

RESEARCH PAYS OFF - VISION -2020

STRATEGIC PLAN FOR ROAD RESEARCH IN INDIA

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STRATEGIC PLAN FOR ROAD INFRASTRUCTURE RESEARCH

1. NEED FOR A STRATEGIC PLAN

1.1 BACKGROUND

India has taken up several ambitious road development programmes. The planning, design, construction, maintenance and operation of these highways are by the traditional procedures and also by adopting conventional materials without major new innovations. There has been significant development across the world in road sector in several areas as listed in Box 1

BOX 1: DEVELOPMENTS IN ROAD RESEARCH ACROSS THE WORLD	
<ul style="list-style-type: none">• improved and more reliable methods of traffic estimation• optimal network planning, use of new and innovative materials• modern construction equipment for faster construction• performance based binder specifications• performance based bituminous mixes• performance based pavement design procedures• innovative financing strategies	<ul style="list-style-type: none">• optimal design of pavements, perpetual pavements• optimal maintenance management of the highways• pavement preservation and asset management• more convincing environmental impact evaluation• realistic economic analysis, use of intelligent transportation system• state-of-art equipment for traffic and pavement performance data collection

These innovations and developments have resulted in significant savings and improvements in road infrastructure in developed countries. IN all these cases, the developments have been made possible through well co-ordinated, well funded and well

represented indigenous research projects carried out by the academia. Therefore, there is an urgent need to bring innovations in road sector in India in the areas of planning, design, construction, maintenance, operation and management of highway pavements to cater to the needs of the highways of the future. The introduction of modern technology for long lasting, better performing highways is possible through sound scientific investigations by indigenous research in the country. There is a need for renewed thrust because of current and projected massive investment in road construction in the country.

A major thrust to the research in the highway sector was given by the Ministry of Road Transport and Highways in early 1980s. About eighty research projects related to various aspects of roads, bridges, traffic management and safety were taken up. These research schemes provided very useful information for cost-effective solutions to the problems faced on the ground, and led to development of several design guidelines and standards suited to Indian conditions. Box 1 illustrates typical applications of the various research schemes sponsored by the Ministry through participation of academic and research institutions, state PWDs, Border Roads Organisation and the private sector in the past.

BOX 1: ILLUSTRATION OF APPLICATIONS OF RESEARCH SCHEMES
<p>R-6 Research Scheme Benkelman beam deflection method for evaluation of structural capacity of existing flexible pavements and design of overlays <i>(An illustration of networking academic institutions in research initiatives)</i></p> <p>The research scheme facilitated construction of test stretches in four zones of the country viz., North, South, East and West and carried out by networking four different academic institutions in the four zones with Central Road Research Institute acting as the nodal agency. Sixty one test sections were constructed with overlays with different thicknesses and materials and the performance was monitored periodically. Temperature and moisture correction factors were evolved for Benkelman beam deflection values and overlay design charts were developed. Based on the research findings, IRC Code of practice IRC- 81 for strengthening of flexible road pavements using Benkelman beam deflection method was evolved.</p>
<p>R-18 Research Scheme Skid Resistance Studies <i>(An illustration of involving Academic Institutions in Technology Initiatives)</i></p> <p>The research project envisaged conduct of laboratory and field studies to determine the skid resistance properties of various types of highways pavement surfacing and also study the variation in skid resistance due to presence of water, sand, oil etc. on pavement surface The project facilitated development of three indigenous equipment viz., portable pendulum type skid tester, a fifth wheel skid resistance tester and a dynamic skid resistance tester. The effect of micro and macro texture of the pavement surface on skid resistance was studied and documented. The indigenous equipment developed as part of the research project results in import substitution.</p>

R-41 Research Scheme

**Role of Geo-synthetics in the Design and Performance of Pavement Overlays
(An illustration of involving academic institutions in Technology Initiatives)**

The research scheme facilitated evaluation of different types of geo-synthetics and conducting laboratory studies on bituminous layers with and without geo-synthetics; construction of flexible overlays with and without geo-synthetics over cracked in-service rigid and flexible pavements and study the relative performance. The performance was periodically monitored and life cycle cost analysis was carried out. The performance prediction models developed based on extensive field data under actual traffic, climate and environmental conditions can be used in design of flexible overlays with geo-synthetics.

