23rd World Road Congress, Paris

National Report of Pakistan on

"Quality of Road Infrastructure"

National Highway Authority
Ministry of Communications
Government of Pakistan

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1.   About Pakistan

1.1   Location

Located in South Asia, Pakistan shares an eastern border with India and a northeastern border with China. Iran makes up the country's southwest border, and Afghanistan runs along its western and northern edge. The Arabian Sea is Pakistan's southern boundary with 1,064 km of coastline. The country has a total area of 803,940 sq. km with a land area of 796,095 Sq. km. From Gawadar Bay in it's southeastern corner, the country extends more than 1,800 km to the Khunjerab Pass on China's border.

The country is composed of towering peaks in the north (including the second-highest mountain in the world, 8611m/28,245 ft K2), dry and scrubby mountains in the west, an inhospitable plateau in the southwest, barren deserts in the southeast and alluvial plains everywhere else. These plains, constituting about a third of the country, are Pakistan's 'heart', where most of its people live and most of its food is grown. Coursing through all this tumult is the Indus River, which falls from Tibet then travels 2500 km (1550 mi) south before emptying through an immense delta into the Arabian Sea.

Location Map of Pakistan

1.2   Population:

The population of Pakistan has increased by over five folds since independence in 1947, from around 30 million to 155 million. The data from the last quarter century indicates overall population growth rate over 3% per

anum (during 1980s), which has now declined to less than 2% per anum. The distribution of population since 1947 has remained almost stable with little or no regional migration; however, the level of urbanization has been on rise and remained concentrated in less than a dozen urban centers.

The increase in population density, strong urbanization and diversification in land uses has resulted in increased demand of mobility and efficient transport system for economic prosperity and social integration.
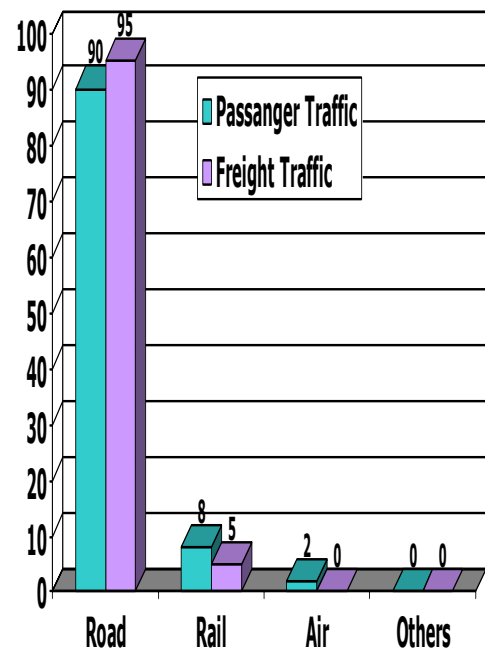
2. Transport system:

2.1 Transport Sector:

The transport share in GDP is 10% and it provides employment to approximately 2.0 million people which are 5% of the country total employment. The existing transport infrastructure is inadequate and needs extensive recovery. Since the trade facilitation systems are archaic therefore they are imposing a cost, in excess of Rs. 220 billion annually on the economy.

2.2 Modal Split:

Pakistan at the time of inception in 1947 inherited a system of transport, which though limited in scope, was functioning quite efficiently. During the last fifty years, however, the system has undergone radical transformation, Some of the old and established modes e.g. railway have lost their pre-eminent role, road transport has acquired a predominant position and civil aviation has emerged as an important carrier. Other modes have also experienced sea change, both negative and positive. Nationally, the freight and passenger traffic has been growing at about 3% and 4.5% per year for the last 30 years. The road sector now accounts for 90 % of passenger traffic and 95 % of freight traffic.

2.3 Existing Transport Infrastructure:

Presently the density of road in Pakistan is 0.32 km per sq.km which is planned to be enhanced to 0.42 per sq.km through a construction of 80,000 km of roads in the years ahead. However the road system have expended to more than 250,000 km since independence in 1947 but still the percentage of

unpaved roads is 37% and there is a shortfall of 150,000 km, which is depriving almost 40% rural population from getting into main stream of the economy.

There are 14 National Highways, Four Motorways and two Strategic roads under the jurisdiction of National Highway Authority. Most sections of N-5 are dualled (4-lane road with median) except Karachi-Hyderabad (M-9) which is being upgraded to a Motorway standard with 6-lane, controlled access under BOT arrangements with a consortium of local contractors.

Motorways are tolled national highways with control access and high speed free flowing traffic lanes, passing through new alignment / virgin corridor connecting Gawadar and Karachi Ports with rest of the country in north.

2.4   Administrative Road Classification:

Three federal ministries and four provincial governments share the responsibility for transport sector.

Pakistan's roads are broadly classified into five main categories, Motorways, National Highways, Strategic Routes and District and inter-urban Roads. National highway and Motorway forms the backbone of the national highway system, providing inter-provincial linkages along major corridors and the provincial roads act as feeder roads to the national routes. The strategic roads are neither of the above but serves the areas of strategic importance of the nation. The Motorway and National Highway are managed by the National Highway Authority, administratively attached with the Ministry of Communications, whereas the provincial roads are managed by the respective province through their own individual system. District roads connect small cities and provide access to the villages and remote areas. The network of farm to market roads also falls under this category. The local / municipal authorities control inter-urban roads of cities and towns for local travel.

