lane based traffic flow, Dynamic Passenger Car Unit (PCU), Passenger Car Equivalent (PCE), Density, Influence Area

Paper ID: 167

**SAFETY EFFECTIVENESS ANALYSIS OF HORIZONTAL CURVES ON NONURBAN ROADS**

Neena M. Joseph1*, Anupama T.1, Harikrishna M.1 and Anjaneyulu M. V. L. R.1

1 National Institute of Technology, Calicut, India

* Email: neenmariya@yahoo.co.in

Abstract

Safety on roads is a major concern in any country, because of its impact on the economy and people’s welfare and to nation as a whole. Crash prevention is the most effective way to reduce the rate of fatalities and improve the safety on roads. This study conducted using data of 30 horizontal curves of National and State Highways in Kerala brings out the influence of various roadway and traffic factors on traffic safety of tow lane non-urban highways. An attempt has been made in this work to predict crashes as a function of traffic exposure, operating speed and road geometrics.

Keywords: Safety performance functions; Crashes; AADT; operating speed; Horizontal curves
USERS’ PERCEPTION TOWARDS BUS SERVICE ATTRIBUTES IN MID-SIZED CITIES IN INDIA: A CASE STUDY ON PATNA

Shiv Priye1*, Sanjeev Sinha1 and Shubhajit Sadhukhan1
1 National Institute of Technology Patna, India
* Email: shivpriye84@gmail.com

Abstract

The quality of public transport is not duly considered in India. Providing a high quality bus service has a paramount importance to encourage users towards public transport. This study aims to assess the bus service quality from users’ perspective. A four-point Likert scale customer satisfaction survey was conducted in Patna, a mid-sized city in India. The database was analysed using Grey Relation Analysis (GRA). The findings show the greater concern of the users towards the quality of bus service that helps the policy makers to understand need for quality improvement of bus service in the city to increase the patronage.

Keywords: Bus service, Customer satisfaction survey, Grey Relation Analysis, Quality of service

ASSESSMENT OF RUTTING CHARACTERISTICS ON FIBER REINFORCED CONVENTIONAL MIXES OVER PMB

B. Srinadh1, A. Ramesh1*, M. Kumar2
1 VNR VignanaJyothi Institute of Engineering and Technology, Hyderabad, India
2 University College of Engineering, Osmania University, Hyderabad, India
* Email: aramesh28@gmail.com

Abstract

One of the typical types of failures in flexible pavement is rutting. Virgin bitumen material will not be able to resist when load condition is increased. Modified mixes or reinforcement is necessary for improving rutting characteristics. In the present study an attempt is made to analyze the rutting characteristics of virgin mix when reinforced with basalt fibers. Polymer modified bitumen, an effective material in rutting property is compared with conventional mix when reinforced with fiber. The results indicate that fiber reinforced mixes exhibits more rutting resistance than PMB mixes when evaluated in immersion type wheel rutting machine at 60 deg. C.

Keywords: Conventional Bitumen, Polymer Modified Bitumen, Basalt Fiber and Rut depth
RESISTANCE OF CONCRETE MIX WITH BLAST FURNACE SLAG TO SULFATE AND ACID ATTACK

B. G. Buddhdev¹*, H. R. Varia²
¹ R. K. University, Rajkot, Gujarat, India  
² Tatva Institute of Technological Studies, Modasa, Gujarat, India
* Email: bhavin_buddhdev@hotmail.com

Abstract
This paper presents the study carried out on concrete mix with blast furnace slag (BFS) as full replacement of fine aggregates (sand) under sulfate and acid attack. Both types of concrete mix with BFS and control concrete made from ordinary portland cement (OPC) have been subjected to 5% sodium sulfate and magnesium sulfate as well as 0.5%, 1%, 2% of sulphuric acid solution. Then results are compared with control concrete. From the results, it is revealed that concrete mix with BFS undergoes very less change in compressive and flexural strength, as well as change in mass. Hence, durability under acid and sulfate attack of concrete mix with BFS is much superior as compared to control concrete, which suggests its good applicability in field especially for coastal area construction.

Keywords: Blast Furnace Slag, Concrete, Sand (Fine Aggregate), Sulfate, Sulphuric Acid

PUBLIC TRANSPORT ROUTE EVALUATION USING DATA ENVELOPMENT ANALYSIS

Ankit Kathuria¹*, Manoranjan Parida¹, Ch. Ravi Sekhar²
¹ Indian Institute of Technology Roorkee, India  
² CSIR-Central Road Research Institute, New Delhi, India
* Email: writetokathuria@gmail.com

Abstract
This paper attempts to evaluate the performance of twelve Bus Rapid Transit (BRT) routes of the Ahmedabad BRTS, India. The performance indices considered in the study were converted into five major efficiencies being route design efficiency, scheduled design efficiency, cost efficiency, service delivery efficiency and comfort and safety efficiency. The individual efficiency of each dimension was estimated firstly based on the basic Charles Cooper and Rhodes Data Envelopment Analysis (CCR DEA) model and then estimating the improved efficiency score based on Super Efficiency Data Envelopment Analysis (SEDEA) After obtaining the individual efficiencies, composite efficiency of routes were estimated based on the Analytical Hierarchy Process technique.

Keywords: Bus Rapid Transit, Route Performance, Data Envelopment Analysis, Analytical Hierarchy Process
ASSESSMENT OF LEVEL OF SERVICE OF SAFETY OF TWO LANE HIGHWAYS USING ROAD SIDE LAND USE

Ranja Bandyopadhyaya¹, Jiwesh Ujjal¹, Sanjeev Sinha¹
¹National Institute of Technology, Patna, India
*Email: ranjaban@gmail.com

Abstract
Identifying high crash locations is essential for road safety improvement. Locations may be categorized based on degree of hazard and safety improvement potential into level of service of safety (LOSS) groups. Determining LOSS requires complex mathematical models and data of crash history, traffic exposure and road inventory.

The present work develops a guideline for determining LOSS of two-lane rural highway with road geometry and roadside features without systematic crash and traffic volume data or predication models. The study, done in Patna, Bihar, identified unique road side and land use factors that govern the LOSS of similar road segments.

USE OF CERAMIC WASTE AS FILLER AS WELL AS AGGREGATE IN BITUMINOUS CONCRETE

Amit Singh¹*
¹ Indus Institute of Technology & Engineering (Indus University), Gujarat, India
* Email: amitsingh9697@gmail.com

Abstract
Bituminous mixes are most commonly used all over the world in flexible pavement construction. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together, laid down in layers and then compacted. Today’s bituminous concrete pavements are expected to perform better as they are experiencing increased volume of traffic, increased loads and increased variations in daily or seasonal temperature over what has been experienced in the past. In this paving mix, normally lime is used as filler material. A study has been carried out in work to explore the use of ceramic waste as filler material in different proportion (3%, and 5%) as well as aggregate to bituminous concrete mix. Marshall Test has been considered for the purpose of mix design as well as evaluation of paving mixes. The amount of optimum binder content was determined by Marshall Stability test for samples. The mechanical performance was determined for Marshall Stability, deformation behaviour or flow, as well as for density and void characteristics base on prevailing Indian standards specifications. Results show that the stability values and other parameters of samples containing ceramic wastes are improved. The benefits of using ceramic waste in bituminous concrete mixture as mineral filler (3% & 5%) as well as aggregate (5%, 10% & 15%) are therefore recommended. The replacement of conventional filler like lime and other mineral in bituminous concrete by ceramic wastes will have major environmental benefits.

Keywords: bituminous concrete, Marshall Properties (flow value, stability), optimum bitumen content, ceramic waste
DESIGN METHODOLOGY OF TRAFFIC SIGNAL USING MICRO-SIMULATION MODEL

Bhaskar Paul*, Bhargab Maitra¹, Sudeshna Mitra¹
¹ Indian Institute of Technology Kharagpur, India
* Email: bhaskar_1232@yahoo.com

Abstract
Micro-simulation models are widely used for evaluation of signalized intersections. It reports better performance evaluation with lesser uncertainty than macroscopic design methods/tools. That gives the opportunity to apply micro-simulation model for design of traffic signal. However, often it is used for design of traffic signal. Present work attempts to design an isolated traffic signal in Kolkata, India. Prior to design, micro-simulation model for the study intersection is calibrated for local traffic scenario which is primarily characterized by heterogeneity in vehicle mix with non-lane based traffic movement. Design output is found to be better than the observed signal timing plan.

Keywords: Non-lane based traffic, Signalized intersection, Model calibration, Design of traffic signal

SIMULATION OF VEHICLE PROGRESSION I.E. A MACROSCOPIC TRAFFIC BEHAVIOUR USING A MICROSCOPIC MODEL

Bhaskar Paul*, Bhargab Maitra¹, Sudeshna Mitra¹
¹ Civil Engineering Department, Indian Institute of Technology Kharagpur, India
* Email: bhaskar_1232@yahoo.com

Abstract
Co-ordinated operation of traffic signals is largely influenced by vehicle progression along a coordinated link. Vehicle progression affects the design of offset and green-split in a coordinated phase. Several macroscopic models are in practice to simulate the vehicle progression. However, use of micro simulation model to simulate vehicle progression is very limited. The primary advantage of micro-simulation model is the consideration of ‘vehicle to vehicle interaction’ within a traffic stream, which gives it edge over macroscopic traffic flow models. In present study a micro-simulation model is developed using VISSIM to replicate vehicle progression along an arterial segment in Kolkata city.

Keywords: Vehicle progression, Micro-simulation model, Model calibration

AN ASSESSMENT ON NETWORK CODING STRUCTURE IN VISSIM FOR SIMULATION OF A FAR-SIDE BUS STOP IN NON-LANE BASED TRAFFIC SYSTEM

Bhaskar Paul*, Bhargab Maitra¹, Sudeshna Mitra¹
¹ Indian Institute of Technology Kharagpur, India
* Email: bhaskar_1232@yahoo.com

Abstract
Micro-simulation model has extensively been used for evaluation of traffic system and found suitable for evaluation of signalised intersection in non-lane based traffic such as in urban India.
Yet, modelling of some discrete features viz. a ‘far-side bus stop’ in VISSIM, a widely used simulation tool fails to replicate the observed dwelling behaviour of transit and para-transit modes and therefore, fails to replicate its’ impact on a vehicle stream. The present work attempts to investigate several network coding structures for a ‘far-side busstop’ operation in VISSIM 8 and its impact on adjacent vehicular stream in a non-lane based traffic system.

Keywords: Non-lane based traffic, Signalised intersection, Far-side bus stop, Calibration

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**SERVICE LIFE PREDICTION FOR BRIDGE STRUCTURES EXPOSED TO AGGRESSIVE MARINE ENVIRONMENT**

Athira G¹, Mahima S¹, Bahurudeen A¹*, Jayachandran K², Moorthy P³

¹ Birla Institute of Technology and Science, Pilani, India  
² Indian Institute of Technology Madras, India  
³ Indian Institute of Technology Bombay, India  
¹ Email: bahurudeen.civil@gmail.com

**Abstract**

Infrastructures are measured as an imperative parameter for development of any nation. In infrastructural projects, construction of concrete bridges is considerably focused to achieve proper connectivity in the coastal cities and harbors. Bridges exposed to marine splash zone or near to coastal zones require more precise and reliable service life prediction. Bridges mostly constructed in hostile environment aids for comfortable traffic flows are severely affected by deteriorating agents such as chlorides and sulphates. Although most of the bridges are constructed more than 1.5 km away from seashore in the coastal cities, they are severely affected because of air borne chlorides. Interaction of the structures with aggressive air borne chlorides results in considerable reduction in strength as well as durability of concrete and leads to reduction in service life. For durability consideration of concrete structures exposed to aggressive marine environment, several prediction models were evolved with certain assumptions finally arrives at the requisite serviceable life of the structures based on probabilistic approach. The probabilistic approach theory needs proper attention of several factors such as concrete cover, diffusion coefficient, diffusion decay index, surface chloride concentration, critical chloride threshold value, type of corrosion and current density for better service life design. Models evolved in course of time has incorporated the above factors and emphasized the incorporation of performance-based design during the design and construction of bridges. A detailed investigation on service life prediction for concrete bridges exposed to Indian marine splash-zone is not available in the literature. It is imperative to study the variation in service life of concrete bridges with respect to Indian marine conditions to achieve durable concrete bridges. In the study, permeability of concrete was determined using Rapid chloride permeability test, the correlation between the charge passed and the diffusion coefficient of chlorides in different concrete was estimated. Service life of concrete bridges in marine splash zone was predicted using Life 365™. From the study, significant enhancement in durability is obtained for fly ash and rice husk ash blended concrete compared to ordinary Portland cement concrete bridges.

Keywords: Service life, Rice husk ash, fly ash, Permeability, Portland cement, Corrosion, Durability
FACORS INFLUENCING USER PERCEPTION OF LOS AT SIGNALIZED INTERSECTION UNDER MIXED TRAFFIC CONDITION

O. Darshana¹, K. V. Krishna Rao²

¹Indian Institute of Technology Bombay, Mumbai, India
E-mail: darshana_o@iitb.ac.in

Abstract
The study aims at identifying the factors influencing the users' perception of Level of Service (LOS) at signalized intersection under mixed traffic condition. User perception questionnaire survey carried out at eight signalized intersections in New Delhi forms the database for the present study. From the analysis of the user perception survey data, it was found that users gave importance not only for the delay but also for other factors like presence of exclusive right turn lanes, the presence of heavy vehicles, the presence of pedestrians etc. Kruskal-Wallis test was carried out to find out the effect of socio-economic and travel characteristics of the users on the rating of various factors. Further studies can be carried out to establish user perceived LOS by incorporating the factors identified in this research.

Keywords: Signalized intersection, Level of Service, User perception, Mixed traffic condition, Delay

THREE-STEP FLOATING CATCHMENT AREA TO QUANTIFY THE SPATIAL ACCESSIBILITY TO HEALTH CARE UNITS

Harish Puppala¹ *, Ajinkya Ingale¹, A. K. Sarkar¹, Ajit Pratap Singh¹

¹ Birla Institute of Technology and Science Pilani, India
* Email: harishpuppala.ce@gmail.com

Abstract
Spatial accessibility is a measure of the ease with which people are getting benefited in terms of access and service. Two step floating catchment area method and Enhanced two step floating catchment area method are few of the popular techniques available to quantify the spatial accessibility. However, the assumption of considering the habitations as choice users overestimates accessibility. To overcome this, Three-step floating catchment area method is proposed in this study. This approach considers habitations as choice users initially and converts them to captive users by using Multicriteria approach, followed by the computation of spatial accessibility. Rural habitations of Jhunjhunu district are considered in this study and the findings are presented.

Keywords: Two step floating catchment area method (2SFCA), Enhanced two step floating catchment area method (E2SFCA), Three step floating catchment area method (3SFCA), Community health care unit (CHC)
ASSESSMENT OF FUNCTIONAL CHARACTERISTICS OF A SIGNALIZED INTERSECTION: A REVIEW

Satyajit Mondal¹, Ankit Gupta¹*
¹ Indian Institute of Technology (BHU) Varanasi, Varanasi, India
* Email: ankit.civ@iitbhu.ac.in

Abstract
The assessment of capacity and level of service are the utmost component for performance evaluation and fruitful planning and designing of a signalized intersection. The functional characteristics of a signalized intersection is affected by the magnitudes of vehicle and its composition along with their desire movements, geometric elements and signal characteristics. The functional characteristics of signalized intersections can be assessed with a procedure of capacity, delay and performance analysis respectively. This paper makes an attempt to critically review the existing literature and their suitability along with the various factors affecting the performance of signalized intersection. A methodological framework is also developed for evaluating different functional characteristics of signalized intersections in mixed traffic condition. The paper concluded with some research gaps where further studies may be carried out.