R-56 Research Scheme

**To develop a computer programme and design charts for analytical design of flexible pavements
(An illustration of involving Academic Institutions in Technology Initiatives)**

The project facilitated collection of field performance data for various types of pavement layers, development of a user friendly software for pavement design based on layered elastic theory and formulation of design charts of pavement design duly considering fatigue as well as rutting criteria. The research project facilitated development of mechanistic-empirical indigenous pavement design procedure for flexible pavements in India and in the revision of IRC-37 for the design of flexible pavements in India.

R-64 Research Scheme

**Establishment of System for Identification and Rectification of Accident Black spots
(Illustration of research initiative with private sector participation)**

The project was taken up to develop a computer aided system for identification and rectification of black-spots on selected national highways in India. The findings of the research study highlighted the causative factors for accidents along major highways and engineering measures to reduce accidents at black spot locations. The findings of the research project helped in revising the IRC code of practice on rural road geometrics and in the design of forgiving highways

1.2 The Imperatives

The several road development programmes involve several complexities due to wide variations in traffic, soil, materials, construction, terrain and climate. Many of the projects are taken up under public-private sector participation under Design-Build-Operate-Transfer format. The Government is shifting from input based specifications to performance based standards. This warrants innovations through the use of better performing new materials, improved as well as new specifications, introduction of modern equipment for construction and maintenance, so that they satisfy the requirements of performance and durability and also result in lower life cycle cost duly factors like material consumption, initial cost of construction, road user cost, maintenance cost etc. The R&D efforts and money spent on relevant research schemes and development of new technologies pay rich dividends to the economy, as has been the experience worldwide.

While systematic visionary research could not be initiated along with the taking up of the huge road development initiative in the country since 2000, let us not miss this opportunity now, of having a huge field laboratory created by the programme across the whole country.

Absence of innovation in such giant development programme is more costly than the cost of the research itself. Thus, there is a need for a comprehensive strategic action plan for road infrastructure research in the country. The shortfall in research has led us to a\ very undesirable conditions of our roads and a failure to reap the benefits of modern materials, technology and processes. As contrast, the US for example invested millions of dollars in research in nineties and their present returns is counted in billions.

1.3 GOALS

The goals of the vision and strategy document is to devise a framework that will ensure conduct of applied research to develop knowledge base, specifications, guidelines, analytical and physical tools/test methods/procedures that enables safe, efficient economic movement of people and goods through environment friendly, long-lasting, cost-effective highway infrastructure that provide high level of service and comfort to all road users. The vision addresses the institutional framework and formulation of R&D strategies , thrust areas for research, financing strategies for R&D, enhancing the utilization and strengthening of academic and research institutions in the country, mechanism for laboratory to field transfer of research findings and development of guidelines for use of new materials and formulation of technical specifications, knowledge pooling through networking and twinning with national and international R&D centres and academic institutions, award and monitoring of research projects and creation of a band of dedicated team of researchers and scientists in the country.

1.4 VISION

“To meet the Nation’s need for planning, design, development, operation, control, maintenance management and preservation of road infrastructure assets by cost-effective and environment-friendly techniques, optimum use of locally available materials and high performance materials for extended service life and improved performance through indigenous research. Only innovative R&D programmes can ensure flawless high quality developments in road sector which can be catalyst for promoting economic well being and better quality of life for the people of the country”

2. RESEARCH PAY OFF

It is well established that investment in road research gives larger benefits. Review of literature suggests that the benefit-cost ratio on the investments in road research is more than 20. There are several clear-well defined research areas with quantifiable future benefits in the country. Internationally, the allocation for research in highway sector is about 2% of the total investment on roads. Currently, an aggregate investment of about Rs.2,80,000 crores from public and private sectors within a span of eight to ten years is envisaged for the development . Considering the international best practices, the desirable investment on road research in the country at 2% of the total investment is about Rs.5,600 crores over a period of eight to ten years, which is about Rs.560 crores per annum. Our investment in road research is negligible compared to the huge investments in road construction. The neglect so far due to not realizing the real value and benefits of road research is quite unfortunate. This gap should be addressed on an emergent basis in the country. The research and development is crucial for the socio-economic growth of a country. Innovations are important for faster development, so that the innovations will result in cost effective solutions which will provide better performing and safer highways in the country. It appears that much of the shortfall is in research management skills and basic understanding of research needs of the country, which were the primary reasons for shying off from research so far.