Administration	Road Category	Extent (Km)
NHA / MoC	National Highway/M.Way/Strategic road	9,000
C&WD/WSD/FHA	Provincial Road	101,000
District Government	District Road	94,000
Municipality / Cantonment	Municipal and army road	54,000

2.5 Road Lengths:

The road network of Pakistan totals about ¼ million km, and close to 1/3 remains unpaved. The proportion of unpaved road is high in Balochistan province, as its vast areas remain un-populated.

	Pakistan	Punjab	Sindh	NWFP	Balochistan
Total Road Length (Km)	258,214	106,140	79,834	30,049	42,191
Percentage of Paved Road	63%	78%	69%	46%	13%
Area km^2.	796,095	206,250	140,914	101,741	347,190
Road Density (km/km^2)	0.32	0.51	0.57	0.3	0.12
Population (million)	148.72	85.33	32.99	23.26	7.14
Road Length /million people (km)	1,736	1,244	2,420	1,292	5,909
Number of Registered Vehicles	4,974,000	2,920,984	1,457,323	430,429	165,264
Road Length / 1000 Vehicles	52	36	55	70	255

2.6 Funding & Approving Government Bodies:

National Economic Council (NEC) is the apex body headed by the Chief Executive setting policy guidelines and approval of macro-economic development programs in the country. Planning Commissions prepares the national Five Year plans and annual Public Sector Development Program (PSDP) for the approval of NEC, besides appraisal of individual transport projects for approval by the CDWP (Central Development Working Party) and ECNEC (Executive Committee for National Economic Council), whereas PDWP (Provincial Development Working Party) approve provincial projects of relatively smaller magnitude.

The road system has been recipient of public sector funding from public exchequers and currently accounts for 86% of PSDP of transport system. Despite such funding the maintenance backlog has assumed alarming position due to previous main focus on new construction rather than on maintenance. Over 50% of national and provincial roads are in poor condition due to insufficient maintenance, overloading and poor construction quality. The deferred road maintenance of national and provincial roads alone is causing the economy Rs. 140 billion per year.

3. The International Scenario:

For international trade purposes, Pakistan is essentially an "island" as over 95% of the trade is through seaports and shipping. Globally, helped by the telecom revolution, the transportation sector is becoming increasingly efficient and the cost of passenger and freight services are falling.

4. The Vision of Pakistan's Transport Policy:

The vision for Pakistan's Transport Policy is to provide:

"A system that provides efficient, safe, reliable, equitable, and environmentally friendly access and mobility for people and goods, thereby supporting the government's goal of increasing public welfare through economic growth, human development and poverty reduction."

5. Traffic Patterns:

There are approximately 5.4 million vehicles in the country, out of which nearly 50% are motor cycles and 15% agricultural tractors. More than half are concentrated in few major cities. The vehicular population has been growing at the rate of 4.3% per anum during last ten years.
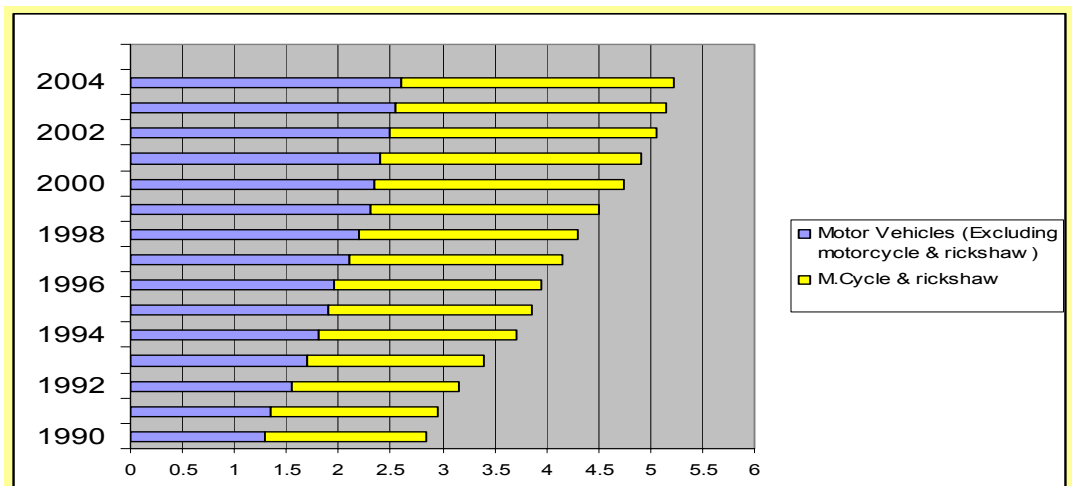
5.1   Motorized Vehicles.

The road transport is almost entirely in the Private Sector. The fleet ranges from multi ownership of single vehicle to few hundred. The private sector public road transport services, while being somewhat efficient, lack quality and reliability.

The road freight services are mostly (95%) in the private sector, though fragmented but very efficient. The public sponsored National Logistic Cell has a 5% market share, and enjoys a preferred status. One of the major hurdles hampering the growth of quality services is the lack of availability of finances for the private sector road transport.

The trucking industry is operating with 9-ton Bedford truck as its main stock. The vehicle is very expensive to operate fuel in-efficient and under-powered to be economically used for long-haul. Transport operation costs are higher besides the damage to the road system due to uncontrolled loading.

5.2   Trends in Strategic Transport Demand:

Total current transport demand in Pakistan has been estimated to be around 239 billion passenger-km and 153 billion ton-km. since 1990 the growth in travel demand both in passenger and freight has been increasing in line with GDP, although at a somewhat higher pace in the last decade and at slightly lower rate since 2000. The growth in passenger and freight traffic volumes over last five years averaged around 3.4% and 3.2% respectively. Road share is by far the largest with 90% of the passenger and 95% of all freight moved by road.