Keywords: Capacity, Delay, Functional characteristics, Headway, Level of service, Saturation flow rate, Signalized intersection

EFFECT OF TRAFFIC CALMING DEVICE GEOMETRY ON VEHICULAR SPEEDS

Jitender Singh¹, Vipul Singhal¹, Ankit Gupta¹*
¹ Indian Institute of Technology (BHU) Varanasi, Varanasi, India
* Email: ankit.civ@iitbhu.ac.in

Abstract
There are many ways to control the speed of the vehicle in which speed humps and bumps are widely in use. To avoid driver discomfort, the vehicle must slow down to a speed of 20-30 kmph while travelling over them. Based on observations made in various case studies, different geometric combinations of speed humps are currently in use (eg. parabolic, sinusoidal, etc.). There are no perfect or ideal guidelines have been introduced and properly enforced by the local authorities in India. In this study the speed data were obtained by using a radar gun and videography technique to attain the spot speed data at the selected speed hump and bump location. At least 100 numbers of speed data were recorded for two and four wheelers at each site. A critical speed change analysis has been conducted and the results are presented for various vehicle category and type of humps. The 85th percentile crossing speed and percent speed reduction was related to the geometric design of the speed humps and bumps by linear regression. The models can be used as a basis for the design of speed hump and bump geometry for a selected 85th percentile speed reduction and provide an easy-to-use guide for engineers to design hump geometry for speed-control.

Keywords: Traffic calming devices; speed hump; speed bump; design speed; aspect ratio
FINITE ELEMENT ANALYSIS OF GEOTEXTILE REINFORCED HIGHWAY EMBANKMENT USING PLAXIS 3D

Athulya G. K.1*, Ankita Kumar1, S. P. Guleria2, J. N. Mandal1

1 Indian Institute of Technology Bombay, Mumbai, India
2 Jawaharlal Nehru Government Engineering College, Sundernagar, Himachal Pradesh, India

* Email: athulyagk361@gmail.com

Abstract
The present study describes the behavior of the highway embankment using finite element method based software ‘Plaxis 3D’. The modeling of the embankment is done using steel slag–soil mixture (30% steel slag with 70% soil) and natural fill material over the soft sub soil. The comparative study of steel slag–soil and natural fill materials as an embankment fill material was performed. Geotextile of different elastic stiffness were used as soil stabilizing material to identify the best suitable Geotextile for embankment construction. The suitability of these embankment fill material for different height of the embankment was analyzed based on stability and displacement criteria. It was concluded that steel slag soil material has good strength and stability compared to the natural fill material. Placing of Geotextile improves the stability of embankments. From the results it was inferred that soil–steel slag mix embankment is stable for heights 4m, 5m, 6m with the addition of different tensile strength of geotextile ranges from 50 kN/m to 1500kN/m.

Keywords: Highway embankment, steel slag, Geotextile, Plaxis 3D

ADAPTATION POLICY FRAMEWORK FOR CLIMATE CHANGE IMPACTS ON TRANSPORTATION SECTOR IN DEVELOPING COUNTRIES

Ashish Verma1*, Harsha Vajjarapu1, Saqib Gulzar1

1 Indian Institute of Science Bangalore, India
* Email: rsashu@yahoo.com

Abstract
The global response to climate change threat has been through mitigation by reducing the GHG emissions but the scientific consensus is that some of the climate change effects are inevitable and unavoidable as such adaptation is seen as a necessary means of addressing climate change effects projected to bring more frequent and severe precipitation resulting in floods and due to rapid urbanization, urban flooding is becoming a looming threat to road transportation which disproportionately affect the developing countries. In this paper, a consolidated review of literature on road transport-related climate change adaptation measures adopted across different countries around the world has been done, followed by the identification of barriers and adaptation challenges in developing countries such as India. Further, a methodological approach has been proposed for shaping adaptation policies in developing countries with an objective of enhancing the resilience of transportation system against climate change-induced urban flooding by reducing its impacts and strengthening the adaptive capacity of the system.

Keywords: Climate change, transportation, developing countries, adaptation, policy
KEY FACTORS AFFECTING CAPACITY AND TRAVEL TIME RELIABILITY OF FREIGHT TRANSPORTATION AT POST DISASTER PHASE

Tanmay Das¹*
¹Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.
*Email:dastanmay84@yahoo.com

Abstract:
A sustainable, resilient and safe freight transportation system is critically important for nation’s economy. This paper discusses the basic parameters of resilience engineering and analyses freight transportation systems during post disaster phase, in order to identify the key factors affecting freight flow through transportation system during and just after a natural disaster. For this a data set of 1000 is collected by conducting a questionnaire survey to the key officials managing the freight transportation in Bangladesh. Key factors contributing to the freight transportation system is determined by Ordered probit (OP) approach. Among the factors “Damaged roadway” and “Traffic control device performance” get the highest weightage. The study findings can be utilized by the transportation officials to improve overall performance freight transportation network during the disaster and post disaster phase.

Keywords: freight transportation system; Ordered Probit; resilient transportation network.

PRELIMINARY CHARACTERIZATION OF WASTE MATERIALS AS MINERAL FILLER FOR ASPHALT PAVEMENTS

Jayvant Choudhary¹*, Brind Kumar¹, Ankit Gupta¹
¹ Indian Institute of Technology (BHU) Varanasi, Varanasi, India
*Email: Jayvantc.rs.civ15@iitbhu.ac.in

Abstract
Road construction industries require continual and frequent supply of quarried aggregates. The uncontrolled quarrying operation of aggregates led to serious depletion of natural resources. Hence reuse of industrial waste materials for pavement construction is of great global interest. The primary objective of this initial investigation was to determine the possibility of utilization of the wastes from various sectors namely; waste glass powder from glass industry, bauxite residue or red mud from aluminum industry, Mustard plant residue ash from agricultural industry and recycled brick dust from construction and demolition industry as mineral fillers in asphalt mixes in India. Physical parameters such as specific gravity, plasticity index and particle size distribution were determined. Morphological and mineralogical analyses were done using Scanning electron microscope (SEM) and X-Ray Diffraction (XRD) techniques. Elemental compositions of materials were determined using Energy Dispersive X-ray (EDX) technique. Apart from these, affinity of materials towards bitumen was assessed using pH value and hydrophilic coefficient tests. Obtained properties were compared with that of conventional stone dust filler and it was concluded that apart from red mud, physical and chemical properties of other materials were within specification limits and they could be potentially be utilized as mineral filler in asphalt mixes.

Keywords: Asphalt; mineral filler; industrial waste; agricultural waste; constructional waste.
BICYCLE USE IN INDIAN CITIES: UNDERSTANDING THE OPPORTUNITIES AND THREATS

Premjeet Das Gupta1*, Kshama Puntambekar1
1 School of Planning and Architecture, Bhopal, India
* Email: premjeet@spabhopal.ac.in

Abstract
The study explores the opportunities and threats with respect to bicycle use in India, with reference to the recent literature on bicycle use. The study attempts to understand the role of bicycles with respect to livelihoods and the urban poor in India, trip characteristics of bicyclists in India, variation in bicycle use in Indian cities, future of bicycle use in Indian cities in do-nothing scenario, and the potential market for bicycle use in India.

Keywords: Bicycle, urban poor, livelihoods, trip length distribution, ‘other workers’, modal share

OPEN SOURCE TOOLKIT FOR PEDESTRIAN EVACUATIONS

Abhay Kumar Chaturvedi1, Ankit Gupta1*
1 Indian Institute of Technology (BHU) Varanasi, Varanasi, India
* Email: ankit.civ@iitbhu.ac.in

Abstract
One of the most promising crowd modeling techniques to emerge over the last 20 years is the social force model. The social forces are nothing but a combination of attractive and repulsive potentials arising from entities like doors, walls, obstacles, furniture, and other pedestrians in the environment. These forces are not physical forces but serve as a shear motivation to act in a given environment. The aim of this study was to use this model to develop a simulator that can be used to determine the optimum flows for passageways, optimum architectural geometries for buildings expecting high pedestrian densities and predicting the occurrence of crowd turbulence and will thus help in simplifying pedestrian evacuation simulations.

Keywords: Pedestrian modeling, Social force model, Evacuation simulation, Open source software

APPLICATION OF STRUCTURAL EQUATION MODELING TECHNIQUE FOR ANALYZING LEISURE TRIP BEHAVIOR FOR DESTINATION CHOICE

Shruti Dave1, Yogesh Shah2*
1 Marwadi Education Foundation, Rajkot, Gujarat, India
2 Institute of Infrastructure, Technology, Research and Management (IITRAM), Gujarat, India
* Email: yogeshfrombaroda@yahoo.co.in

Abstract
This paper analyzes the traveler’s behavior about making leisure trips. Analysis of trip behavior helps in finding out the approaches and factors which affect the destination choice and mode choice. A questionnaire survey was carried out on tourists to understand their mindset and attitude towards the decision making while selecting a mode and destination for leisure trips. Two destinations viz. Dwarka and Diu situated in Gujarat state were selected for the study. Dwarka is one of the most holiest places for Hindu’s and which a part of ‘Chardham yatra’ is also, having religious leisure value.
Diu is a union territory having sea sites and beaches, waterfronts having recreational leisure value. The factors considered in the survey included the social factors like income, family composition and trip duration as well as some qualitative factors like safety, comfort, weather of the place, atmosphere, etc. Other factors affecting their choices like trips per year, budget of trip, mode of travel etc. were also included.

It results from surveys revealed that direct connectivity is the most important factor for deciding the mode of trip and destination place by the tourists. The factor such as safety, comfort, sight-seeing locations, availability of multi cuisine, shopping facilities were not much important for selection of religious place i.e. Dwarka but was given a higher weightage by tourists for selection of Diu. Availability of time and budget were having similar importance for selection of both the places. It was observed that most of the tourists were using a private mode like car rather than public mode for commuting to these places. For analyzing the influencing factor for making mode choices, two structural equation models one for each location were developed. The factors affecting the mode choice are analyzed and discussed based on the result of these models. The outcomes of the study will be important for making policy decision by tourism department to attract more tourists at such destinations by increasing the connectivity through public modes.

Keywords: Leisure trips, mode choice, destination choice

CONSTRUCTION OF BITUMINOUS MACADAM USING PLASTIC WASTE

Mehdi Karimi Cheshmehgol\textsuperscript{1,\*}, Malik Shoeb Ahmad\textsuperscript{1}

\textsuperscript{1} AMU University, Uttar Pradesh, India
\textsuperscript{\*} Email: mehdi_karimi_1361@yahoo.com

Abstract

The present investigation was carried out to use of plastics for the modification of bituminous concrete mix. Initially, penetration, ductility and viscosity tests were carried out to know the most significant percentages of the plastic waste, and that lead to get the best combination of bituminous concrete. These tests were conducted on plain bitumen as a control specimen and bitumen mixed with 2-14\% with two percent increment of plastic wastes. Mix Specimens for Marshall and IDT tests were prepared for Bituminous Macadam (BM) and compared with control specimens. The improvement in characteristics of plain bitumen and bituminous mixes have been observed.

Keywords: Bituminous Macadam (BM), IDT, Marshall Stability Tests, Plastic Waste, Stripping Value

FRAMEWORK FOR ROAD SAFETY AUDIT OF HIGHER EDUCATIONAL INSTITUTES: A CASE STUDY OF IIT (BHU) CAMPUS

Abhishek Yadav\textsuperscript{1,\*}, Ankit Gupta\textsuperscript{1}

\textsuperscript{1} Indian Institute of Technology (BHU) Varanasi, Varanasi, India
\textsuperscript{\*} Email: abhishekylink@gmail.com

Abstract

Road safety is a serious concern in the developing countries. In India, the growth in vehicular population without adequate road infrastructure has been responsible for increase in the number of accidents. Heterogeneous mix of traffic, poor road geometrics and ineffective traffic control are some of the important contributing factors to the high accident rates. An effective and efficient safety
training program and creating the awareness about the road safety in the people fulfill the safety needs of the roads. In the present study, a road safety audit for IIT (BHU) has been conducted and presented in this paper to enable a framework for higher educational areas. The need for road safety audit on Indian Institute of Technology (BHU) Varanasi campus is highlighted by observing the safety deficiencies on the selected stretches. Road safety audit was conducted at the selected major intersections, mid-blocks and few minor midblock locations. Pedestrian crossing facilities, shoulders, edge markings, directional arrow markings, warning signs at various locations were found inadequate. Suitable remedial measures are suggested to improve the road safety in IIT (BHU) campus.

**Keywords:** Road Safety Audit (RSA), IIT (BHU), Checklist, Intersections, Mid-blocks

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**MODELLING THE ROUTE CHOICE BEHAVIOUR UNDER STOP-&-GO TRAFFIC FOR DIFFERENT CAR DRIVER SEGMENTS**

Saxena N.\(^1\)*, Rashidi T. H.\(^1\), Dixit V. V.\(^1\), Waller S. T.\(^1\)

\(^1\) UNSW, Sydney, Australia
* Email: n.saxena@student.unsw.edu.au

**Abstract**

Stop-&-go (S&G) waves are often a nuisance and lead to increased emissions and safety risks. Due to its frequent and annoying nature, drivers tend to avoid travelling on routes with more occurrences of S&G waves. This study evaluates the effect of the number of S&G waves on route choice. An online survey was conducted on a sample of regular car drivers residing in Sydney and its neighbouring suburbs. The collected data was analysed using a latent class choice modelling formulation which provides concise segment specific information making it attractive to policy makers. Results showed that nearly three-quarters of the sample had a negative and significant disutility towards the number of S&Gs. The updated model would facilitate realistic assessment of transportation projects and policy decisions.

**Keywords:** Stop-&-go traffic, route choice, stated choice experiment, latent class choice model, traffic assignment

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**ON-STREET PARKING DEMAND ESTIMATION MODEL: A CASE STUDY OF KOLKATA**

Debasish Das\(^1\)*, M. Ali Ahmed\(^1\), Saptarshi Sen\(^1\)

\(^1\) National Institute of Technology Silchar, Assam, India
* Email: debasishd89@gmail.com

**Abstract**

Shortage of on-street parking space in the urban Central Business District (CBD) is the common problem in Indian metropolitan cities. In Indian cities, due to lack of off-street parking and poor service quality of transit system in the CBD area; visitors are forced to park their vehicle on the streets leading to create huge on-street parking demand. The objectives of this study are to estimate modified parking demand estimation model and also to calculate the parking level of service (LOS). Two CBDs, namely Dalhousie (office area) and Gariahat (shopping area) are chosen as case study area.

**Keywords:** Present parking scenario, survey, LOS estimation, factors affecting on-street parking demand, parking estimation model
EFFECT OF HEADWAY ON FREE FLOW SPEED OF FOUR LANE URBAN ROADS UNDER MIXED TRAFFIC

Sanjeev Sinha\textsuperscript{1*}, Sashi Ranjan\textsuperscript{1}, Ranja Bandhopadhyaya\textsuperscript{1}, Shubhajit Sadhukhan\textsuperscript{1}

\textsuperscript{1} National Institute of Technology Patna, India
* Email: sanjeev@nitp.ac.in

Abstract

Prediction and knowledge of headway and free flow speed describes behaviour of traffic stream by considering the details of individual vehicles. It also plays an important role in assessment of capacity and level of service of any facility and also helps in solving problem of traffic control, gap acceptance etc, where the driver’s choice of weaving, merging and passing depends on suitable headway between vehicles. Free flow speed on the other hand has a significant role in planning, operational analysis and performance evaluation. In the present study, an attempt is made to determine the relation between microscopic parameter time headway and macroscopic traffic parameter free flow speed for four lane urban roads under mixed traffic condition.