3. CHALLENGES AND STRATEGIES

3.1 CHALLENGES

There are several areas of concern which need the attention of the experts in the profession on priority. The challenges that the professional face include the following:

- i) Preserving the environment by making use of locally available materials
- ii) Creation of durable road assets
- iii) Cost-effective design of the road infrastructure considering life cycle cost analysis

- iv) Extension of service life of the existing highway infrastructure through appropriate timely maintenance
- v) Use of new materials in construction to extend the life and improve the performance
- vi) Pavement preservation and road asset management
- vii) Design of forgiving safe highways
- viii) Use of modern technology for efficient operation and management of the road infrastructure
- ix) Corridor management
- x) Operation and control

Effectively addressing these challenges will require a multifaceted, multidisciplinary and collaborative approach. The success requires active involvement of stakeholders from all levels of the government, contractors, concessionaires, consultants, industry, academia and researchers. This also requires research work spanning the full technology continuum viz., from fundamental research to advanced applied research to create knowledge on existing and new techniques that will result in efficient design and operation of the highway infrastructure. The success of these initiatives also depends on technology transfer (lab to land transfer) as well as policy and programme management initiatives. This also requires research work spanning the full technology continuum viz., from fundamental research to advanced applied research that will result in efficient design, operation and management of the highway infrastructure. The success of these initiatives also depends on technology transfer (lab to land transfer) as well as policy and programme management initiatives.

3.2 STRATEGIES

To leap frog on the research deliveries, a set of all encompassing strategies are required. An open minded approach is required to implement such a strategy, which is required to be totally opposite to the present philosophy of unnecessary caution, confusion and dilemma. Thus, the strategies are:

3.2.1 Major Strategies

- i) Creation of an independent road research board for management of road research schemes/programmes and to act as clearing house for all road research in the country
- ii) Identification of thrust areas for research and development
- iii) Sponsoring of research projects for basic and applied research through collaborative efforts in association with the industry

3.2.2 Strategies through a centralized funding mechanism

- iv) Use of new and innovative materials and their accreditation for improved performance and extension of service life
- v) Creation of a centralized data base and knowledge centre, and a search engine driven archive of research results of all R&D programmes in the country
- vi) Dissemination of the findings of the research projects through established, but strengthened channels of IRC
- vii) Technology transfer (lab to land) of research findings
- viii) Networking with national and international agencies in the different areas of road research
- ix) Capacity building by networking of institutions and enhancing the synergies among academia, research agencies, construction industry and the concerned government agencies
- x) Identification, creation and maintenance of dedicated non-lapsable funding for road research

These strategies are based on the experience of successful research program in developed nations but set in the tone to match Indian conditions and requirements.

4.0 MAJOR AREAS OF RESEARCH

4.1 Pavement Engineering

- Study new, cost-effective and innovative design using new materials, industrial wastes, recycled materials and development of guidelines/manuals/best practices to extend the life of the pavements, performance and ensure road user satisfaction
- Long lasting better performing highway infrastructure through use of appropriate technology and standards in material selection, design, construction, quality control and timely maintenance
- Development of appropriate technology that will ensure faster highway construction reduce delay, congestion and accidents in work zones through appropriate use of modern machinery and equipment and techniques
- Development of appropriate mechanistic – empirical pavement design methods and specifications combining academic research and field performance data through innovative materials and construction practices
- Development of low-cost indigenous equipment for pavement evaluation and on-line transmission of construction quality and performance data
- Creation of a data base and documentation of performance of the highway infrastructure under varying traffic, climate and environmental conditions; performance evaluation of new materials; quantification of benefits of innovative technologies; quantification of cost-effectiveness; studies on road user satisfaction and increased life; quantification of improved performance and longevity
- Knowledge dissemination and technology transfer through seminars/manuals/guidelines/training programmes/reports/best practice/state-of-art reports to accelerate the implementation of innovative technologies, materials and techniques that will improve pavement life (lower life cycle cost) , performance and reduced maintenance needs and road user satisfaction.