5.3   Change in Modal Share:

Road transport both of passenger and freight has been increasing rapidly, while railway passengers have been increasing only slightly whereas the railway freight have been showing decreased trend in terms of ton-km. the share of air transport is minimal.

Fiscal Year	Passenger Traffic				Freight Traffic			
	Passenger-Km (million)		Composition (%)		Ton-Km (million)		Composition (%)	
	Road	Rail	Road	Rail	Road	Rail	Road	Rail
1990/91	128,000	19,964	86.5	13.5	32,211	5,709	86.0	14.0
1992/93	135,000	17,082	88.9	11.2	53,719	6,180	89.7	10.3
1994/95	146,132	17,545	89.3	10.7	75,770	5,611	93.0	7.0
1996/97	163,751	19,144	89.6	10.4	84,345	4,607	94.8	5.2
1998/99	185,236	19,980	90.7	9.3	95,246	3,967	96.0	4.0
2000/01	208,370	19,590	91.4	8.6	107,085	4,520	95.9	4.1
2002/03	215,872	22,306	90.6	9.4	110,172	4,820	95.8	4.2
2003/04	222,779	23,045	90.6	9.4	114,244	4,796	96.0	4.0

5.4   Traffic Volumes and Road Safety:

The safety record of the road transport, both passenger and goods, is appalling, which is incurring a total loss of Rs. 45 billion per year. The rate of road accidents though declining over the past one decade but is still very high as compared to the developed countries. The root cause of accidents is the

road-user behavior, quality of roads, vehicle fitness, education / awareness of drivers etc.

6. National Highway Authority

National Highway Authority is an Autonomous body, established in 1991, through an act of Parliament. Administratively it is attached with the Ministry of Communications.

NHA has been assigned the task to plan, promote and organize programs for construction, development, operation, repairs & maintenance of National Highways, Motorways & strategic roads.

6.1 Vision of National Highway Authority

"National Highway Authority (NHA) to grow into an efficient service provider to road users in Pakistan for Safe and Comfortable travel on National Highways and Motorways".

6.2 Aim of National Highway Authority

The aim of NHA is to maintain and operate National Highways Network, to minimize the road transportation cost, to provide driving comfort and safety to the road users at all times and preserve the Asset investment in Roads and Bridges.

6.3 NHA Standard Specifications:

Standard specifications have been produced by National Highway Authority to match with the local traffic conditions, type of loading and materials available. Following types of activities are the basis for NHA's Standard Specifications.

a. Construction of Motorways & New Highways
b. Bridges and allied works
c. Rehabilitation and improvement of existing net work
d. Maintenance and existing road and structure

The specification describes the requirement and procedures for execution to achieve required quality. The materials shall conform to the specification and testing procedures as per following latest international standards.

a. AASHTO
b. ASTM
c. BS Standards.

6.4   MAINTENANCE NEEDS

Due to population explosion, economic growth and ever increasing dependence on roads, the pressure on Pakistan's national highway network is multiplying day by day. The importance of an efficient road network for sustained economic development, creation of employment opportunities & poverty alleviation hardly needs an emphasis. In this scenario, continued and quality maintenance, rehabilitation, up-gradation and preservation of Pakistan's precious highway asset are absolutely vital to the growth of national economy. This factor assumes added significance as the surveys conducted on conditions of Pakistan's national highway network show that almost 20% are in very poor state and require major rehabilitation and maintenance.

It is brought out that with no service life remaining; the pavements are candidates only for rehabilitation and reconstruction. After detailed review of all maintenance related factors and budget availability at that point in time, the only viable strategy formulated by the higher authorities of NHA in 2001–02 was to implement a three–tiered program of reconstruction, rehabilitation, and preventive maintenance. An extensive maintenance of national highways has been carried out after 2001, which has considerably improved road conditions, safety and travel time. The concept of functional periodic maintenance, which is relatively a new concept, has also been put to test at different reaches of the highway network and has proved very successful.
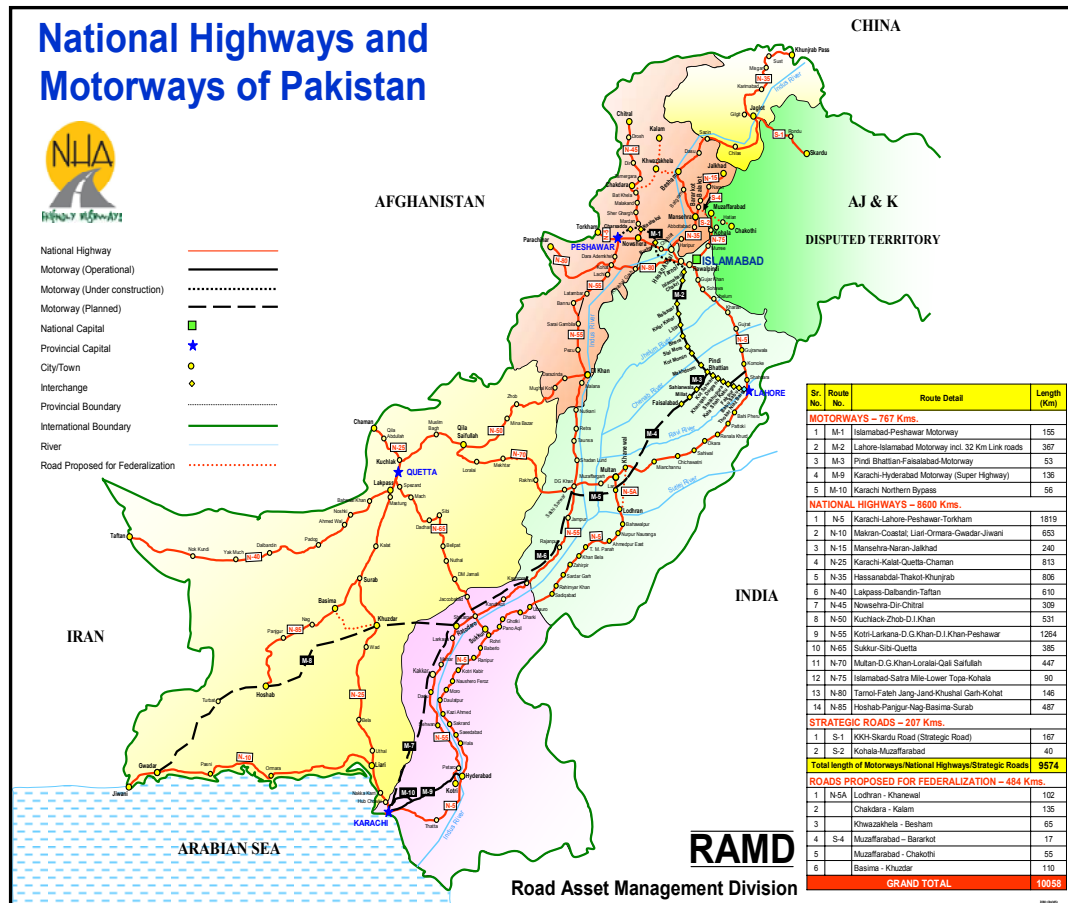
6.5   NHA Road Maintenance and Safety Achievements:

NHA is currently responsible for the maintenance and upkeep of around 9574 KM of federalized national highways. This network comprises only around 3.65% of Pakistan's total road network (i.e.260,000 KM) but country's 80% commercial traffic plies on it.

Obviously, the network is always under tremendous strain and its utility from economic dependence point of view hardly needs an emphasis. Despite the immense gap in maintenance needs and maintenance resources, NHA has achieved significant success in past Four (04) years by gradually increasing the quality of maintenance through periodic overlays (Structural as well as Functional), provision of rigid pavement at places of rutting, replacement / rehabilitation of old bridges along with provision of services such as urban area development including provision of facilities like services lanes, lighting, bus bays, taxiways, parking lots, underpasses, overhead bridges, flyovers, etc, through toll revenue.

NHA is also focusing attention on highway safety measures for safe and smooth traffic flow. Highway safety devices have been designed and installed on international guidelines ensuring improvement of accident–prone locations and optimum safety of road users. New technological developments and traffic safety materials are being utilized. The process of installing road signs,

delineators, cat eyes, guard rails, provision of U-turns etc, has been geared up. Improved riding quality of roads and provision of road safety devices/signs has significantly brought down the number of accidents on the national highways despite manifold increase in the traffic volume.

National Highways and Motorways of Pakistan

Sr. No.	Route No.	Route Detail	Length (Km)
MOTORWAYS – 767 Kms.			
1	M-1	Islamabad-Peshawar Motorway	155
2	M-2	Lahore-Islamabad Motorway incl. 32 Km Link roads	367
3	M-3	Pindi Bhattian-Faisalabad-Motorway	53
4	M-9	Karachi-Hyderabad Motorway (Super Highway)	136
5	M-10	Karachi Northern Bypass	56
NATIONAL HIGHWAYS – 8600 Kms.			
1	N-5	Karachi-Lahore-Peshawar-Torkham	1819
2	N-10	Makran-Coastal; Liari-Ormara-Gwadar-Jiwani	653
3	N-15	Mansehra-Naran-Jalkhad	240
4	N-25	Karachi-Kalat-Quetta-Chaman	813
5	N-35	Hassanabdal-Thakot-Khunjrab	806
6	N-40	Lakpass-Dalbandin-Taftan	610
7	N-45	Nowshera-Dir-Chitral	309
8	N-50	Kuchlack-Zhob-D.I.Khan	531
9	N-55	Kotri-Larkana-D.G.Khan-D.I.Khan-Peshawar	1264
10	N-65	Sukkur-Sibi-Quetta	385
11	N-70	Multan-D.G.Khan-Loralai-Qali Saifullah	447
12	N-75	Islamabad-Satra Mile-Lower Topa-Kohala	90
13	N-80	Tarnol-Fateh Jang-Jand-Khushal Garh-Kohat	146
14	N-85	Hoshab-Panjgur-Nag-Basima-Surab	487
STRATEGIC ROADS – 207 Kms.			
1	S-1	KKH-Skardu Road (Strategic Road)	167
2	S-2	Kohala-Muzaffarabad	40
Total length of Motorways/National Highways/Strategic Roads			**9574**
ROADS PROPOSED FOR FEDERALIZATION – 484 Kms.			
1	N-5A	Lodhran - Khanewal	102
2		Chakdara - Kalam	135
3		Khwazakhela - Besham	65
4	S-4	Muzaffarabad - Bararkot	17
5		Muzaffarabad - Chakothi	55
6		Basima - Khuzdar	110
GRAND TOTAL			**10058**

RAMD
Road Asset Management Division

NHA has also embarked upon a major axle overload control program through installation of weigh stations and other suitable measures to control the damage caused by overloaded trucks. As per international standards, improvement of road, installation of requisite road Furniture caters for 90% reduction in accidents and 10% accident management is through enforcement of legal limits.