Though several researches have been carried out on modelling of headway and analysis of free-flow speed separately, however, literature is not available for researches to assess the influence of headway on free-flow speed. Data collection was carried out at six Mid-block sections of four lane divided urban roads using video graphic technique. The speed-volume relationship for different sections was plotted to obtain free flow speed and capacity. The headway data was also collected for different sections and statistical analysis was carried out. The headway data were divided into different class interval and the mean value was found out. It was observed that there was some correlation between the headway and free flow speed. The headway first decreased with increase in free flow speed and after reaching a minimum value, it again increases. The capacity of the road is maximum, when the time headway is minimum and this happens for an optimum value of free flow speed. There is a decrease in capacity with an increase in time headway.

GENERATION OF AN INTEGRATED PAVEMENT MANAGEMENT STRATEGY FOR FLEXIBLE PAVEMENTS IN INDIA

Shivraj S. Borade\textsuperscript{1*}, Anjan Kumar S.\textsuperscript{1}

\textsuperscript{1} Indian Institute of Technology Guwahati, Assam, India
* Email: s.borade@iitg.ac.in

Abstract

This study presents a framework to generate maintenance strategies for a newly constructed pavement based on historical performance data of similar pavements. The data collected comprises of structural and functional condition. The performance modelled based on the data collected is utilised to estimate the condition of new pavement. Treatment strategies are proposed based on collective analysis of the maintenance data available. Standard cost analysis is conducted and treatment is selected by optimising benefits per unit cost. The framework aims to aid the road developers to envisage the budget required to maintain the asset and/or the prospective road developer to forecast investments necessary to operate the project.

Keywords: pavement performance, pavement management systems, maintenance, performance optimization, LCCA
A SIMULATION STUDY FOR IMPROVING THE TRAFFIC FLOW EFFICIENCY AT AN OVERSATURATED INTERSECTION COUPLED WITH BRT

Narayana Raju*, Akhilesh Chepuri1, Vinayaraj V. S.1, Shriniwas Arkatkar1, Gaurang Joshi1
1 Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India
* Email: s.narayanaraju.10@gmail.com

Abstract
This study mainly focuses on improving traffic flow efficiency of Bhathena intersection coupled with BRT system located in the city of Surat, India. With the help of field data, the study intersection is modelled in microscopic simulation software VISSIM 8.0. Based on this, simulation model is calibrated and validated by comparing travel time of the probe-vehicle and the observed queue lengths among other observed data and simulation results in such way that absolute percentage error is limited to 15 percent. In order to improve the traffic flow behavior at the intersection in terms of reducing travel time, traffic signal design is carried out using Webster’s approach of signal design. The various scenarios include the design of 2-phase, 3-phase, 4-phase signal systems. In each of the scenarios, signal design is carried out based on Webster method and same traffic signal system is simulated in VISSIM model and the travel time results across the arms were compared with the base case. It was observed that 3-phase system is suitable to the intersection keeping in consideration BRTS operation.

Keywords: BRTS, simulation, traffic signal design, traffic flow behavior, Webster’s method

DEVELOPMENT OF COST PREDICTION MODEL FOR RURAL ROAD

Prakashkumar Makwana*, Praveen Kumar1
1 Indian Institute of Technology Roorkee, India
*Email: prakashkumar.makwana@gmail.com

Abstract
India have agricultural economy and its mostly dependent on villages. The rural connectivity is of prime importance for the evolution of any nation, the cost of a road required high investment and cost predication models gave flexibility to cope money.

This work aims at making an accurate and robust cost prediction model for rural road of Saurashtra region using multi-linear regression (MLR), multi-layer perceptron (MLP) and radial- basis function (RBF) methods. The model has been prepared using sets of parameters, those have significant force on road cost, for this, independent variables such as PI, MDD, OMC, soaked CBR, rainfall, crust thickness, traffic in MSA and the cost of cleaning and grubbing are finalized and used in SPSS tool. Data’s are extracts from total thirty DPRs of a different district of Saurashtra region. Observed SSE of 1.869 in MLR, 0.396 for training and 0.503 for testing in MLP and 0.314 for training and 0.320 for testing in RBF models. This is indicative of good performance of RBF followed by MLP and MLR methods.

Keywords: cost prediction, multi-linear regression (MLR), multi-layer perceptron (MLP) and radial-basis function (RBF)
EVALUATION OF POST-INCIDENT TRAFFIC MANAGEMENT STRATEGIES: A CASE STUDY OF KOLKATA CITY

Kaniska Ghosh1*, Bhargab Maitra1
1 Indian Institute of Technology Kharagpur, India
* Email: kgmd123@gmail.com

Abstract
Occurrence of an incident can greatly intensify the existing congested traffic conditions at a particular location at a particular instant of time. The immediate effect of the incident propagates to the surrounding road network as shock wave resulting in blockage; which eventually may spread over a larger network if efficient measures are not taken immediately. This paper presents an initial investigation to evaluate various traffic management strategies involving different levels of diversion control and route guidance measures during or immediately after traffic incidents to enable a traffic system controller to favourably manage traffic conditions in real time.

Keywords: Incident, Traffic Management Strategies, VISSIM, Delay, Scenarios, Micro-Simulation

IDENTIFYING TIPPING-POINTS OF DISRUPTIONS ON URBAN ROAD NETWORKS

B. K. Bhavathrathan1*, Gopal R. Patil1
1 Indian Institute of Technology Bombay, Mumbai, India
*Email: bhavathrathanbk@gmail.com

Abstract
Roadways are susceptible to a variety of disruptions. Most frequent disruptions are non-severe ones, but occur at multiple locations simultaneously. Capacity disruptions, if left unaccounted, will result in suboptimal network design decisions. The objective of this work is to study multiple simultaneous disruptions and to establish a consequent critical state on the network. A critical state is such where the network bears the worst possible operable cost at a given level of service. From the critical state problem, one can find the network operational cost—at the critical state—which is irreducible even by re-assignment. The critical state is identified using a minimax optimisation problem that is solved employing a two-space genetic algorithm. The relative difference of the critical value and the best possible value is interpreted as the network’s resilience. This resilience measure is demand-specific. To generalise the resilience measure, its sensitivity to change in demand is studied. Using two-space genetic algorithm, which belongs to the class of coevolutionary algorithms, computational experiments are performed on different network sizes and topologies to bring out a relationship between network resilience and demand. Also, it is found, upon analysing different solutions that certain links contribute more to the critical state. This observation is used to identify link criticality on urban road networks.
DEVELOPMENT OF URBAN ROAD SAFETY AUDIT TOOL KIT

S. M. Hassan Mahdavi M.1, G. Tiwari1, K. Ramachandra Rao1*
1 Indian Institute of Technology Delhi, New Delhi, India
* Email: rrkalaga@civil.iitd.ac.in

Abstract
Urban Road Safety Audit (URSA) is meant for accident prevention rather than accident reduction. It is a safety performance examination of an existing road or a future road by an independent audit team. The audit can be conducted at any stage of a project, starting with the project planning stage to the final design stage. It can even be conducted on roads that have already been completed and started operating. Road Safety Audit is dependent on the kind of activities and characteristics of a geographical area and can be classified into three types depending on its applicability; namely application to Highway, Rural areas and Urban areas. In urban areas, safe people’s movement is most important. URSA Toolkit attempts to integrate all the issues concerned with transportation in order to promote safety, cleaner air, and energy conservation. The prime user for whom the tool kit is being prepared is city officials who are required to supervise and monitor consultant’s work. This tool kit would also assist the other user groups and civil society to monitor the improvement in urban road safety.

Keywords: Safety Audit, hot-spots, density clustering, checklists

EXPRESSING TRAFFIC FLOW ON INTERCITY EXPRESSWAYS IN INDIA: LANE VS. DIRECTIONAL TRAFFIC FLOW BEHAVIOUR

Nipjyoti Bharadwaj1, Shriniwas Arkatkar1*, Ashish Bhaskar2, Gaurang Joshi1
1 Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India
2 QUT, Brisbane, Australia
* Email: sarkatkar@gmail.com

Abstract
This paper aims to empirically study traffic flow operations on Intercity Expressways in India for direction-wise (aggregate for all lanes) and lane-wise (individually for each lane) traffic levels. The data is obtained from two sections on (i) Ahmedabad-Vadodara and (ii) Mumbai-Pune Intercity Expressways. These sections have varying number of lanes, traffic flows and proportion of heavy vehicles (trucks). The effect of percentage of heavy vehicles on one lane on the speed of the adjacent lane is analysed. Speed-flow curves for lane wise and direction wise are developed for different proportion of heavy vehicles. The curves are used to evaluate the free flow and congested regions. The results were compared with Highway Capacity Manual (HCM) and German Handbuch für die Bemessung von Strassenverkehrsanlagen (HBS) recommendations. Findings reveals significant variations in free flow speed and capacity between lane-wise and direction-wise speed-flow plots which is attributed to the lane distribution and proportion of trucks. The paper discusses about the capacity estimation and speed-flow relationships for typical shoulder side lane of Indian expressways with very high variation of truck proportion (10-100%). The findings of this study will give insight about the appropriateness of using one of the two techniques i.e. lane-wise and direction-wise for estimation of capacity. The findings of this study also contributes to the ongoing development of the Indian Highway Capacity Manual (Indo HCM).

Keywords: Speed-flow plots, Lane wise traffic, Directional traffic, Effect of heavy vehicle, Distribution of heavy vehicle, Lane independency
COMPARATIVE STUDY OF PCU ESTIMATION METHODS ON MULTI-LANE URBAN ROAD IN INDIA

Pallav Kumar¹, Joyjeet Chakraborty², Ayush Mishra³, Shrinivas Arkatkar¹*, Gaurang Joshi¹, Ashish Bhaskar³
¹ Sardar Vallabhbhai National Institute of Technology, Surat, Gujarat, India
² MVJ College of Engineering, Bangalore, India
³ QUT, Brisbane, Australia
* Email: sarkatkar@gmail.com

Abstract
The knowledge of traffic volume is extremely important in design and operational analysis of any roadway facility. However, to represent traffic volume in terms of vehicles/hour/direction, would be quite inappropriate, particularly under heterogeneous traffic conditions prevailing in different Asian countries like India. This study puts an emphasis on estimation of Passenger Car Unit (PCU) estimation using different methods on an eight-lane divided carriageway multilane urban road in Delhi. A well calibrated and validated simulation model is developed in VISSIM for the study section to study the variation in PCU at different flow levels. Three methods, which are examined for its accuracy, are: (i) PCU estimation using TRRL (Transport Road Research Laboratory, UK) definition (ii) PCU estimation using Speed-Area Ratio concept (iii) PCU estimation using a proposed methodology in this study. To start with, PCU values of different vehicle categories were determined based on TRRL definition, considering speed and area occupancy as measure in the definition. It is found from the study that both speed and area occupancy as measure for PCU in TRRL definition revealed the same results at different V/C ratio. Thus, it validates the concept of area occupancy for PCU estimation under heterogeneous traffic prevailing on multilane urban road in India. Further, dynamic PCU values were also determined using speed-area ratio concept (Chandra and Sikdar, 2000) and hence, range of PCU values are suggested at any V/C (Volume to Capacity) ratios for the prevailing traffic and roadway conditions on multilane urban road selected in this study. Although, dynamic nature of PCU values is well appreciated, practitioners may prefer single set of optimized PCU values (unique for each of the vehicle categories) for any given range of V/C ratios keeping in view the ease of its application in real-world projects. Therefore, a new methodology using matrix solution is proposed in this study, to estimate the optimized or unique set of PCU values using area occupancy as performance measure for different range of V/C ratios. This method is devised based on two traffic streams (cars-only as well as heterogeneous traffic conditions) at different flow levels.

In order to check the credibility of the three methods mentioned above for PCU estimation, the comparison of converted equivalent traffic flows (PCU/h) obtained using PCU values estimated from different methods with carsonly traffic flow levels (obtained from validated simulation model expressed as passenger-cars/h) is made for same V/C ratios. The results show that the PCU values suggested by Speed-Area Ratio, generally overestimates the flows, at different traffic volumes. However, the values obtained using TRRL definition (considering speed or area occupancy as measure of base) and optimized PCU concept using area occupancy concept are found to be consistent with the traffic flow in cars-only traffic situation at different flow conditions. MAPE (Mean Absolute Percentage Errors) values for TRRL definition, Speed-Area Ratio concept and Optimized PCU (proposed in this study) are found to be 6%, 12% and 7% respectively. Macroscopic speed-flow diagram was also developed by converting heterogeneous traffic flow into homogeneous equivalent using the above mentioned three methods of PCU estimation and 100% Cars scenario. It is found that at capacity level flow, TRRL definition, Speed-area ratio and optimized PCU concept shows difference in capacity as 4%, 8% and 3% respectively when compared with 100% cars capacity. One of the important outcome of this work is set of optimized PCU values proposed at different V/C ranges. These values may be useful for traffic engineers, researchers and practitioners
SAFETY ANALYSIS OF VEHICULAR INTERACTIONS IN MIXED TRAFFIC CONDITIONS

Tushar Kanti Bag¹, Bharath Vardhana Rao Kona¹, K. V. R. Ravi Shankar¹*
¹ National Institute of Technology Warangal, India
* Email: kvrrshankar@gmail.com

Abstract
A rapid growth in the number of vehicles and drivers attitude towards an aggressive behaviour has resulted in lot of safety concerns in the highway sector especially in mixed traffic conditions. The driving behaviour of two wheelers will not be the same as that of other vehicle types. The behavioural characteristics coupled with vehicular characteristics will have a high bearing on the safety aspects. The present research work tries to identify the driver behaviour differences with different vehicles combinations in mixed traffic conditions using following situations. The present research work helps in a better understanding of drivers’ risk making levels and safety of the traffic system.

Keywords: Following behaviour; Vehicular characteristics; Safety parameters; Time to collision

DEVELOPMENT OF PEDESTRIAN LEVEL OF SERVICE ON INDORE BRT CORRIDOR

Tejas Parmar¹*, Pritesh Bhana², S. M. Narulkar³
¹ S.G.S.I.T.S., Indore, India
*Email: tejasrocks91@gmail.com

Abstract
The City of Indore is having a BRTS. Present study is aimed at assessing the Pedestrian Level of Service (PLOS) around BRTS lane. An opinion survey was carried for the qualitative information about the pedestrian amenities for safety and comfort. The results of the survey were converted in to quantitative PLOS indicating the quality of facilities at a station or a group of stations. Factor Analysis, Simple and Weighted Multiple Regression are adopted for the computations. Kaiser-Meyer-Olkin and Bartlett’s tests are performed to evaluate the best combination of parameters. For the computation of the PLOS weighted linear regression was adopted.

Keywords: BRT, Pedestrian Level of Service, KMO & Bartlett’s Test, Weighted Regression
EVALUATION OF CROWDING EFFECT IN MUMBAI SUBURBAN RAIL SYSTEM

Anirban Guharoy¹, Prasanta Sahu²*, Gajanand Sharma², Ashoke Sarkar²
¹ Indian Institute of Technology Bombay, Mumbai, India
² Birla Institute of Technology and Science Pilani, Pilani, India
* Email: prasantsahu222@gmail.com

Abstract
This study deals with evaluating quantitative and qualitative attributes that influence the choice of commuters of suburban rail system in Mumbai, which is one of the most crowded train systems in the world. The effect of crowding on choice of slow or fast moving train was studied by conducting a stated preference experiment. The behavioral data from 250 responses were analyzed using N-logit. A multinomial logit model was developed to understand the level crowding which affects the choice of train type. Model results show that super dense crush load condition in the fast train affects maximally to the users to change their choice to slow moving train. These estimation results may be helpful for decision making and policy framework development on issues related to level of service improvement for the suburban rail system in India.