- Quantify the effect of construction quality on performance and life cycle cost
- Safer, environmental friendly, sustainable highway infrastructure through development of design, materials, construction, operation techniques by use of recycled materials, industrial by-products and industrial wastes, reduced noise levels and development of highways that are environmentally acceptable
- Road Asset Management through appropriate pavement performance information system, decision support tools, use of new materials, test track studies, studies on effect of overloading, development of optimal maintenance strategies
- Warranty for construction projects
- Development of indigenous accelerated loading and testing equipment / instrumented pavement sections

4.2 HIGHWAY OPERATIONS, CONTROL AND MANAGEMENT

- Modeling mixed traffic and development of a highway capacity manual for the Indian conditions and ensure that the road should is not only be vehicle specific but user specific as well.
- Highway safety under mixed traffic through safety management and data systems, accident analysis and investigation and mitigation measures, road safety audit and evaluation of safety measures and development of guidelines /manuals and best practice reports for design, construction and operation of forgiving highways; use of smart materials and sensors to improve safety
- Efficient movement of people and goods by considering optimal demand-supply relationships through development of new approaches, tools, techniques that offer improved operational efficiency with reduced road user costs
- Congestion pricing and assess the impact of road pricing on road usage, development of pricing mechanism and strategies; demonstrate the feasibility and benefits of

congestion pricing on transportation facilities.; incident management through use of appropriate tools and technologies

- Freight management through freight forecasting, promotion of cost-effective tools, techniques and guidelines for design of infrastructure for freight movement; management of overloading problem through introduction of multi-axle trucks and advanced technologies.

5.0 DATA BASE AND KNOWLEDGE CENTRE

Currently, major projects on National Highways are under Design, Build, Operate and Transfer model. Data base on traffic viz., volume, speed, density, composition, accident, congestion, axle load etc., are essential for the planning, design, operation and management of the future highways, as well as existing highways. The design of the pavements using alternate/new materials require data on performance of the test tracks constructed using new/innovative materials under actual climate, traffic and environmental conditions. In addition, the performance of the highways needs to be evaluated and performance monitored periodically. The data base helps in:

- Capacity augmentation of existing highways
- Creation of expressways / high speed corridors along corridors of high growth
- Safety prediction and design of safer highways
- Development of core road network
- Assessment of the factors affecting pavement performance and establishment of common procedures for the acquisition of pavement performance data
- Accelerated load testing programmes at national level through the use of the Heavy Vehicle Simulator acquired by the Central Road Research Institute
- Development of performance prediction models

- Creation of a centralised pavement performance database for the country for all category of roads under different traffic, climate and environmental conditions and periodical updation of pavement performance data
- acquisition of traffic and axle load data

The scientific users of the results of performance of the constructed highway facilities are designers, researchers, decision makers in the field of pavement management. Pavement performance equations form the core of pavement management systems (PMS). The professional users of such systems are active at national, state and municipal levels across the country. PMS enable the forecasting and prioritising of future maintenance budgets. They also enable the estimation of costs associated with delayed maintenance, and thereby assist in defining the consequences of variations in maintenance strategies. For end users (road users), more efficient maintenance will lead to reduced costs, better and safer roads and less traffic congestion. Thus, there is a need for the development of a web-based data bank which can solve majority of the problems related to availability of data on performance of data of all categories of highways under actual traffic, climate and environmental conditions to all users. There should also be a mechanism for the periodical updation of the performance data and its monitoring, analysis and generation of reports, which will help the planners, designers and administrators. This will also help in avoiding costly and time consuming duplication of efforts.