6.5.1 STANDARDIZATION OF MAINTENANCE ACTIVITIES

Under the constraints of low budget and higher traffic volumes on an ever–expanding highway network, the usage of available resources and budget has been optimized in order to maintain the desired standards of performance and serviceability. After undertaking detailed scrutiny, analyses and deliberations, an NHA decided, in year 2002, that the maintenance standards employed on national highways / motorways of Pakistan, which had become primitive and outdated worldwide, shall be improved considerably in consonance with

internationally accepted standards and procedures, that is, all roads shall be maintained to the highest quality standards achievable.

It was decided that international maintenance procedures and standards adopted world over such as AASHTO, ASTM, Asphalt Institute with their relevant guidelines will be adopted extensively to perform all maintenance activities. Although the maintenance cost has doubled but concurrently, the improvement in techniques, standards and quality of work has increased tremendously. NHA has succeeded in achieving pothole–free national highways, which can largely be attributed to standardization of maintenance work.

The longer, continuous sections are now picked up in periodic maintenance (Functional) schemes so that the pavement life cycle of the entire stretch is increased. This new technique also significantly increases the riding comfort of the road users, having a direct relationship with the Vehicle Operating Cost (VOC) which is reduced, rendering a healthy influence on the national exchequer. It is estimated that an amount of Rs. 7 Billion spent on various maintenance activities reduces the VOC by about Rs. 120 Million. Hot recycling is relatively a new maintenance technique in Pakistan which has been included in Annual Maintenance Plan of FY 2006–07. This technique has considerable advantages over other conventional forms of functional overlays. Supply and utilization of quarry materials (including aggregates and sand) and bitumen is reduced. Besides being environmentally very friendly, the technique is extremely time–efficient as about 1.5 km of pavement per day can be hot–recycled. For uphill sections on the national highways / motorway network having problems of rutting due to excessive overloading, reinforced rigid pavement has been constructed which has had a positive impact in curtailing the recurring maintenance expenditures. Another achievement of NHA by improvement of maintenance techniques is that emphasis on rehabilitation and reconstruction schemes has been reduced to a sufficient degree.

It is foreseen that due to shortage of funds, a maintenance backlog shall be created in 2 – 3 years time. The maintenance needs of the national highways and motorways are met through different types of regular and periodic measures, including Routine Maintenance, Periodic Maintenance, Rehabilitation, Emergency Maintenance, Geometrics Improvement, Highway Safety Improvement, Corridor Management, Hill Slope Stability, etc.
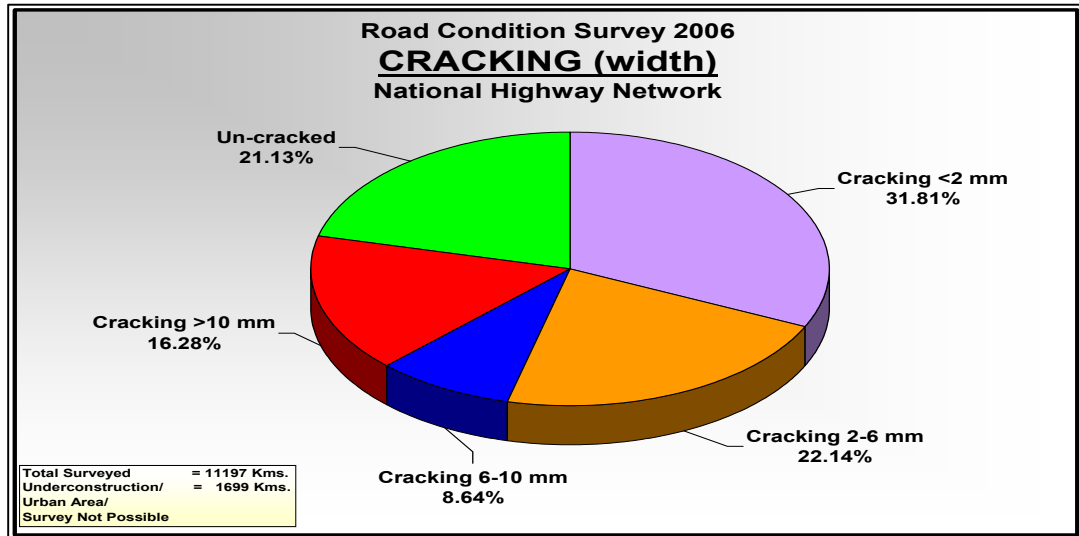
7.   Condition of Existing Roads:

7.1   STRATEGY ANALYSIS OF NHA NETWORK

In year 2006 the strategy analysis of the entire national highways network was carried out in order to define future road maintenance funding needs. The analysis has been done using the Strategy Analysis Module of the Highway Development and Management Tools, HDM-4, Version 1.3. The HDM-4 simulates total life cycle conditions and costs for different rehabilitation and maintenance activities, either for a given road section or for an entire road network, and provides economic criteria for decision making. Optimization of multiyear programs of expenditure under budgetary constraints is done using incremental benefit/cost analysis techniques, as provided by the Strategy Analysis Module of the HDM-4.