Keywords: Utility function, Multi-nomial logit model, Stated preference survey, Crowding, Transit user perception

TRAVEL TIME RELIABILITY ANALYSIS ON SELECTED BUS ROUTE OF MYSORE USING GPS DATA

Chethan Kumar M S¹*, Akhilesh Chepuri², Shriniwas S Arkatkar², Pooja Bhanegaonkar¹, Gaurang Joshi²
¹ MVJ College of Engineering, Bengaluru, India
² Sardar Vallabhbhai National Institute of Technology, Surat, India
* Email: chethanmulpur@gmail.com

Abstract
This research study aims at evaluating the travel time reliability indices like Buffer Time Index (BTI), Planning Time Index (PTI) and Travel Time Index (TTI) over space and time on selected city bus route of Mysore city, India. Also, the study focusses on developing the correlation models between the bus journey speed, traffic stream speed (including all vehicles) and flow for different type of urban roadway conditions. Further, the variation of volume-to-capacity (V/C) with travel time reliability indices is also studied in detail. The k-means clustering analysis is performed for classifying the reliability measures with respect to V/C and Coefficient of Variation (CV). It is expected that the developed reliability measures may be useful for defining level of service for bus routes in class-II cities (cities with lesser population than metropolitan cities).

Keywords: Travel time reliability, k-means clustering, Silhouette analysis
MODELLING ESTABLISHMENT BASED FREIGHT GENERATION FOR TWO CITIES IN KERALA
Agnivesh Pani¹, Prasanta K. Sahu*, Ashoke K. Sarkar¹, Gopal R. Patil²
¹Birla Institute of Technology and Science Pilani, India
²Indian Institute of Technology Bombay, Powai, India
* Email: prasantsahu222@gmail.com

Abstract
This paper discusses a set of city wide freight generation models for Cochin and Palakkad. The models are developed with three representatives of establishment business size such as employment, floor area and business years. Ordinary least square linear regression method is used to understand the association of business size with freight activity. The estimation results revealed that business size could able to explain up to 96% of freight generation from establishments. These models are expected to be useful for facility planning such as freight corridor development, establishment accessibility planning and logistics planning. Additionally, the models can give some insight while assessing the impact of freight activity on regional economic development.

Keywords: Freight generation, FG models, Regression, Establishment survey, Business size

PERFORMANCE OF PREDICTIVE SPATIO-TEMPORAL QUERY PROCESSOR FOR PREDICTING TRAFFIC CONGESTION
Pankaj Mukheja¹*
¹ Indian Institute of Technology Bombay, Mumbai, India
* Email: pankaj.mukheja@iitb.ac.in

Abstract
Increasing attention is being given to analysis of human location histories due to the widespread usage of GPS that allow users to share location-based services information which can help in prediction of human movement and congestion control. For this work, Spatio-temporal queries become more relevant when future locations are predicted and this overall analysis of human behaviour will provide good approach to predict congestion in a road network and also help in traffic management. Existing approaches predict location information of moving objects without considering road conditions and traffic which limits their prediction accuracy as vehicle cannot run continuously at a constant speed in real world. "Predicting Future Location using Markov Model (PFLMM)" is proposed which overcome this deficiency of existing models. In this proposed model, traffic and road conditions impact is incorporated in the form of travel time. Comparing with the existing location prediction model PFL-MM allows us to account with location characteristics as unobservable parameters, with the effects of each individual's previous actions.

Keywords: Markov Models, Spatio-temporal queries, Traffic management, Congestion, Traffic Prediction
PAVEMENT PERFORMANCE MODELS ON VARIOUS GEOGRAPHIC AND TRAFFIC CONDITIONS

Sourav Behera\textsuperscript{1*}, Harsha V.\textsuperscript{1}, M. R. Archana\textsuperscript{1}, Anjaneyappa\textsuperscript{1}, M. S. Amarnath\textsuperscript{2}

\textsuperscript{1} RV College of Engineering, Bangalore, India
\textsuperscript{2} Bangalore University, Bangalore, India
* Email: sourav.boney@gmail.com

Abstract
Performance prediction model characterizes a significant component of road infrastructure asset management system or pavement management system. These models are effective to calculate any distress parameter based on performance declining level. An attempt has been made in his paper to provide a most suitable pavement performance distress model for predicting the characteristic deflection of flexible pavement. This models are based upon linear regression analysis to predict the deflection with substantial precision, based on different pavement related data. To develop the models 20 trial section of roads selected from southern part of India and monitored throughout its design period. As pavement performance is directly related to deflection of pavement under a wheel load, surface deflection was considered as major parameter for evaluating performance of flexible pavement. Rest of the collected data includes data related to age, pavement thickness, traffic, moisture content, CBR, plasticity index, original pavement thickness. The basic relationship between deflection and 5 independent variables were established with respect to various traffic condition and soil types. Statistical analysis tool “ANOVA” from MS Excel was used to develop the performance deterioration models. Validation for chosen best fit model was carried out.

Keywords: Pavement Serviceability Index, Rebound Deflection, Pavement Performance, Linear Regression Analysis

VISCOELASTIC CONTINUUM DAMAGE ANALYSIS FOR BINDERS USING DYNAMIC SHEAR RHEOMETER

D. Latha\textsuperscript{1*}, V. Sunitha\textsuperscript{1}, Samson Mathew\textsuperscript{1}

\textsuperscript{1} National Institute of Technology Tiruchirappalli, India
* Email: latha.dharmarajan1@gmail.com

Abstract
Viscoelastic Continuum Damage (VECD) analysis has been carried out on the bituminous binder. The characteristics of the rate of damage accumulation in the binder can be used to evaluate the fatigue performance of the asphalt binder. The results indicate that PMB 40 (E) has more fatigue resistance than VG30 binder since the number of cycles to Failure, \(N_f\), is higher for all applied strains in PMB 40 (E) binder. It gives an expected result that the polymer modified binder is used to improve the fatigue behavioral performance of the bituminous pavement.

Keywords: Rheology, Unmodified and Modified Binder, Linear Amplitude Sweep, Damage Analysis
PHASE PRIORITIZATION AND DELAY MINIMIZATION APPROACH FOR COORDINATED SIGNAL SYSTEMS OF FOUR ARM INTERSECTIONS

Shah Pranay M.1*, Varia H. R.2
1 Government Polytechnic, Godhra, India
2 Tatva Institute of Technological Studies, Modasa, Gujarat, India

* Email: pranaymshah@rediffmail.com

Abstract
This paper discusses three phase plans with time-space diagram to solve two-way coordination problem. Phase Prioritization in Delay Minimization Scheme 1 (DMS1) reduces delay and treat all movement more judiciously. Equal cycle with demand responsive phase timing in DMS 2 is effective for reduction of delay up to 41.29% to 98.24% in both the direction for right turner and straight movers. Application of phase prioritization with equal cycle and equal phase length in DMS 3 reduces right turner delay up to 64.31% and unobstructed movement for straight traffic along the corridor in both directions.

Keywords: Phase prioritization, Two-Way coordination, Delay Minimization Scheme and Time-space diagram

LATERAL GAP MAINTAINED BY VEHICLES UNDER CONSTRAINED CONDITIONS

Anuj Kishor Budhkar1, Nilanjan Adhikary1, Akhilesh Kumar Maurya1*
1 Indian Institute of Technology Guwahati, Guwahati, Assam, India
* Email: maurya@iitg.ernet.in

Abstract
This paper evaluates the change in lateral clearance maintaining behavior of a vehicle under constrained condition (interacting with two vehicles on either side simultaneously) versus unconstrained condition (interacting with one vehicle at a time) in a heterogeneous weak lane discipline traffic. Instrumented vehicle equipped with ultrasonic sensors and GPS devices measure lateral clearance and vehicle speeds in real traffic stream. Collected data shows that lateral clearance maintained between interacting vehicles increases with the speed. Vehicle under constrained conditions maintains lesser gap than unconstrained condition i.e. vehicle compromises from safety under such constrained condition.

Keywords: Lateral gap, Heterogeneous traffic, multiple vehicle interaction, Ultrasonic sensors
SPEED PREDICTION MODELS OF FOUR-LANE HORIZONTAL CURVES FOR INDIAN
DRIVING BEHAVIOR

Suresh Nama¹*, Gourab Sil², Akhilesh Kumar Maurya¹, Avijit Maji²
¹ Indian Institute of Technology Guwahati, Guwahati, Assam, India
² Indian Institute of Technology Bombay, Mumbai, India
* Email: nsureshce@gmail.com

Abstract
The aim of this research is to develop operating speed prediction models of cars and trucks in four-
lane highway facility. A range of explanatory variables like radius, curve length, gradient, superelevation and extra widening are used to predict operating speed at point of curvature, center of curve and point of tangent. The geometric features and vehicle speed data from NH-47 and NH-3 are used to develop and validate the models, respectively. These models are explicitly for Indian driving behavior in mountainous terrain and can be helpful in designing safer horizontal alignment.

Keywords: Operating speed, Speed prediction model, Mountainous terrain, Horizontal curves, Four-lane highway

PERFORMANCE BASED DESIGN FOR RURAL ROADS WITH 50% RELIABILITY

Dhany Vinay Kumar¹, Printal Chandra Halder¹, T. L. Rytathiang¹*
¹ Indian Institute of Technology Guwahati, Guwahati, Assam, India
* Email: lyngdoh@iitg.ernet.in

Abstract
The programme, Pradhan Mantri Gram Sadak Yojana (PMGSY) that was started by the Govt. of India in 2002, saw two important publications related to pavement design - ‘Rural Road Manual’ in 2002 for flexible, rigid and special pavements and IRC special publication, “SP:72-2007”, in 2007 exclusively for flexible pavement. SP:72 provides pavement catalogue for different axle load repetitions with respect to subgrade CBRs. Though one can select a pavement composition from the publication for a particular ESAL and CBR; yet the criteria for design is not spelled by the publication. Therefore, in the present study, a 50% reliability model based on performance data as per IRC 37-2012 with rutting criteria was developed and pavement design was carried out using IITPAVE. A design catalogue was developed with a comparison to SP:72.

Keywords: Flexible pavement, 50% reliability, rutting criteria, IITPAVE, pavement catalogue
EFFECT OF SIDE FRICTION ON THE TRAFFIC FLOW BEHAVIOUR OF MULTILANE DIVIDED URBAN ROAD AT MID-BLOCK SECTIONS

G. Pallavi¹*, Arpan Mehar¹, D. Neeraja¹
¹ National Institute of Technology Warangal, India
* Email: pallavi.gulivindala@gmail.com

Abstract
Side friction activities are generally observed on urban roads located in and around city centres or commercial zones. Side friction on a roadway not only restricts the continuous or smooth vehicular flow movement but also affects maximum flow and level of service. Present study estimates the effect of side friction events on traffic flow variables and analyses the maximum flow. No significant reduction in stream speed is found from lower to medium levels of side friction but the reduction was found significant at higher traffic flow level. Keywords: Side friction, urban roads, traffic characteristics

Keywords: Side friction, urban roads, traffic characteristics

VEHICLE TRAJECTORY CORRECTION USING EMPIRICAL MODE DECOMPOSITION

Dibyendu Pal¹*, C. Mallikarjuna²
¹NERIST, Nirjuli, Arunachal Pradesh, India
²Indian Institute of Technology, Guwahati, India
*Email: d.pal@iitg.ernet.in

Abstract
Analysis of microscopic traffic data such as instantaneous speed, acceleration, longitudinal headways, lateral gap, etc. is essential for microscopic traffic flow modeling. Most of these data can be extracted from the vehicle trajectories. In this study, the vehicle trajectories were extracted using image processing software, TRAZER. The obtained raw trajectories usually contain processing errors. The raw trajectories were corrected using Empirical Mode Decomposition (EMD) technique. The comparison of the observed (obtained using V-Box) and the smoothed data showed that the application of this method results in more accurate trajectory data. The same was also evident from the comparison of results obtained using various other techniques.

Keywords: Trajectory correction, Trajectory smoothing, EMD, TRAZER, Heterogeneous traffic

EVALUATION OF MICROSURFACING MIX FOR PAVEMENT PREVENTIVE MAINTENANCE WITH TYPE II AGGREGATE

Printal C. Halder¹*, Luckystar Syiemiong¹, Teiborlang L. Rytathiang¹
¹Indian Institute of Technology, Guwahati, India
*Email: printal@iitg.ernet.in

Abstract
Microsurfacing being the most advanced preventive method and low-cost have been known to retard deterioration of the pavement and increase the service life of the pavement by 3 to 8 for relatively heavy traffic and may be considerably longer for low to medium traffic. This paper presents the
laboratory studies on microsurfacing mix by Wet Track Abrasion Test, Loaded Wheel Test and Schulz Breuer Abrasion Test that was carried out on aggregate collected from a crusher plant located close to IIT and on emulsion manufacture by local company. Based on the studies, it was observed that microsurfacing mix are able to pass the Wet Track and Schulz Breuer tests but not the Loaded Wheel Test.

**Keywords**: Aggregate, Emulsion, Wet Track Abrasion Test, Loaded Wheel Test and Schulz Breuer Abrasion Test

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**STUDY OF DIFFERENT VEHICLES’ LATERAL PLACEMENT AND SPEED ON INDIAN ROADS**

Subhadip Poddar¹, Geetimukta Mahapatra¹, Akhilesh Kumar Maurya¹*

¹Indian Institute of Technology, Guwahati, India

*Email: akmaurya@gmail.com

**Abstract**

With the heterogeneous and no-lane disciplined traffic on Indian roads, the lateral placement of a vehicle becomes one of the most critical parameter to define the speed of the vehicle. Road width, an important parameter for lateral placement, is studied in this study.

Video recording was carried out on four different road geometries and the lateral placement and speed of different vehicles are determined using a trajectory tool. Using these, grouped scattered plots were compiled and finally the speed versus lateral placement are studied for different vehicle types on same road and same vehicle type on different roads.

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**STUDY OF PEDESTRIAN BEHAVIOUR ON WALKWAY AND SIDEWALK FACILITIES FOR A COMMERCIAL AREA IN GANGTOK, SIKKIM**

Arunabha Banerjee¹*, Akhilesh Kumar Maurya¹

¹Indian Institute of Technology, Guwahati, India

*Email: arunabhabanerjee77@gmail.com

**Abstract**

The aim of the paper is to study pedestrian behaviour on walkway and sidewalk facilities using quantitative method along with general pedestrian characteristics which affect walking speed such as age, gender and carrying of luggage or not for a commercial cum shopping area in Gangtok, Sikkim. Data were collected during peak hours and pedestrian flow characteristics like speed, flow rate and density were estimated. Results show that pedestrian flow characteristics are highly affected by age, gender and presence of luggage.

**Keywords**: Walkway, sidewalk, quantitative method, flow characteristics, statistical analysis, fundamental relationships
**EVALUATING SERVICE CRITERIA OF URBAN STREETS IN DEVELOPING COUNTRIES BASED ON ROAD USERS’ PERCEPTION**

Suprava Jena¹*, Priyanka Atmakuri², Prasanta Kumar Bhuyan¹

¹NIT Rourkela, India  
²IIT Madras, India  
*Email: suprava728@gmail.com

**Abstract**

The objective of this research is to develop a model with the help of road user’s satisfaction survey that can be used to assess Level of Service (LOS) delivered by urban street segments in developing countries. A questionnaire was developed related to the factors affecting user’s satisfaction. The 33 questions are summarized into eight uncorrelated sets of variables using factor analysis. Multiple linear regression analysis was carried out with a R² value of 0.709 considering eight factors as independent variables and Overall Satisfaction (OS) as dependent variable. The OS scores are classified into six LOS classes by applying k-means clustering.