6.0 NEW TECHNOLOGIES

An expert group has been constituted under the aegis of the Highway Research Board specifically to recommend the usage of patented/accredited new materials/products in the ongoing road and bridge works on experimental basis. However, the expert group comprises of representatives from the Central Road Research Institute, National Highway authority of India, Ministry of Road Transport and Highways, representatives from states, a representative from National Rural Road Development Agency and two co-opted members from the Central Public Works Department and Army Headquarters. As in the case of expert task groups in all other

countries, representatives from the academia should be co-opted as members of the identified group of experts. The academic experts from National institutions of international repute keep themselves abreast of day to day developments and innovations in new materials and technologies, patented products etc. The findings on the performance of these products should preferably be certified by the researchers from academia and national research laboratories before recommending the products for large scale usage. Nano-technology applications should be explored. Use of artificial aggregates and their development should be taken up on priority.

7.0 TEST TRACK STUDIES

No practicing engineer will be satisfied with laboratory trials and its satisfactory performance. A full scale road performance alone will guarantee the performance of a new product or a new technology. It is worthwhile to identify and stipulate three separate lanes on state and national highways of selected length in different states, so that one of the three lanes would cater to the experimental specifications and the other two would cater to the normal traffic during the construction of the experimental test section, which could be opened to the traffic later. When the test section fails, the traffic may be diverted to the already constructed two lanes. It is also desirable that each road project should have a provision for constructing atleast 5% of the approved road section length as an experimental section using new materials or technology. The funding for the same should be made available exclusively and the experimental study should form an integral part of the bid document. In case of pre-mature failures, the lessons learnt should be documented and the failure is to be accepted without any issues as a normal process.

The concept of sharing the benefit of good research idea and the risk of not sharing good research idea between the agency and the contractor has to be recognized and accepted and implemented, since after all, both agency and contractor as well as the public who will use the road network belong to the same nation.

8.0. ROAD RESEARCH BOARD

An independent road research board (RRB) with funds provided from all relevant stakeholders viz., Ministries/Govt. Agencies and private players, is to be established like a trust to deliver/coordinate all the strategies for road research in the country. RRB will develop a shared vision to mobilize all stakeholders and co-ordinate the research efforts. The board will have the active participation of top level representatives from all stakeholders from the government to the private sector alike having serious stake on the R&D results. A new form of co-operation is needed for road transport research. The Road Research Board may be formed with representatives from the government, academia, research organizations and the industry. The board shall be responsible for all R&D management tasks including periodic monitoring of the progress and ensuring timely completion of R&D projects. The board may be headed by the Secretary, Transport of the Govt. of India.

The Highway Research Board of the Indian Roads Congress has identified few thrust areas and topics for inviting research proposals for support. These research topics are in the areas of pavement materials, pavement design, pavement management, traffic and transportation engineering, geotechnical engineering and bridge engineering. The proposed Road Research Board may consider these identified areas of research and also invite new research problems/topics from the industry/road builders and prioritise them based on the need and urgency. The identified topics for research are to be formulated as research problem statements clearly defining the problem, objectives and scope, tasks, deliverables and milestones, required funding level and the project duration. The prioritized research projects should be published in the Indian Highways and leading National newspapers and project proposals should be invited periodically every quarter. The project proposals should be evaluated by a group of experts, and based on a presentation by the Principal Investigator to the Board, the project may be awarded. Each subject area of R&D should have a Planning and Implementation (P&I) Group (as in the past) consisting of subject experts from the sponsoring agency, academia, research institutions and user industries. The activities of the Board may be monitored by the Highway Research Board of IRC at its bi-annual meetings. The board may develop policies for continuous refinement of the research programs through proper

consideration of feedback regarding the program. Thus a feedback mechanism is to be evolved to evaluate the research programs from time to time and refine the process.

9.0 PUBLIC-PRIVATE PARTNERSHIP IN ROAD RESEARCH

Currently, all major road infrastructure development on National Highways is taken up by the private sector. There is a need to develop 'forgiving' highways in the country besides better amenities to the users who would be paying the fee for the use of these facilities and therefore, expect higher level of facilities than available traditionally now. The existing guidelines permit the use of international standards and specifications, whenever Indian standards are either not available or if available, are not adequate. The definition of time and money has changed after the concept of private sector participation in road construction in the country. The country needs durable road assets, improved performance and longer service life through use of new and innovative materials, faster construction techniques and best maintenance practices. The private sector will be greatly benefited by the findings of the research projects. Currently, there is no mechanism for sponsorship, monitoring the progress and dissemination of research findings for problem statements defined by the industry. The modalities for the sponsorship of the research schemes need to be worked out. The Road Research Board may monitor the progress and disseminate the findings of such the research schemes through the Indian Roads Congress.