As per annual condition survey carried out this year about 2294 km are having a **rut depth** of less than 6 mm which becomes 24% of the total network, whereas about 6232 km are un-rutted which certainly is big achievement.
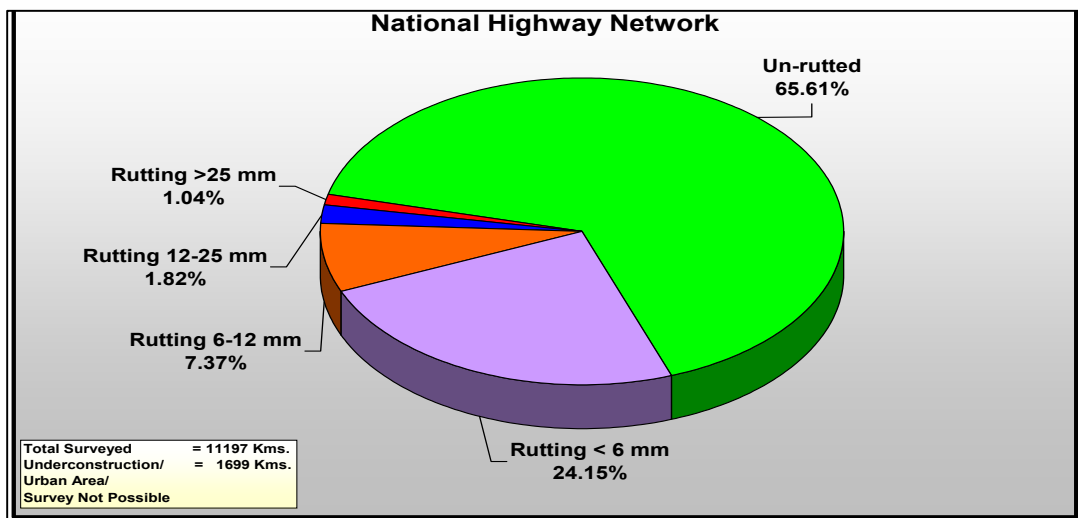
The cracking analysis shows that about 31.81% of the network is having less than 2 mm **cracking** and the maximum cracked size i.e. 10 mm is about 16%.

Road Condition Survey 2006
CRACKING (width)
National Highway Network

Un-cracked 21.13%
Cracking <2 mm 31.81%
Cracking >10 mm 16.28%
Cracking 2-6 mm 22.14%
Cracking 6-10 mm 8.64%

Total Surveyed = 11197 Kms.
Underconstruction/ = 1699 Kms.
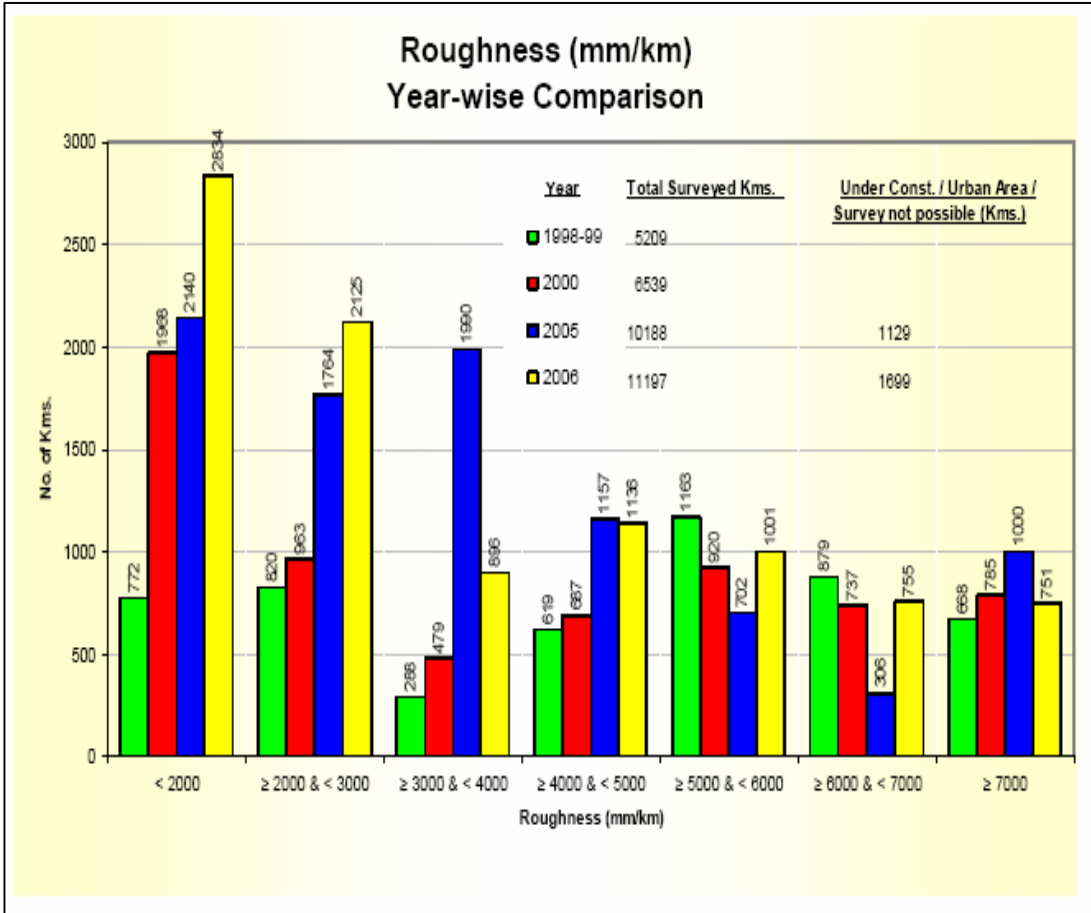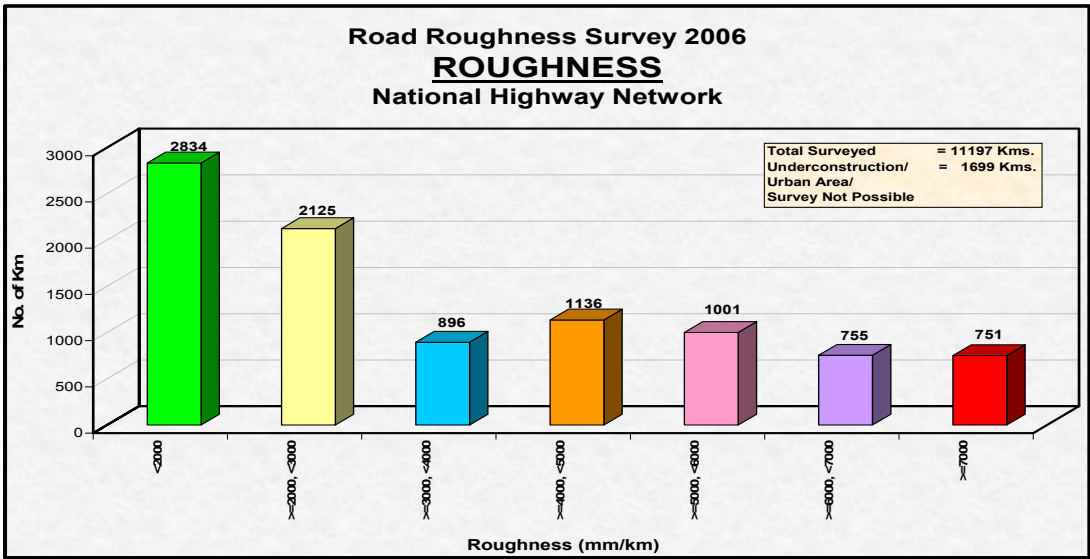Urban Area/
Survey Not Possible