**Keywords**: Level of service, Road user perception, Factor analysis, Multiple linear regression, k-means clustering

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**ESTIMATION OF PEDESTRIAN SAFETY INDEX VALUE AT SIGNALIZED INTERSECTIONS**

S. Marisamynathan¹*, P. Vedagiri¹

¹Indian Institute of Technology Bombay, Mumbai, India  
*Email: marisamy1989@gmail.com

**Abstract**

The movement of pedestrians in the urban environment is vital for sustaining the social and economic relationships which are essential to the quality of life and it is important to maintaining a healthy life. To enhance pedestrian safety, there is a need to improve the pedestrian facilities at signalized intersections. The objective of this study is to develop pedestrian safety index model in crosswalks at signalized intersections under mixed traffic conditions. The required data were collected from selected eight signalized intersections in Mumbai, India by conducting video graphic and questionnaire survey. Pearson correlation test was performed to identify significant factors with respect to pedestrian perceived safety index score. Stepwise linear regression method was applied to develop safety index model at 95% confidence interval and k-means clustering was used to define the threshold values for each safety index rating. The proposed model and threshold values were validated with selected ninth location in Mumbai, India. The validation results prove that the proposed model and threshold values were estimate accurate safety level of pedestrian at signalized intersection. Finally, the sensitivity of each model variable was analysed with respect to Tornado diagram and improvement measures were applied and analysed theoretically at selected signalized intersection. This study is helpful to improve existing conditions of intersections and recommends for adequate facilities to be provided to the pedestrians to cross the crosswalk with safety and comfort.

**Keywords**: Pedestrian, Safety Index, Signalized Intersection, Regression, Clustering
EFFECT OF VEHICULAR COMPOSITION IN IDEAL-SECTION CAPACITY OF DIVIDED URBAN ROADS IN INDIA

Shankara S¹, Kalaanidhi S², Karthiga K¹, Gunasekaran K¹*
¹Anna University, Chennai, India
²NIT Karnataka, Mangalore, India
*Email: kgunasekaran@hotmail.com

Abstract
Estimation of capacity of urban roads is required for infrastructure enhancements and transport planning of urban road network. Indian traffic is heterogeneous in terms of vehicle type and driving behaviour. Adopting the capacity values suggested for developed countries has limitations. Many studies are attempted to estimate the capacity of urban roads in India. The non uniformity in vehicle composition observed on roads of Indian cities has often posed challenge in arriving capacity values of urban roads. The variations in capacity values obtained from traffic flow measurements in various Indian cities needs an introspection to identify the underlying reasons. In this study, the reasons for such variations were analysed to quantify the influence of the traffic composition on the carrying capacity of urban roads.

Keywords: Urban Roads, Operating Speed, Lane Capacity, Traffic Composition

AN APPROACH OF ESTIMATING VEHICLE EQUIVALENCY FACTORS AT TOLL BOOTH IN INDIA

Yogeshwar V. Navandar¹, Ashish Dhamaniya¹*, Dilip A. Patel¹
¹SVNIT, Surat, India
*Email: adhamaniya@gmail.com

Abstract
The present paper introduced the concept of equivalency factors at toll booths. Two approaches for estimating PCU values have been discussed. The service time approach gives higher PCU values for a vehicle type as compared to headway approach. This variation in service time and headway may be due to the mixed flow and varying toll rate for different vehicle types requires more attention of the operator. Collected data at two toll plaza shows that there is a wide variation in service time and headway of a vehicle type that leads to the variation in PCU values. The study may be useful for planner to improve the design of toll booth in order to achieve its maximum effectiveness.

Keywords: Equivalency Factor; Service time; Headway; Toll Booth; Mixed Traffic
MICROSCOPIC AND MACROSCOPIC DIAGNOSIS OF THE IMPACT OF WEATHER CONDITIONS ON TRUCK TRAFFIC PATTERNS IN REGIONAL URBAN COMMUTER TYPE HIGHWAY

Hyuke Jae Roh1*, Satish Sharma1, Prasanta Sahu2
1City of Regina, Regina, Canada
2Birla Institute of Technology, Pilani, India
*Email: roh204@uregina.ca

Abstract

Literature indicate that the total traffic and passenger car volumes are influenced by both snowfall and cold temperature, but the total truck volume is not greatly affected. This paper aims to confirm that truck traffic is not affected by weather condition both at micro and macro level of analysis. Micro level impact analysis is carried out to investigate the variations of truck traffic volumes at different levels of snowfall and temperature. Macro level analysis is conducted to investigate month to month (or season to season) truck traffic variations. The trucks are classified into single-unit trucks, single-trailer, and multi-trailer units and non-parametric Chi-squared test combined with Binomial probability test are utilized for the analysis. As a case study, the research is conducted with truck traffic data collected for 5 years from 2005 to 2009 from a Weigh-In-Motion (WIM) site located on Highway A, which can be classified as regional urban commuter type highway due to its closeness to the City of Leduc, Alberta, Canada. Non-parametric test results indicated that truck type distribution was not affected by winter conditions. Truck traffic variation is not associated with the months or seasons either. In other words, the proportion of each truck types is maintained stable during the 5 years study period. It is believed that the findings of this study can provides insights helping highway agencies in developing programs and policies related to efficient monitoring of truck traffic throughout the year.

INFLUENCE OF CEMENT-AGGREGATE INTERFACE ON EVALUATION OF ULTRASONIC PULSE VELOCITY TEST FOR RIGID PAVEMENT

Subair M.1, Moorthi P. V. P.2, Aniruddha T.3, Sanket R.3, Bahurudeen A.3*
1Indian Institute of Technology Madras, India
2Indian Institute of Technology Bombay, India
3Birla Institute of Technology and Science, Pilani, India
*Email: bahurudeen.civil@gmail.com

Abstract

In the present era, infrastructure development is measured as a backbone for development of any country. In addition to construction of new highways and bridges, considerable funding is allotted for assessment, maintenance, and repair. Due to exceptionally high cost of construction, it is not preferred to replace the structure entirely and hence, maintenance and repair are chosen over the replacement. Non-destructive techniques are widely used for rigid pavement assessment to attain scientific insight on damages with more accuracy in less time. Ultra-sonic pulse velocity (UPV) test is one of the Non-destructive test and it is universally used in the assessment of rigid pavements and bridges. Although significant number of previous research studies focused on UPV testing, a comprehensive evaluation of modelling on propagation of ultrasonic waves and its influence of interfacial transition zone are not reported in the existing literature. The paper describes simulation and interpretation of ultrasonic wave propagation through concrete specifically in the interfacial transition zone (ITZ). As numerical models and simulation are gaining colossal importance in the
modern computerized era, hence the study will act as a robust technique for the design engineers to accurately simulate the UPV to achieve proper assessment. In the study, concrete with different voids were modelled using ABAQUS with inclusions of elastic aggregates for low grade concrete. Moreover, propagation of ultrasonic waves and corresponding velocity were measured. Results from the study showed significant reduction in velocity with increase in voids in the concrete system.

**Keywords**: Ultrasonic-pulse velocity, interfacial transition zone, simulation, non-destructive testing, internal flaws, cracks, finite element analysis

**Abstract**

Behaviour pattern of pedestrians and motorists significantly influences the occurrence of pedestrian accidents while crossing road under heterogeneous traffic conditions. Due to inadequate pedestrian infrastructure facilities, pedestrians may lead to unsafe situation while crossing the road. Generally, at mid-block sections of road, pedestrians may have to cross in presence of different vehicles, which in turn lead to conflict zone, both for pedestrians as well as approaching vehicles, resulting into a serious threat at uncontrolled midblock crossing locations, particularly under mixed traffic conditions. In order to understand the behavioural characteristics of pedestrians while crossing the mid-block, pedestrian data related to individual characteristics (age, gender, luggage condition), delay at curb side, gap acceptance behaviour, rolling gap (stage wise gap acceptance), pedestrian-vehicular conflict, and effect of platoon size gap acceptance are collected using videography survey. Results from the study shows that the pedestrians size different speeds depending on city characteristics, and geographical condition. It was found that younger pedestrians walk faster than the rest. Similarly, based on gender basis male pedestrians walk faster than female. It was also found that with increase in number of traffic lanes and vehicular flow, pedestrian crossing time increases and hence results in stage wise crossing. Study results show that the male pedestrians bear less waiting time compared to female, attributing there by higher probability of accepting gap with more risk. Further, it is observed that delay at curb side is higher due to rejection of smaller gaps but same gap can be accepted due to increase in platoon size and also due to behaviour while crossing pedestrian rolling. It is expected that the inferences from the results can be useful for deriving few measures for operational monitoring of pedestrian facility with suitable safety measures.

**Keywords**: Pedestrian, Crossing behaviour, Delay, Mid-block, Uncontrolled
COMPARITIVE STUDY OF PEDESTRIAN FLOW CHARACTERISTICS AT SELECTED MIDBLOCK CROSSWALKS SECTIONS IN INDIA

Vinayaraj V. S.1*, A. R. Chaudhari1, Shrinivas S. Arkatkar1, Guarang Joshi1
1SVNIT, Surat, Gujarat, India
*Email: vinayaraj4u@gmail.com

Abstract

In India, most of the pedestrian uncontrolled crossings at midblock are observed on urban roads. At mid-block, there are higher chances of conflict between a crossing pedestrian and an approaching vehicle. Therefore, uncontrolled midblock pedestrian road crossing is a serious menace, particularly under heterogeneous traffic flow conditions. For the present study, in order to corroborate the influence of physical characteristics of the facility, geometry, and cultural diversity of folks, two different locations (study sites) have been selected in the western cities of India, namely Mumbai and Ahmedabad. The field surveys were carried out through videographic technique, which captures the mixed traffic flow and pedestrian crossing pattern at both the study sections during 8:00am to 6:00 pm. The present research work is carried out to focus on the determination of pedestrian critical gap using Maximum Likelihood Method (MLM), Raff’s Method, Root Mean Square (RMS) Method, and Probability Equilibrium Method (PEM). Further, a gap acceptance behaviour model is to be developed at uncontrolled mid-block crosswalk section for Indian urban road conditions. The study results reveal that vehicle speed and rolling gaps are the important parameters for a pedestrian uncontrolled road crossing. The results of this study may be useful to design pedestrian facility and suggest appropriate remedial measures to improve pedestrian safety.

Keywords: Pedestrian speed, Mid-block, Critical Gap, behavior, Raff method, RMS, MLM, PEM, Gap acceptance

INVESTIGATING THE INFLUENCE OF AGE TOWARDS BICYCLIST’S ROUTE AND MODE CHOICE: A CASE STUDY OF ASANSOL CITY, INDIA

Bandhan Bandhu Majumdar1*, Sudeshna Mitra1
1IIT Kharagpur, Kharagpur, India
*Email: bandykolkata@gmail.com

Abstract

This paper evaluates user perception towards bicycle route and mode-choice in a discrete choice modelling framework based on perceived-benefit or WTP in Asansol, India. For the stated purpose, a set of key attributes influencing bicycle route-choice (level-of-risk, route-visibility, road-width, bicycle-operating-cost, bicycle-journey-time) and mode-choice (physical criterion, bicycle-parking-facility, bicycle-operating-cost) were used to design a stated-preference (SP) survey and collect user-perception. Random-Parameter Logit (RPL) model was used for modeling bicyclist-perception. Also separate models are developed for two age-groups to elicit the influence of age on user-perception. Results reveal level-of-risk and bicycle-parking-facility to be the most influencing factor towards bicycle route and mode-choice respectively.

Keywords: Bicycle, Age, route choice, mode choice, Willingness-To-Pay (WTP), Random Parameter Logit (RPL)
BARRIERS AND FACILITATORS TO BICYCLE USE IN URBAN FRINGES OF BHOPAL

Premjeet Das Gupta*, Jagannath Das¹, Jyoti Yadav¹
¹School of Planning and Architecture, Bhopal, India
*Email: premjeet@spabhopal.ac.in

Abstract
A pilot study was conducted in the urban fringes of Bhopal to learn about the perceptions of the environment in which cycling takes place, study the trip-making pattern on socio-demographic, socio-economic and trip-related dimensions, and validate the studied perceptions through both active cyclists as well as individuals currently not cycling. Bicycle trips accounted for 15% of the total reported trips with proportion of bicycle trips in work trips being double that in non-work trips. Some of the perceptions initially gathered regarding aspects of the environment that discourage and encourage bicycle use did not seem to be valid when tested through a questionnaire survey.

Keywords: Bicycle, urban fringe, rural, village, Bhopal, environment, perceptions, trip purpose, average trip length

ACCIDENT PREDICTION MODELING OF A MAJOR ROAD OF AHMEDABAD

Punit Goyal¹*, Sanskruti Joshi¹, Hemanth Kamplimath¹, Dhruv Prajapati¹
¹Institute of Technology, Nirma University, Ahmedabad, Gujarat, India
*Email: 13bcl030@nirmauni.ac.in

Abstract
In today’s time due to galloping urbanization and development ridership has increased. This has subsequently led to perilous situations for drivers as well as for pedestrians as the number of accidents over the past years has significantly increased. The study focuses on developing a regression model to predict the number of accidents along the selected stretch of road in Ahmedabad city of India. Best fit trends for various parameters have been found and among the selected parameters various linear regressions have been carried out to arrive at the best model from the analysis using MS Excel 2007 and Origin Software.

Keywords: Road Accidents, Accident Prediction, Road Geometrics, Traffic Volume

STUDY ON EFFECT OF GRADIENT ON STREAM EQUIVALENCY FACTOR FOR UNDIVIDED TWO LANE HIGHWAYS

Deepika Mohan*, Bino I. Koshy¹, Anusha S. P.²
¹Rajiv Gandhi Institute of Technology, Kottayam, Kerala, India
²College of Engineering, Thiruvananthapuram, Kerala, India
*Email: deepikamohan93@gmail.com

Abstract
The concept of Passenger Car Unit has been widely used for dealing with heterogeneous traffic. At present, most studies make use of static values suggested by Indian Road Congress which proves inadequate as these values fail to replicate the pronounced dynamic effect of each category of vehicle. Stream Equivalency Factor (SEF) as proposed in recent research has proved the dynamic
nature of Indian traffic. The aim of this paper is to develop SEF for undivided two lane highways with the main focus in studying its effect on varying gradient. The generalized solution determines SEF for any combination of observed vehicles and specified geometric features.

**Keywords:** Passenger Car Unit; Stream Equivalency Factor; Heterogeneous traffic

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**EVALUATION OF CABLE PROPELLED TRANSIT (CPT) SYSTEM: A CASE STUDY OF VASHI AREA, MUMBAI**

Palaniappan S.1, Rohan Joshi1*, K. V. Krishna Rao1
1 Indian Institute of Technology, Bombay, India
*Email: rohanjoshi.92@gmail.com

**Abstract**

Cities are regarded as engines of growth for a country in the 21st century. For smooth functioning of the city, a multimodal integrated public transport is needed. Solving the problem of last mile connectivity will attract more users towards public transport. An innovative transit system like cable propelled transit (CPT) can be very viable and efficient to act as a last mile connector. This paper aims to evaluate Cable propelled transit (CPT) system as an access mode to mass transit systems proposed in Mumbai A simple quick estimation technique was developed to estimate the travel demand using SP & OD survey data.

**Keywords:** Cable propelled transit, SP survey, Last mile connectivity, access mode

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**REVIEW OF TRANSPORT-RELATED EMISSION ESTIMATION STUDIES**

Srinath Mahesh1*, Gitakrishnan Ramadurai1
1 Indian Institute of Technology Madras, Chennai, India
*Email: srinath.nda@gmail.com

**Abstract**

Transport sector contributes significant amount of emissions in urban areas leading to deterioration in air quality. Quantifying these emissions is a difficult task and many researchers have used different approaches based on the mode of transport, scale of estimation, or type of pollutants. This review summarizes emission estimation studies conducted worldwide and discusses the results obtained. Heavy-duty vehicles are major sources of particulate matter emissions whereas passenger cars emit significant volume of carbon monoxide. This review also highlights the increasing attention on quantifying emissions from transport sector by developing sophisticated models and the lack of consensus among researchers regarding the model to be used. Further, the mitigation measures adopted in different regions are discussed and recommendations for reducing emissions from transport sector are suggested focusing on Indian conditions.