10.0 DISSEMINATION OF RESEARCH FINDINGS

10.1 Need

Currently, the findings of few selected research schemes are published as a brief research digest in the Indian Highways Journal. However, many of them have not found place during the formulation of new codes and during the revision of the codes and specifications. The final reports of all research projects are to be made available to all user agencies as a web-based freely downloadable document in portable document format, pdf with the option of

buying hard copies. This will help in the dissemination of the research findings to all the user agencies in India and abroad. During the annual sessions of the Indian Roads Congress, a dedicated session may be ear-marked for the dissemination of research findings of the research schemes.

Currently, the Indian construction industry has to depend on costly foreign expertise and equipment for specification and experience. This is a loss to the Indian public, since our precious tax money is spent on generating revenue of foreign companies.

10.2 From Theory to Practice

The findings of research schemes are based on limited data collected for a few years. Few of the laboratory based research findings may or may not show significant benefits when executed on large scale due to difficulties in maintaining the strict construction quality, variations in material properties, heavy axles, variations in climate and environmental factors. If the performance of new materials/pavements constructed using new/innovative technology are satisfactory, there is no 'single-window' system for large scale field implementation. Many of the road developers are not willing to take the risk and use the new products/materials. A simple mechanism for the large scale implementation of research findings is to be worked out.

10.3 Networking Road Research Institutes in India and Abroad

India has taken up large scale road development programmes. Comparing many of the developed countries like USA, UK, Japan, Germany etc., the performance of the Indian highways may be further improved to international standards. Many of the new products/materials have been tested at many International accredited research laboratories. Networking with research institutions of repute like the USDOT, Transport Research Laboratory, UK, Federal Highway Administration etc., will help in the transfer of technology of best practices in planning, design, construction, maintenance, operation and management of the highways so that, the country can boast of roads of International standards. All publications of the Indian Roads Congress should be made available on-line. An editorial board is to be created to ensure publication of

research papers of International standards with experts from different countries serving as members of the editorial board and to ensure publication of research papers and catalogue of papers that report results of implementation ready research.

11.0 CAPACITY BUILDING

There is a need for capacity building by networking of institutions and enhancing the synergies between academia, research agencies, construction industry and the concerned government agencies. Availability of competent, experienced, knowledgeable professionals with government departments, contractors, consultants and other road developers should be given prime importance. Construction translates design recommendations to reality. Only when the practicing engineers are trained on the effective utilization of modern materials and machinery, the country can experience better performing highways. The Central Road Research Institute should continue as a nodal centre for road research in the country. For a vast country like India, one national institute for road research is not adequate. Many more research centres are to be established for training, testing, monitoring and certification of new products and technology. The state roads departments should ensure that the engineers and research personnel working in these laboratories are motivated and involved in research work in that state. Additional incentives or even a separate cadre for such personnel will go a long way in producing better results.

A fraction of the road research fund may be ear-marked for the establishment of **University Centre's of Excellence in Road Research** in National premier technical Institutions of International repute like IITs / NITs / State and Central Universities. The mission of such centres should be to advance the latest technology and expertise in the many disciplines of highway, traffic and transportation engineering through the mechanisms of education, research and technology transfer. These centres can help the country in capacity building, creation and updation of data base on performance, analysis of data, report preparation and as well as their maintenance through the funding provided for centres of excellence and in all, as an extended arm of the Government departments for planning, design, construction, maintenance and

management of the highways and roads in the country. This will also enable the institutions to acquire knowledge from real world examples through engagement of under-graduate and post-graduate students and research scholars and help in their teaching as well.

Most of our engineering college including IIT's are not equipped with modern testing equipments as Falling Weight Deflectometer, Rolling Thin Film Oven tester, Dynamic Shear Rheometer, Beam Fatigue testing equipment.etc. No private lab in the country is having these equipments. MORTH therefore should come out with scheme of funding IITs, NITs, Govt Engineering colleges, Govt. aided Engineering colleges and road research laboratories of the state governments every year for the procurement of modern equipment as well as their maintenance. These educational institutions may be associated in all road development projects as being done in case of Pradhan Mantri Gram Sadak Yojana for design audit, construction supervision and quality control, periodical performance monitoring and evaluation, data base creation and management, traffic studies etc. This process will help in the creation of employable next generation engineers from the educational institutions and will be a win-win situation.