The third major contributor in pavement performance is roughness. As per annual **Roughness** Survey carried out from December 2005 to March 2006, the road network about 76% (range between 2 IRI to 5 IRI).

In relation to roughness, one can observe that:

  (a) 52% of the paved network is in good condition (2 to 3 IRI),
  (b) 22% is in fair condition (3 to 5 IRI),
  (c) 18% is in poor condition (5 to 7 IRI).
  (d) 8% is in very poor condition (more than 7 IRI).

The current average network roughness is 4.7 IRI (9498 Km), comparing to 10 in year 2000 for a network of 8039 km. This is mainly due to the fact that during last four years NHA has shifted its focus from Rehabilitation to Periodic Overlays (i.e. Functional & Structural Overlays) which has contributed significantly in improving the network In addition to this it is fact that during last year survey conducted of NHA Network, the section which have shown Zero (0) Remaining service life are basically N-35, N-45, S-1, S-2 & Jhelum Valley Road which are either maintained by FWO or recently transferred to NHA or affected by earthquake, which shows that maintenance standards adopted by NHA has improved the condition of road network

13

Road Roughness Survey 2006
ROUGHNESS
National Highway Network

Total Surveyed	= 11197 Kms.
Underconstruction/	= 1699 Kms.
Urban Area/	
Survey Not Possible	

Roughness (mm/km)
Year-wise Comparison

Year	Total Surveyed Kms.	Under Const. / Urban Area / Survey not possible (Kms.)
1998-99	5209	
2000	6539	
2005	10188	1129
2006	11197	1699

The current survey was conducted over a total network of 11197 and present road condition reveals that 3845 km is under poor to very poor condition which is 34% of entire network length. It shows that during last year about 4.7% reductions occurred in state of zero **remaining service** life sections. Further the trend shows that due to Periodic Maintenance (Functional &