**Keywords:** Emission models, transport, air pollution, emission mitigation
EVALUATION OF THE EFFECT OF GEOMETRY OF RECYCLED PET FIBRE ON THE PROPERTIES OF CONCRETE FOR RIGID PAVEMENT

Abhishek Kumar¹, S. K. Suman¹*
¹National Institute of Technology Patna, Bihar, India
*Email: sksuman@nitp.ac.in

Abstract
The aim of this paper is to fruition waste material like PET bottles in concrete pavement to saves natural resources, saves energy and reduces solid waste. An experimental investigation was carried out to look over the effect of five geometrical shapes of PET fibres on M30 concrete characteristics after adding 0.5% fibres by volume of concrete. Multiple physical, mechanical and performance experiment were performed on concrete constituent materials along with fresh and hardened concrete. SCCF indicates better improvement in results when added in the concrete mix. Therefore, this may be utilized in concrete pavement construction to bridge cracks, increase ductility and reduce permeability.

Keywords: Polyethylene Terephthalate (PET), ductility, mechanical properties, Ultrasonic pulse velocity

ROAD GEOMETRY PARAMETERS COMPUTATION USING MOBILE TERRESTRIAL LASER SCANNING

Manohar Yadav¹*, Ajai Kumar Singh¹, Bharat Lohani²
¹Motilal Nehru National Institute of Technology Allahabad, Allahabad, India
²Indian Institute of Technology, Kanpur, India
*Email: ssmyadav@gmail.com

Abstract
Periodical measurement of road geometry parameters is important for road condition assessment and budget planning for road maintenance. Mobile terrestrial laser scanning (MTLS) is frequently used for roadway data collection due to its capability of accurate and dense three dimensional data acquisition at highway speed. High-precision road terrain obtained in terms of point cloud data is used as basic data for road geometry parameters computation. A new method is proposed in this research paper for computing road geometry using MTLS road surface data points. Convex hull and TIN based approach is used to compute road boundary points using road surface points. Then equation of line as a best fit polynomial is used to draw road boundary lines followed by computation of road centerline. MTLS data points at road boundary and road centerline are used to compute road slopes. The root mean square error (RMSE) of 2.1%, 2.5%, and 2.2% for longitudinal slope, cross slope (left lane), and cross slope (right lane), respectively were obtained. Proposed method works efficiently on MTLS data points of complex and heterogeneous India roadway scene.

Keywords: Mobile terrestrial laser scanning system (MTLS), Road geometry parameters, longitudinal slope, Cross slope
PROGRAM LEVEL ANALYSIS USING HIGHWAY DEVELOPMENT AND MANAGEMENT MODEL (HDM – 4): A CASE STUDY

Pavan R. Vyas¹*, Anjaneyappa¹, B. Ravi²
¹R. V. College of Engineering, Bengaluru, India
²Karnataka Public Works Ports and Inland Water Transport Department. Karnataka, India
*Email: pavanrbetta@gmail.com

Abstract
Three road section of about 140 km part of the core road network of the State Highways in Kolar district of Karnataka State are selected, as they contain all type of traffic conditions. The functional condition data which includes roughness in IRI, rut depth surfaces distress like cracking, raveling, patching including geometric characteristics are collected using Road Measurement and Data Acquisition System (ROMDAS) Equipment. The structural condition of the pavement was determined using a falling weight deflectometer. Deflection bowl data are collected at every kilometer. The maintenance and rehabilitation history, current pavement compositions and layer thickness, traffic volume are collected from the Karnataka Public Works, Ports and Inland Water Transport Department for all road sections. A program analysis is performed using HDM – 4 software with an analysis period of 10 years and assuming a discount rate of 12%. The output of the analysis includes the deterioration of the pavement, the change in deterioration of the pavement on application of different maintenance and rehabilitation strategy. The economic indicators like Internal rate of return and Net present value / Cost ratios are obtained for different maintenance strategies. Four different budget constraints are defined and a budget optimization is carried out in HDM – 4 to obtain the optimum alternative for particular section. The road network can be maintained at 2.94 m/km of IRI for a period of 10 years by spending Rs. 91.75 Crores. The average roughness of the network varies between 2.94 m/km to 3.9 m/km for budget between Rs. 100 – 25 crores for 10 years.

Keywords: Highway Development and Management – 4, Pavement Maintenance, Project Analysis, Pavement Maintenance and Management

IMPROVEMENT OF TRAFFIC OPERATIONS IN CONGESTED INTERSECTIONS – A CASE STUDY OF AGARTALA CITY

Amandeep Jaiswal¹*, Manish Pal¹
¹NIT Agartala, Tripura, India
*Email: matrixaman.jaiswal2010@gmail.com

Abstract
Agartala, the capital city of Tripura, faces traffic congestion at different human operated unsignalized intersection. Intersections are usually considered as the critical points within the network and the evaluation of their performance provides valuable understanding and useful indication about the performance of the system. The vissim software helped identify the problems faced during traffic flow, mainly overcrowding at the stretch of road and the queue length. Successful implementation of traffic signals in Paradise Chowmuhani(meaning intersection), Agartala; several other intersections in the city can be taken into consideration and traffic flow can ease congestion in the intersection, the risk of right-angled crashed was reduced , which in turn can help ease the flow of traffic.

Keywords: Congestion, traffic operation, VisSim software, intersection
STUDY OF INTERACTION OF MOTORISED TWO-WHEELERS ON ‘RURBAN’ HIGHWAYS UNDER MIXED TRAFFIC CONDITION

P. A. Godse1*, V. S. Hokam2, V. S. Landge2
1Priyadarshini Indira Gandhi College of Engineering Nagpur, India
2Visvesvaraya National Institute of Technology (VNIT) Nagpur, Maharashtra, India
*E-mail: parimalgodse@gmail.com

Abstract
A new terminology ‘Rurban’ highway has been introduced in the paper to demonstrate traffic condition on rural-urban road links. A car-following model; Enhanced Intelligent driver model (IDM) and lane-change model MOBIL has been incorporated in the development of the microscopic simulation tool-Passing Simulation PASSIM. The proposed model parameters are calibrated as per Indian traffic condition. In the present paper, PCUs have been estimated using this tool at different composition of two-wheelers. An interaction of twowheelers represented through variation in acceleration/deceleration rate, average traffic stream speed and average operating speed of each type of vehicle on four-lane divided rurban highway.

Keywords: motorized two-wheeler; multilane rurban highway; mixed traffic; PCU; speed; car-following; lane-change; adaptive cruise control; microscopic simulation

NON-LANE-BASED MICROSCOPIC MODELLING UNDER HETEROGENEOUS TRAFFIC CONDITIONS

Venkata Varsha Gandla1*, Moses Santhakumar1
1NIT Tiruchirappalli, India
*Email: gvvarsha93@gmail.com

Abstract
Efficient modelling of vehicular traffic has become the most debated issue in India, where heterogeneous traffic conditions exist. Most of the studies done are for homogeneous traffic streams. In India, it is commonly observed that vehicles will move into available gaps. The absence of lane discipline implies that a vehicle interacts longitudinally as well as laterally. Neural networks can replicate the uncertainties of this kind of vehicular behaviour. Here, neural network is used to model vehicle type and lateral separation-dependent following behaviour. An attempt is also made to model the same using VISSIM, a microscopic traffic simulation software that is gaining acceptability in India. The results show that the neural network modelling is more apt and accurate to predict the vehicle following vehicle behaviour closer to field data.

Keywords: Following Behaviour; Vehicle type; Lateral separation; Microscopic Simulation; Neural Network
APPLICATION OF PAVEMENT PERFORMANCE PREDICTION MODELS FOR MAINTENANCE MANAGEMENT OF INDUSTRIAL ROAD NETWORK

Vivek S. Hokam¹*, Parimal Godse¹, V. S. Landge¹
¹Visvesvaraya National Institute of Technology (VNIT) Nagpur, Maharashtra, India
*Email: vivekhokam@gmail.com

Abstract

The pavement management system is expected to be a critical component of managing and maintaining the transportation infrastructure. Over the years, there has been tremendous support for pavement management, which has a significant influence on its importance to transportation agencies. This paper emphasis on development of pavement performance models for managing the maintenance of industrial road network. The main purpose of this system is to manage a limited annual maintenance budget that the maintenance authority obtains. This system is a combination of maintenance module and budgetary module. In this paper deterioration model due to overloading of vehicles is also discussed.

Keywords: Pavement maintenance, management, rehabilitation, performance, prediction, overloading, deterioration

DEVELOPMENT OF A METHODOLOGICAL FRAMEWORK OF ROAD SAFETY MANAGEMENT FOR INDIAN METRO CITIES

Sudeshna Mitra¹, Dipanjan Mukherjee¹*, T. Subudhi¹
¹Indian Institute of Technology, Kharagpur, West Bengal, India
*Email: ddiipp90@gmail.com

Abstract

In India, systematic planning for road safety management is missing in a large scale. In this study we focus on road traffic safety in urban India with specific focus on metropolitan cities and show how a framework for road safety management could be developed to identify the hazardous areas in a city. For this purpose the concept of risk priority number and equivalent property damage only measures are adopted. Using these measures a macro level ranking of black zones are identified and three distinct groups of zones, e.g. high risk, medium risk and low risk are obtained for network level studies.

Keywords: Road safety management, Risk, Risk Priority Number, Equivalent Property Damage Only
EVALUATION OF PROPERTIES OF RECLAIMED POLYETHYLENE TEREPTHALATE MODIFIED BITUMINOUS CONCRETE MIXES

Rajan Choudhary*¹, Kishori Murkute¹, Abhinay Kumar¹, Ashok Julaganti¹
¹Indian Institute of Technology Guwahati, India
*Email: rajandce@iitg.ernet.in

Abstract

Reuse of waste plastics in asphalt industry has emerged as a promising way to enhance sustainability in highway construction from environmental and economic standpoint. This study attempts to evaluate mix volumetrics, Marshall parameters, and moisture sensitivity characteristics of Bituminous Concrete (BC) mix with Polyethylene Terephthalate (PET) derived from municipal waste. The effect of method of incorporation of PET and PET content on BC mixes is investigated, and results are compared with conventional BC (control) mix. Results showed that addition of PET improved the Marshall stability, stiffness, and moisture damage resistance of BC mixes. Inclusion of PET in BC mixes has shown promising outcomes and appears to be an effective technique to utilize reclaimed PET.

Keywords: polyethylene terephthalate, plastic waste, bituminous concrete, stiffness, moisture damage

EFFECT OF MARKET PENETRATION OF AUTONOMOUS VEHICLES ON THE PERFORMANCE OF ROAD NETWORK WITH MIXED TRAFFIC OF HUMAN DRIVEN AND AUTONOMOUS VEHICLES

Amit Kumar¹, Sabyasachee Mishra²*
¹ Georgia Institute of Technology, Atlanta
² Intermodal Freight Transportation Institute University of Memphis, Memphis
* Email: smishra3@memphis.edu

Abstract

The automated vehicle (AV) technology is rapidly moving towards reality and promises to provide a safer, faster and energy efficient travel. When AVs will be introduced to public they are likely to share the road with human driven vehicles. An adequate planning and infrastructure investment is required to harness maximum benefits of AV technology which entails estimation of network flows. This study proposes a mixed user equilibrium assignment approach for road network under mixed traffic of human driven and automated vehicles. The proposed approach achieves deterministic user equilibrium (DUE) for AVs and stochastic user equilibrium (SUE) for non-AVs while incorporating the benefit of platooning. The mathematical programming formulation for the mixed DUE-SUE traffic assignment problem is proposed and its properties are analyzed. Numerical experiments have been conducted to understand the properties of the proposed formulation. Results of the numerical experiment establishes the validity of proposed formulation. Insights from numerical results also help to understand the effect of market penetration of AVs and variation in model parameters values on the path flows and overall network performance.

Keywords: Mixed traffic assignment problem; mixed user equilibrium; automated vehicles; stochastic deterministic user equilibrium; platooning of automated vehicles
EVALUATION OF MOISTURE-INDUCED DAMAGE OF AN ASPHALT BINDER MODIFIED WITH A WAX-BASED ADDITIVE

Syed Ashik Ali¹*, Rouzbeh Ghabchi², Shivani Rani¹, Musharraf Zaman¹

¹The University of Oklahoma, Norman, USA
²South Dakota State University, Brookings, SD
* Email: syed.a.ali@ou.edu

Abstract
Warm Mix Asphalt (WMA) technologies are known to result in cutting energy consumption and preserving the environment, because of reduced asphalt production and compaction temperatures. Adding wax as a WMA additive to the asphalt binder (called blended binder) results in a reduction in binder’s viscosity, which makes it possible to lower the asphalt production temperature. The present study was undertaken to evaluate the effect of using different amounts (0%, 1.5% and 4%) of a wax-based WMA additive on the moisture-induced damage properties of an Oklahoma binder (PG 64-22). The moisture-induced damage potential of the asphalt binder with one type of Oklahoma limestone was evaluated using the surface free energy (SFE) approach. The SFE study revealed that the use of the wax-based WMA additive is expected to reduce the moisture-induced damage potential of an asphalt mix produced using the aforementioned materials.

Keywords: Warm mix asphalt (WMA), wax-based WMA additive, surface free energy, moisture-induced damage

A MULTI-CRITERIA BASED APPROACH TO IDENTIFY CRITICAL LINKS IN A TRANSPORTATION NETWORK

Amit Kumar¹, Khademul Haque²*, Sabyasachee Mishra², Mihalis M. Goliass², Timothy F. Welch¹

¹ Center for Quality Growth and Regional Development, Georgia Institute of Technology, Atlanta
² University of Memphis, Memphis
* Email: khaque@memphis.edu

Abstract
A wide range of severe and relatively short-term disruptive events occur on transportation networks on a daily basis which causes disturbances to traffic flows. These events have intense impacts on traffic travel time. Moreover, extreme lack of funds is forcing national, regional and local governments to carefully prioritizing their investments. Therefore, reliable quantitative tools are needed so that the allocation of available resources is optimized. In this research, the authors attempt to understand the relative importance of links in a road network and suggest a methodology to rank the links according to three importance factors.

Keywords: link ranking, network investment, traffic assignment, pswarm algorithm
IMPACT STUDY OF ITS PROJECT ON MYSORE CITY BUS TRANSPORT OPERATIONS
USING NON-PARAMETRIC TECHNIQUES

Raviraj H. Mulangi1*
1 National Institute of Technology Karnataka, (NITK), Surathkal, Mangalore, Karnataka, India
* Email: ravirajmh@nitk.edu.in

Abstract

Public transport organization (PTO) is inclining towards usage of intelligent transport system (ITS) to improve their operational efficiency and service to the commuters. Objective of this paper is to identify various parameters and propose methods to evaluate the performance of public transport before and after implementation of ITS. ITS project has been implemented to Mysore City Transport Division (MCTD) in 2012 by Karnataka state road transport corporation (KSRTC). Bootstrapped-Data Envelopment Analysis (DEA) model has been developed and has shown the discrimination between the efficient and inefficient decision making units (DMUs), which was not observed in DEA alone.