12.0 DEDICATED RELAPSABLE ROAD RESEARCH FUND

Investment in road research should be viewed as a long-term investment to put the country on highest pedestal in the field of highways. A suitable funding mechanism need to be evolved because availability of funds for research are apparently lacking. There is a need for pooling of both physical and financial resources from different stake holders viz., Ministry of Shipping, Road Transport and Highways, Ministry of Rural Development, Ministry of Urban Development, Planning Commission, oil producing PSUs, major construction industries, material manufacturers etc. Considering the huge investments made in road infrastructure development in the country, it is desirable that a modest fund of 2 to 3 % of the total outlay for road construction should be allocated and distributed among the research outfits in the industry, academics and research institutes of the states and the centre every year. All user agencies may contribute to the dedicated non-lapsable 'Research Pooled Fund'. Private sectors are to be

considered while undertaking major research schemes and efforts should be made to make the private sector companies to contribute to the pooled research fund. A scheme of setting apart about 0.5 to 1% of the total government allocation in the highway sector on yearly basis may be made as a recurring contribution to the proposed Research Pooled Fund. The highway research pooled fund should be managed by the road research board with representatives from government, academia, research institutions and industries with a major share in the pooled fund. Creation of a research pooled fund will give the needed boost and thrust to the much needed research studies in highway sector in the country. Tax incentives could be considered by the Government to encourage their financial support by the private sector. The private sector may be encourages to identify research needs of their interest and sponsor projects through pooled fund studies. The new technologies developed, if any may be patented and the returns on the use of the patented technology will make the system more self-sustaining.

13.0 ROLE OF THE GOVERNMENT

The Government seems to be committed to promote research, development and technology initiatives in the road sector. The Government has a major role to play to enable effective and time-bound implementation of the research schemes. The Government should play a pro-active role for the successful implementation of the research schemes. They may be:

- i) Identify centres of excellence from premier national institutes in the country on the basis of their R&D capacity
- ii) Create centres of excellence and strengthening the R&D institutions in the country with latest equipment for basic and applied research, initially and also for their maintenance
- iii) Providing tax incentives to the private sector for their generous contribution for research funds
- iv) Making available project sites for field trials for lab to land transfer

- v) Creating mechanism to write-off failures of trial technologies on the ground with no blame game but evolving lessons learnt for future projects and sharing the risk and benefit of research
- v) Develop a mechanism for transparent procurement of R&D work from academic and research institutions on a cost - plus and time-bound basis, rather than on competitive bidding. A planning and implementation (P&I) group consisting of experts from academic institutions and research centres could be evolved for peer review of the proposals, award of the projects and monitoring the progress from time to time. Representatives from the Government will help in solving bottlenecks if any, in project implementation.
- vi) Enable and encourage contractors and developers to use the findings of research to bring cost-effective solutions without compromising on durability and performance. Contract conditions/documents are to be reviewed for effecting such strategies.
- vii) Networking/facilitating collaboration with national and international knowledge centres and research institutions

14.0 RESEARCH OUTCOME AND APPLICATIONS

The expected outcome of the research and development initiatives will be:

- Indian highway infrastructure that are planned, designed, constructed and maintained with appropriate materials that provide longer and more reliable performance
- Indian highways that are operated with systems, tools, methods and practices that will ensure reduced congestion and are comfortable to drive
- Highway infrastructure that will offer a high level of service to the road users that will ensure safe, efficient and economic movement of people and goods

- Techniques, tools, methods and specifications that will ensure appropriate and timely maintenance and preservation of the road infrastructure that are built at huge investment
- Environment sensitive highway infrastructure that are sustainable and are designed, constructed and maintained through appropriate technology viz., use of renewable materials, waste materials, recycled materials, locally available materials
- Design of world class forgiving highways that are safer, efficient and economical and the guidelines will form the manual for design of highways.

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