Keywords: PTO, ITS, KSRTC, MCTD, performance evaluation, Bootstrapped-DEA

VARYING SPATIAL CRITICAL GAPS AT UNCONTROLLED INTERSECTIONS

Digvijay S. Pawar1*, Gopal R. Patil2
1 Indian Institute of Technology Hyderabad, Kandi, Sangareddy, India
2 Indian Institute of Technology Bombay, Powai, Mumbai, India
* Email: dspawar@iith.ac.in

Abstract

At unsignalised intersections drivers on minor stream are generally at risk because of the difficulty in judging safe gap between major stream vehicles. Any misjudgment by driver may result in collision with major stream vehicles. The concept of varying critical gap has evolved from the fact that driver’s critical gap is not a constant value. This papers provides important insights for determining and analyzing spatial critical gaps of drivers at high speed and medium speed uncontrolled intersections. The Spatial Critical Gap Line (SCGL) fitted for the accepted and rejected gaps using binary logit model provides critical gap values at 15th, 50th and 85th percentile speed. This makes it easier to understand the impact of different speeds on spatial critical gaps. Also the individual effect of conflicting vehicle’s (oncoming vehicle) speed and distance on the subject vehicles (crossing vehicles) decision is modeled. The analysis results revealed that spatial gaps are affected by the speed of the conflicting vehicle whereas the temporal gaps remain unaffected. The spatial critical gaps corresponding to 15th, 50th and 85th percentile speed for medium speed intersections were 32 m, 38 m and 46 m respectively and for high speed intersections these values were 64 m, 76 m and 104 m respectively, clearly stating the effect of speed on spatial critical gaps. The insights from the study can be used to improve the performance and safety of the uncontrolled intersections.

Keywords: Varying Spatial Critical Gaps, speed, uncontrolled intersections, logit model, driver behaviour
ANALYSIS AND MODELING OF TWO-WHEELER-OVERTAKING-LMV MANEUVER IN HETEROGENEOUS TRAFFIC STREAM

Ujjwal Sugandhi1*, C. Malllikarjuna1
1 IIT Guwahati, Assam, India
* Email: ujjwalbusinesssugandhi@gmail.com

Abstract
Traffic streams on urban roads in India consist of various types of vehicles with no lane discipline. Modeling such a kind of traffic stream requires combined treatment of lateral and longitudinal movements of the vehicles. In this study, an attempt was made to understand and model the path selection behavior of the motorized twowheeler (MTW), when traveling in the heterogeneous traffic stream. A motorized two-wheeler traveling in the heterogeneous traffic stream has two alternative paths to choose from, and various factors influence the final choice. The path selection behavior is crucial for modeling the lateral movement behavior at a microscopic level. A binary choice problem was formulated to model the path selection. Width available on a particular path for overtaking or passing and the extent of the shift to any one side has the highest impact on the decision of the MTW in choosing a particular path.

MODELLING PAID ON-STREET PARKING POLICY FOR CBD AREA OF VADODARA CITY USING SOFT COMPUTING TECHNIQUE

Sanjay M. Dave1, G. J. Joshi1*, Kayitha Ravinder2, Nandan H. Dawda3
1 Sardar Vallabhbhai Patel National Institute of Technology, Surat, India
2 CSIR-Central Road Research Institute, New Delhi, India
3 The Maharaja Sayajirao University of Baroda, Gujarat, India
* Email: gjsvnit92@gmail.com

Abstract
Major cities of India are facing on-street parking problem specifically in CBD area. Lack of data for on-street parking demand and absence of concrete parking policy leads to business as usual condition on major streets of CBD area. Therefore, a 12 hour parking inventory using license plate method was carried out for the two busy urban streets of the CBD area of Vadodara. Survey witnessed demand spilling over the supply with poor turnover for major duration of the inventory. This study was an attempt to model the response of the vehicle parkers using on-street parking for a policy measure framed under guideline of National urban transport policy (NUTP 2014). The survey data was analysed using fuzzy technique revealed that house hold income, frequency of trip and duration of parking influenced the parking choice behaviour of driver.

Keywords: On-street parking, fuzzy logic, NUTP, Commercial Business District (CBD)
FACTORS INFLUENCING TRAFFIC ACCIDENTS - A CASE STUDY OF TIRUCHIRAPPALLI CITY

Hemanthini A. R., S. Moses Santhakumar

1National Institute of Technology, Tiruchirappalli, India

* Email: hemumalu@gmail.com

Abstract

Road safety is the main concern in many developing countries including India. Road accidents are influenced by many factors and the factors that influence road accidents interact in obscure ways which are not easily identified. Hence, factor analysis is used to classify observed variables into several groups and also to reduce the number of observed variables to a smaller set of factors. In this study, factor analysis is used to analyze the correlation among observed variables in order to estimate and describe the number of fundamental dimensions that underlie the observed data. The model suggests that road factors and traffic factors, both exhibit strong correlations among themselves and are also strongly related to traffic accidents.

Keywords: Fatal Accidents, Factor Analysis, Spot Speed, Varimax Rotation

MAJOR ROAD DRIVERS BEHAVIOR IN RESPONSE TO AGGRESSIVE MANEUVERING OF THE MINOR ROAD DRIVERS AT UNCONTROLLED INTERSECTIONS: A DRIVING SIMULATOR STUDY

Digvijay S. Pawar*, Gopal R. Patil

1Indian Institute of Technology Hyderabad, Kandi, Sangareddy, India
2Indian Institute of Technology Bombay, Powai, Mumbai, India

*Email: digvijayspawar@gmail.com

Abstract

Drivers' inattention, human error and aggressive behavior are often linked with vehicle crashes. This research studies how major road drivers respond to the aggressive maneuvering of the minor road drivers at uncontrolled intersections. The study was also designed to investigate the effect of a distracted driving (engaged on handheld phone) on driving performance. In our experiments, 49 drivers were tested for four different events using a driving simulator. The test track comprised of a stretch of 10.4 km having 9 uncontrolled intersections. At each intersection a different conflicting event was designed for major road drivers. The major road driver behavior was evaluated using three variables derived from the driving simulation, these include Brake Response Time to Conflict (BRTC), average speed while approaching intersection and at the intersection, and deceleration rate. The driver characteristics data such as age, gender, years of driving, education level, and frequency of mobile phone usage were also collected. The analysis results showed that the BRTC values against the right turning vehicles were very low indicating high risk against right turning vehicles. The 90th percentile BRTC values were found to vary from 6.3 to 9.4 seconds for different events. The driving speed of the drivers was not significantly impacted by the cell phone task. The approach speed for all drivers at the intersection was found to be lower by 35% to 40% compared to speeds before applying the brakes. The average decelerating rate for all the drivers was found to be 3.73 m/s² and 4.23 m/s² when the participants were driving without phone and with phone respectively. The insights from this study can be used to understand pre-crash driver actions which
are necessary for implementation of appropriate countermeasures and to assess the level of safety at uncontrolled intersections.

**Keywords:** Driver simulator, brake response time to conflict, approach speed, uncontrolled intersection

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**EFFECT OF REHEATING ON VARIOUS PROPERTIES OF VISCOGRADE AND POLYMER MODIFIED BITUMEN**

Arpit Gondaliya 1*, Vishwas Kelkar2, Sanjay Dave3, Dipak Rathva4

1 The M S University of Baroda, Gujarat, India
2 IL&FS Transportation Networks Ltd., Ahmedabad, Gujarat, India
* Email: arpit_jg@hotmail.com

**Abstract**

Performance of bituminous roads is dependent on the mix design parameters and which is governed by quality and mixture of raw materials like aggregates and bitumen. Past research as well standard practice adopted in various countries suggests to avoid reheating of bitumen as it may change premium properties of bitumen. In this paper, study focuses on change in physical, chemical & rheological properties of Viscograde bitumen and polymer modified bitumen due to reheating as well in its bituminous mix properties. Study reveals reheating affects all the premium properties of bitumen in varying proportion and identifies the reason for avoiding reheating of binder as far as possible.

**Keywords:** Reheating, Viscosity Grade (VG) Bitumen, Polymer Modified Bitumen (PMB), Dynamic Shear Rheometry (DSR), Asphaltene

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**DISPATCH PLANNING OF MULTI PETROLEUM PRODUCT FOR PIPELINE NETWORK**

Sushant A. Darji1*, Gopal R. Patil 2

1 The Maharaja Sayajirao University of Baroda, Gujarat, India
2 Indian Institute of Technology of Bombay, Powai, Maharashtra, India
* Email: darjisushant@gmail.com

**Abstract**

Pipelines provide an economic mode of fluid transportation for petroleum systems, especially when large amounts of these products have to be pumped for large distances. For multiproduct pipeline, have to prepare a scheduling for dispatching. But lack of synchronization between batch arrival and ullage available hinders whole scheduling. The method discussed in this paper is composed of a petroleum refinery, a multiproduct pipeline connected to several terminals that receive large amounts of Motor Spirit, High Speed Diesel, Superior Kerosene Oil, Naphtha and Army Diesel and it is focused on calculation of a batch size (quantity of the petroleum product). The method must satisfy all the operational constraints, such as quantity balances, distribution of the products and product demands at different connected terminals. Results generated include the inventory levels at all locations, the distribution of products to the terminals and the best ordering of products in the pipeline.

**Keywords:** Multi petroleum product pipeline, Batch scheduling in pipeline network, Dispatch planning of petroleum products
AIR AND NOISE POLLUTION MONITORING AT SIGNALIZED INTERSECTIONS

Koushik N.1*, Prasanna Kumar R.1, Subramanyam B.1
1 SASTRA University, Thirumalaisamudram, Thanjavur, India
* Email: koushikhari6@gmail.com

Abstract
Urbanization in cities has led to an increase in the transportation modes and facilities. Pollution due to vehicular emissions has become a major problem in the recent times. So it has become essential to monitor the air and noise pollution caused due to these vehicular emissions. Signalized intersections are the hot spots where emissions will be high. Therefore, in the present study it is planned to analyse the air and noise pollution at these hot spots. As part of this work four signalized intersections in Trichy city have been selected as study intersections. At these chosen intersections traffic data was collected for three parameters: traffic volume, air pollution and noise pollution simultaneously. To collect data on traffic volume Video graphic technique was used. The vehicle exhaust was collected using the instrument Respiratory Dust Sampler. The noise emitted from the vehicles was measured using the Noise Level Meter. Then, the traffic volume for each approach of the chosen intersections was retrieved from the videos taken. Saturation flow for all the signal spots was also noted. Dust density was calculated and compared with the available standards from which the extent of air pollution in the selected locations was obtained. Equivalent noise was calculated for each approach of the locations chosen and compared with the noise standards given by MoEF [Ministry of Environment and Forest]. From the comparison the extent of noise pollution was observed. An equation was developed showing the dependency of noise on the traffic volume which can also be used to predict future pollution levels. Then, various possible remedial measures including signal redesign, installation of noise barriers were suggested.

Keywords: Air & Noise pollution, Trichy Signalized Intersections, Noise level meter, Respiratory dust sampler

SENSITIVITY OF AXLE LOAD SPECTRA ON RUTTING PERFORMANCE OF A FLEXIBLE PAVEMENT USING MECHANISTIC EMPirical PAVEMENT DESIGN GUIDE

Nur Hossain1*, Dharamveer Singh2, Musharraf Zaman3
1 Kleinfelder, Inc., Norman, USA
2 Indian Institute of Technology Bombay, Mumbai, India
3 The University of Oklahoma, Norman, USA
* Email: NHossain@kleinfelder.com

Abstract
The traffic input parameters in the Mechanistic Empirical Pavement Design Guide (MEPDG) are: (a) General Traffic Inputs, (b) Traffic Volume Adjustment Factors, and (c) Axle Load Distribution Factors/Axle Load Spectra (ALS). Of these three traffic inputs, most researchers have indicated ALS to be the most important and sensitive, which can significantly affect design of and prediction of distress in flexible pavements. Since, developing ALS is a tedious and time consuming process, the highway agencies need to know how frequently they require to develop ALS. To address this issue and to assess the sensitivity of ALS, in this study, four years (from 2008 to 2012) of traffic data were collected from an instrumented test section on I-35 in Oklahoma. Site specific ALS and other pertinent traffic input parameters were developed. The developed site-specific ALSs were compared among themselves and also with the default inputs in the MEPDG. It was observed that significant differences exist between the default and site-specific ALS values. However, the
differences in the yearly ALS data, developed for these four years, were not found to be as significant when compared to one another. In addition, quarterly field rut data were measured on the test section and compared with the MEPDG predicted rut values using the default and developed ALS values for different years. It was found that significant differences exist between the measured rut and the MEPDG predicted rut when default values were used.

CONTROLLABILITY AND OBSERVABILITY ANALYSIS FOR INTELLIGENT TRANSPORTATION SYSTEMS
Shaurya Agarwal1*, Pushkin Kachroo2, Saumya Gupta, Santonu Goswami
1 California State University, Los Angeles, USA
2 University of Nevada, Las Vegas, USA
* Email: agarwal2@unlv.nevada.edu

Abstract
This paper presents a novel approach for studying the controllability problem on a general topology of a traffic network. We develop a new framework which investigates controllability in terms of flow information on arcs and the routing information. We utilize lumped parameter based ODE-model to model traffic (ρ) dynamics on a network arc and then combine it with the ODE-model of the routing (π) dynamics, to develop a state space model for the network dynamics. We then linearize it about the steady state flows and calculate the controllability matrix of the state dynamics and apply the rank condition test on it. We then present an alternate analysis for controllability problem by treating the problem as a dual of observability problem.

Keywords: Observability, Traffic Networks, Dynamic Network Modeling, Origin Destination (O-D) flow estimation, link flow estimation

EFFECT OF NATURAL ASPHALT ON PERFORMANCE CHARACTERISTICS OF BITUMEN AND ITS MIXES
Ambika Behl1*, Gajendra Kumar1
1 CSIR-Central Road Research Institute, New Delhi, India
* Email: behl.ambika@gmail.com

Abstract
Trinidad Lake Asphalt (TLA) is natural bitumen. The soluble bitumen in Trinidad Lake Asphalt has a high viscosity and if this is blended with paving grade bitumen, it can produce a material with high resistance to deformation and with suitable weathering properties. In this study TLA pellets have been used as a modifier to modify VG-30 (viscosity grade-30) grade paving bitumen, and it was found that it improved the properties of the VG 30 grade binder. Various binder properties were checked like softening point, penetration value, viscosity indices, and properties of modified and unmodified binder after short term aging were studied, and rheology of binders was also studied. After witnessing the improved properties of binder, bituminous (asphalt) mixes were prepared to check the performance characteristics of TLA modified asphalt mixes. Results of wheel tracking test, beam fatigue test, and tensile strength ratios indicate that a worthwhile improvement in resistance to deformation, comparable to conventional asphalt mix, can be obtained by the addition of 2% of TLA by weight of VG 30 grade bitumen.

Keywords: Trinidad lake asphalt, rheology, bituminous mix, wheel tracking test, beam fatigue
MOISTURE SUSCEPTIBILITY AND COMPACTION CHARACTERISTICS OF WARM MIX ASPHALT

Ambika Behl\textsuperscript{1}*; Satish Chandra\textsuperscript{1}

\textsuperscript{1} CSIR-Central Road Research Institute, New Delhi, India
* Email: behl.ambika@gmail.com

Abstract

Compaction plays a very important role in the performance of hot mix asphalt (HMA) pavement. Most premature failures of asphalt pavement are concerned with poor compaction. High quality compaction improves the bearing capacity, temperature stability and durability of the pavement. Warm Mix Asphalt (WMA) was developed with the objective of reducing the CO\textsubscript{2} emissions in the production and placement process of hot mix asphalt (HMA) by reducing the temperature at which the bituminous mix is produced and compacted. However this reduction in mixing and compaction temperatures must not affect the final performance of the asphalt mixture. This paper focuses on the laboratory investigation of the compaction characteristics and moisture susceptibility of warm mix asphalt (WMA) using three different warm mix asphalt additives. Viscosity grade bitumen and polymer modified bitumen were used for this study and the WMA additives used in this study were Evotherm\textsuperscript{TM}, Rediset\textsuperscript{®} and Sasobit\textsuperscript{®}. Investigation of the ease of compaction showed that the asphalt mixtures containing warm mix asphalt additives allowed the compaction at lower temperatures and the design percentage of air voids of HMA were achieved for WMA in lesser number of Marshall Blows. Data obtained from indirect tensile strength test, tensile strength ratio test and moisture induced sensitivity test (MIST) showed that the mixes containing warm mix asphalt additives performed better in comparison to hot mix asphalt.

Keywords: warm mix asphalt, compaction, air voids, moisture susceptibility

INVESTIGATING PEDESTRIAN RISK FACTORS LEADING TO PEDESTRIAN FATALITIES IN KOLKATA CITY ROADS

Priyanka Priyadarshini\textsuperscript{1}; Sudeshna Mitra\textsuperscript{1}

\textsuperscript{1} Indian Institute of Technology Kharagpur, Kharagpur, India
* Email: ppriyadarshini2014@gmail.com

Abstract

In India, pedestrian fatalities are considerably high in urban areas compared to national average. While pedestrians’ behaviour and road use influence risk of pedestrian crashes, several built environment and road infrastructure planning and design features, traffic volumes, speed, visibility and pedestrian volume also significantly affect likelihood and consequence of pedestrian crashes. However, effects of these factors at locations experiencing high number of pedestrian crashes in general and fatal pedestrian crashes in particular have not been extensively studied across Indian cities. This study makes an attempt to fill the gap by analysing fatal pedestrian crashes obtained from Kolkata police and identifies locations on road network posing highest risk to pedestrians. Subsequently a model for unsignalized intersections was developed to identify factors influencing likelihood of fatal pedestrian crashes. Results indicate that high pedestrian volume and wider minor roads are associated with higher pedestrian fatalities, whereas higher traffic volume, higher post-encroachment time and wider cross walks showed diminishing effects on fatal pedestrian crashes.

Keywords: Pedestrian fatality, Probit model, Poisson model, BE, Urban traffic features
HOUSEHOLD DAILY NON-MANDATORY ACTIVITY PARTICIPATION AND DURATION
MODELING ACCOUNTING FOR PERSON LEVEL BUDGET CONSTRAINTS

Rajesh Paleti1*, Abdul Pinjari2
1Old Dominion University, Norfolk, Virginia, USA
2University of South Florida, USA
*Email: rpaleti@odu.edu

Abstract
A key methodological and behavioral innovative component in recent Activity-Based Models (ABMs)
used for transportation planning is the household-level non-mandatory activity participation
component. While traditional ABMs use a series of simple models to predict non-mandatory activity
participation decisions in a sequential manner (which is often not correct), the Multiple Discrete
Continuous Extreme Value (MDCEV) model can model both individual and joint non-mandatory
activity participation and time allocation decisions in different out-of-home activities of all household
members simultaneously. A key advantage of the MDCEV framework is that it accounts for complex
intra-household interactions among different household members by allocating the total household
time available in a day to different household members in a utility-consistent manner. However, the
earlier time-use models worked with a single household level budget constraint. So, the model
ensures consistency of time predictions with the total household available time but it can violate
person level budget constraints. Second, it is common to predict extremely low participation
durations from the MDCEV model because it does not enforce minimum time allocation. The primary
objective of the proposed study is to enhance the behavioral and prediction accuracy of the MDCEV
model in the time-use context by developing an improved model that (1) handles multiple person
level budget constraints, and (2) ensures that the time predictions are always greater than certain
minimum duration levels.

DEVELOPING A PLANNING SUPPORT SYSTEM FOR MUMBAI: LESSONS IN RESEARCH
CHALLENGES AND OPPORTUNITIES

Arnab Chakraborty1*, Bev Wilson1
1University of Illinois at Urbana Champaign, USA
*Email: arnab@illinois.edu

Abstract
While urban modeling is increasingly common in developing countries to understand the processes
of growth and change (Wilson & Chakraborty, 2013), its influence on policy analysis and decision-
making has been limited. This disconnect can be attributed to a lack of reliable information (Barredo
& Demicheli, 2003), an inability of modelers to communicate the functioning of models to decision
makers, and an overemphasis on improving the predictive abilities of the models at the expense of
its analytical potential (Couclelis, 2005; Waddell, 2011). In the case of Mumbai, India, such models
can help inform ongoing planning questions such as the impact of proposed increases in Floor-
Space Index on land use and transport, benefits of stricter development control regulations,
especially in coastal areas, and interdependence of planned settlements with informal ones.

Our paper documents an ongoing and collaborative research effort to develop a planning support
system with the capability of addressing some of the above questions. Specifically, we focus on
three aspects: (1) leveraging open data and civic technologies to identify resources that offer useful
information in data poor environments, (2) re-conceptualizing urban spaces using these datasets to improve our understanding of the empirical relationships between land use and transport, (3) creating a larger toolbox for planners to use the above knowledge for decision-making. Our paper uses two recently completed projects – a land use change model for Mumbai region, and an analysis of Twitter data to identify features of the built environment – to illustrate our key contributions and research challenges.

References:


DEVELOPMENT OF TRUCK ROUTE CHOICE MODELS USING LARGE STREAMS OF GPS DATA

Trang Luong¹, Abdul R. Pinjari¹*
¹University of South Florida, USA
*Email: apinjari (at) usf.edu

Abstract

Appropriate measurement and modeling of travel route choice is essential for numerous transportation planning applications. Yet, most transportation models make simplistic assumptions of route choice such as shortest path assumptions. This is partly due to the difficulty in collecting (or observing) route choices through traditional travel surveys. In the recent past, Global Positioning Systems (GPS) data has gained popularity for the measurement and modeling of travel route choices. However, except a handful of recent studies (e.g., Hess et al., 2015), most research on using GPS data for route choice analysis has been limited to passenger travel (as opposed to goods movement). In this research, large streams of truck-GPS data will be utilized to analyze the route choice behavior of long-haul trucks traveling within, into, and out of the state of Florida in the United States. Specifically, the following aspects will be analyzed, diversity of observed truck route choices, choice set generation algorithms for truck route choice modeling and methods for modeling route choice.
EVALUATION OF LABORATORY AND FIELD COMPACTION OF DENSE GRADED AGGREGATE BASES

W. K. Mampearachchi1*
1University of Moratuwa, Sri Lanka
*Email: wk.mampearachchi@gmail.com

Abstract

Compaction of Aggregate Base Course in road construction projects, plays one of major role, as it directly contributes to project cost, quality, time and natural environment. In order to achieve the optimum energy level, the relationship between Optimum moisture content (OMC), Maximum dry density (MDD) & Compaction effort (Compaction Energy) should be identified.

Lab and field studies were done to observe the compaction behavior of Dense graded aggregate bases at different moisture & energy levels. Based on the results it is observed that higher compaction effort is ineffective, when compacts at moisture level which is not closed its OMC. Research finding shows that dynamic compactor hammer is more effective compared with proctor compaction hammer in DGAB compaction. Furthermore, it shows that dry unit weight is increased rapidly with lesser no. of roller passes, when it has moisture content lower than the OMC. Finally dry densities are reached to constant value after higher no. of roller passes in all range of moisture levels.

It can be concluded that selection of compaction effort mainly depends on its moisture content and the compaction method. Therefore appropriate compaction effort should be identified after testing it’s moisture content prior to compaction, in order to achieve cost effective, better quality, timely completion & environment friendly Job.

USING REAL TIME TRAFFIC DATA AND SATELLITE IMAGERY TO UNDERSTAND THE RELATIONSHIP BETWEEN LAND USE AND CONGESTION: A FRAMEWORK FOR INDIAN CITIES

Arnab Chakraborty1, Bev Wilson1*
1University of Illinois at Urbana Champaign, USA
*Email: bevwilso@illinois.edu

Abstract

More than one-half of the world’s population currently lives in urban areas, and these numbers are expected to rise over the coming decades. One of the central challenges for urban planners in the 21st Century is how to manage the environmental impacts of urbanization (Wilson and Chakraborty, 2013) and a coordinated approach to land use and transportation is key to achieving this goal. As megacities like Mumbai, India grow, air quality is increasingly a concern (Cervero, 2013). This paper presents a framework for leveraging big urban data to better understand travel behavior (Lenormand and Ramasco, 2016) in the K-West Ward of Mumbai. These techniques are particularly important in a developing nation context where data availability can impede empirical research (Chakraborty et al. 2015) and also where important factors like the distribution of jobs and housing in space and the vehicle fleet (e.g., rickshaws and two-wheelers) differs significantly from the U.S. (Shirgaokar, 2014).
We collect real-time traffic information from the Google Maps API for a series of origin-destination pairs across the study area and analyze how travel time (i.e., a proxy for congestion) varies within and between routes for automobile traffic. Data are collected twice daily (morning and evening rush hour) for the shortest route in terms of travel time and more detailed information for alternative routes. These data are then used to visualize patterns of congestion and to connect with underlying land use characteristics and development regulations like the floor space index. We also employ web scraping techniques to capture real-time air quality information for existing monitoring stations in Mumbai and visualize how the spatial distribution of traffic congestion and key air pollutants varies over the course of the day. Finally, this paper considers whether the proposed framework and data collection techniques can be scaled up and used to explore the relationship between urbanization, land use planning, traffic congestion, and air quality at the city or regional level.

References:


Abstract

Navi Mumbai Controversially the biggest planned city in the world. The city is based on TOD and a planned city with only 46 years of age and already planning all modes of transport possible. Based on several building blocks the city &Industrial development corporation is spearheading and becoming the torch bearer for development of future smart cities in India. The presentation is all about sharing the plans for this future city.
SHIFTING OF UTILITIES DURING CONSTRUCTION OF CONCRETE PAVEMENT

Vishal R. Thombare
1MCGM, Mumbai, India
*Email: thombarebmc@yahoo.com

Abstract
Mumbai Municipal Corporation has about 1941 Kilometers of road network. Out of which nearly 1200 kilometer is paved with asphalt and about 670 kilometer road is paved with concrete and remaining is paved with thin white topping and paver blocks.

During construction of concrete pavement many underground utilities have to be shifted from centre alignment to the shoulder portion. These require meticulous planning and designing of utilities to be placed at different levels as per there functions.

In Municipal Corporation of Greater Mumbai before inviting tenders for concrete roads all the utility agencies have to submit next 25 years plan for laying new utilities. Accordingly plan is prepared and work is carried out during the excavation of concrete road construction. These utilities are placed inside strips of concrete road at different levels depending on their respective functions. The side strips are mainly constructed with flexible material. So that during repairs of utilities main carriageway is not disturbed. At every junctions and 100 m a cross ducts are provide for crossing the utilities. In Mumbai there are about 32 utility agencies. A spreads engineering wing deals with these agencies for coordination and implementation.

EXPLORING THE CHARACTERISTICS OF SHORT TRIPS:
IMPLICATIONS FOR WALK MODE CHOICE

Venu M. Garikapati1, Ram M. Pendyala1, Daehyun You2, Chandra R. Bhat3, and Sanjay Paul4
1Arizona State University, 660 S. College Avenue, Tempe, AZ 85281
2Maricopa Association of Governments, 302 N. First Avenue, Suite 300, Phoenix, AZ 85003
3The University of Texas at Austin, 301 E. Dean Keeton St. Stop C1761, Austin, Texas 78712
4Lee Engineering, LLC, 3610 N 44th Street, Suite 100, Phoenix, AZ 85018

Abstract
People undertake many short trips, which may be defined as those under five miles, or under two miles, or even under one mile in length. Although these trips have lengths that make them candidates for bicycling or walking, i.e., the use of sustainable non-motorized modes of transport, it is found that a substantial share of these short trips are undertaken by car. Though there has been some research into the reasons why short trips are not largely undertaken by walk and bicycle, much remains to be learnt regarding the nature of short trips and the potential constraints that limit the ability of travelers to use non-motorized modes for these trips. This paper offers a detailed examination of short trips, with a view to exploring the potential factors inhibiting the use of walk and bicycle modes for these trips. The paper offers a detailed descriptive analysis of short trips in two major metropolitan regions using data from the 2008-2009 National Household Travel Survey in the United States. It is found that trip chaining patterns may be playing a significant role in preventing walk as the ‘preferred’ mode for short trips. Based on a characterization of short trips in the survey data sets, the paper offers planning and policy strategies that may help bolster the share of walking and bicycling for short trips.
TOURIST ATTRACTIONS IN MUMBAI

Hanging Gardens: Hanging Gardens and the Kamala Nehru Park both provide relaxing atmosphere & greenery is 34.4 kms from the conference venue and it takes approximately 1 hour 10 mins.

Juhu Beach: Juhu Beach is a vendor’s delight with innumerable food counters just 17.8 kms from the conference venue and takes approximately 50 mins.

Marine Drive: Marine Drive is also famous as the Queen’s Necklace is 32.4 kms from the conference venue and it takes approximately 1 hour 10 mins.

Gateway of India: Gateway of India is 26 mtrs high stone archway is the first landmark of Bombay and is at a distance of 32 kms from the conference venue and it takes approximately 50 mins.

Elephanta Caves: Elephanta Caves is well known tourist spot is accessible by boat from the Gateway of India.

Mani Bhavan: Mani Bhavan a memorial dedicated to the Father of the Nation, Mahatma Gandhi. It is 31.5 kms away from the conference venue and it takes approximately 1 hour 10 mins.

Siddhivinayak Temple: Siddhivinayak Temple where the idol of Ganesh is two and a half feet in height and two feet in width which is 21.5 kms away and takes approximately 55 mins. Distance: 15 kms

Haji Ali Mosque: Haji Ali Mosque a whitewashed fairytale mosque is at a distance of 26.5 kms and approximately 1 hour from the conference venue.

Sanjay Gandhi National Park: Sanjay Gandhi National Park is a large protected area encompassing an area of 104 km². It is from a distance of 20.5 kms from conference venue and approximately 1 hour 10 mins from the conference venue.

The Kanheri Caves: The Kanheri Caves constitute a group of rock-cut monuments that are located to the southeast of Borivali on the western outskirts of Mumbai. Located within the forests of the Sanjay Gandhi National Park, the caves are 6 kms from the main gate and 23.5 kms from the conference venue. Tourists can enter after 9:00 a.m. The Kanheri Caves demonstrate the Buddhist influence on the art and culture of India. They were chiseled out of a massive basaltic rock outcropping.
RESTAURANTS IN AND AROUND THE CAMPUS

Civil Cafe (Terrace Garden, 3rd floor, Civil engineering Department, IITB Campus)

Gulmohar Cafe (3rd floor, Canara Bank building, IITB Campus)

Cuisine: Indian/Chinese, Wallet Factor: Rs. 150-200 per person

Lakshmi (Opposite to IIT main gate)

Cuisine: South Indian- Vegetarian, Wallet Factor: Rs. 300-350 per person

Saffron Spice (near Pizza Hut)

Cuisine: Indian, Wallet Factor: Rs. 550-600 per person

Galleria, Food Court (Hiranandani)

Cuisine: Indian/Punjabi/Chinese, Wallet Factor: Rs. 150-200 per person

Mainland China (In Hiranandani, next intersection from D-mart)

Cuisine: Chinese, Wallet Factor: Rs. 900-1000 per person

Utsav Cuisine (Near Hiranandani Foundation School)

Cuisine: Indian, Wallet Factor: Rs. 450-500 per person

ESSENTIAL INFORMATION

General Emergency Services in Mumbai:

Police: 100, Fire: 101

IIT Bombay Hospital inside campus. Call 1110 from any land phone inside the campus if in need of an ambulance. Call 02225761110 from mobile for ambulance.

Powai Polyclinic & Hospital, 19/a, Opposite IIT Main Gate, Phone: 022 25780707

Hiranandani Hospital (1.5 km away from IIT Main Gate), Hill Side Avenue, Hiranandani Gardens, Powai. Phone: 022 25763300 / 33. Accident and emergency care no. 022 25763322 / 3323 / 3328.

Powai Police Station: 022 25702492, 25702863, 25702690
EXHIBITORS


2. JP Scientific Equipments

3. CHIR-AYU Controls Pvt Ltd.

4. Anton Paar

5. Traffic Infra Tech

6. Mumbai Metro Rail Corporation Limited (MMRC)