Structural Overlays) road service life was improved and there is even distribution among the RSL graph trend.
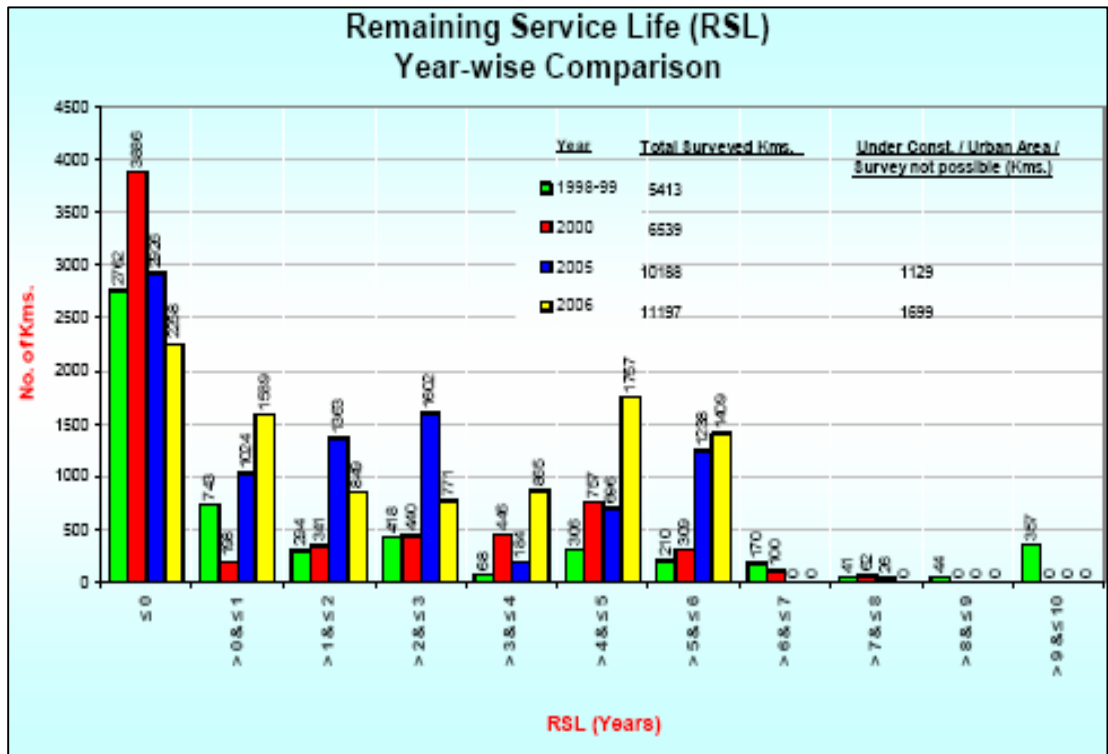
Road condition progression with the given budget (Rs. 10.5 Bill/year for the first five years) is given in the following chart. With the intervention criteria used road roughness will be improved from level 4.6 IRI to level of about 3 IRI, and this level is forecast to be sustainable in the future, if the annual budget is about Rs. 10.5 Billion per year on average over 5 year period.
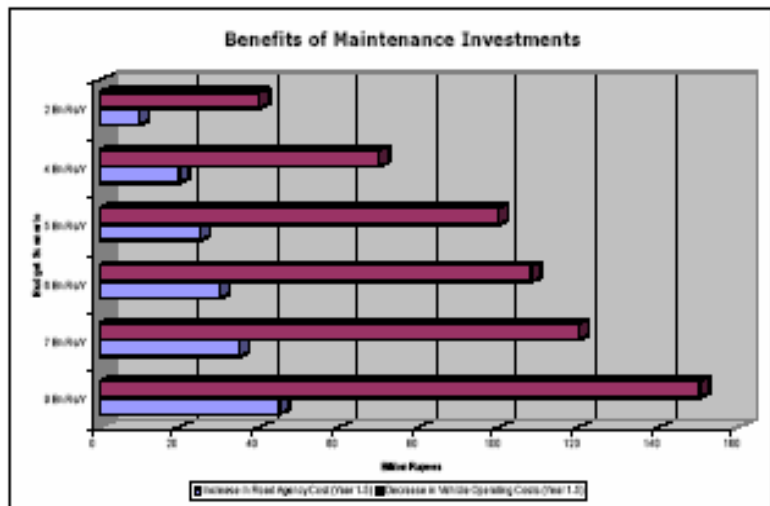
8. **Quality Assurance:**

Recently NHA has undertaken a comprehensive research development program for road design methodology under National Highway Improvement Program, funded by the World Bank. This program is envisaged to have far reaching implications on our road design standards and specifications.

The asset value of road network in Pakistan is Rs. 2500 billion and unfortunately, most of it has been or is being lost in the form of premature fatigue cracking and rutting and their rapid progression to the high-severity level on asphalt concrete pavements in Pakistan. Currently in Pakistan AASHTO guide for design of pavement structure is used and Marshall Method is most widely used for design of AC pavement / bituminous mixtures.

NHA has learned from both the successes and failures of pavement, therefore to produce pavements that last the design life, cater for hot climate conditions, resist heavy axle loads and high tire pressure, local material characteristics etc, it has launched a comprehensive pavement study program entailing a Laboratory and Road Testing Experiments.

National Highway Authority is also conducting the tests on trial sections with Crumb Rubber, Hardened Bitumen of grade 40-50, and Polymer Modified Asphalt & Stone Mastic Asphalt (SMA) to evaluate / analyse the pavement performance under local climate, materials and loading conditions.

8.1 Research & Development within NHA Framework

The details of the R & D program are presented below. The PART 1 of the program (already in the pipeline) is specific in context given the inadequate funds under the technical assistance of the World Bank. The overall aim is to carry forward the R & D program within the National Highway Authority for which adequate funds need to be raised/generated. Part 2 of the program is also detailed below.

8.2 PART- 1 (Purpose)

NHA intends to launch a comprehensive pavement study program entailing a laboratory and road test experiment to evolve a pavement design methodology suiting local conditions. To develop adequate and cost-effective asphalt concrete (AC) pavement structural and bituminous mixture designs, thereby improving life and quality of NHA's road network and its value to the National economy.

8.3   Objectives of a Research Program

Laboratory Test Experiment

The overall aim of laboratory test experiment is to evaluate performance-related properties of a series of bituminous mixtures for AC wearing course and AC base course, designed at different air void and asphalt contents with specific objectives as follows:

(a) Evaluate the rutting propensity (dilatancy characteristics) of the above mixtures using Repeated Simple Shear Test at Constant Height (RSST-CH) and abridged procedure presented in TRB paper # 940236 (Sousa-Solaimanian, 1994).

(b) Screen rut-prone mixes and identify from the remaining mixes, the mixes that gave the best rut performance (one for AC wearing course and three for AC base course - one each from the three aggregate sources).

(c) Select the combinations of air void and asphalt contents for the above-identified mixes for field testing in the "Road Test" phase.

(d) Develop laboratory fatigue models for the above-selected bituminous mixtures using the SHRP fatigue test equipment, and performance-based specifications for Pakistan.

The following tests and/or other tests recommended by advisory research consultants shall be performed on AC wearing and base course bituminous mixtures:

(a) Simple Shear and Frequency Sweep Test
(b) Uniaxial Strain and Volumetric Test
(c) Constant Height Repeated Shear Test
(d) Asphalt Fatigue Test (bending beam and/or indirect tension)
(e) Resilient Modulus Test

The testing shall be carried out using the MTS CS7200 SHRP SUPERPAVETM Shear Test System.

In addition to the above tests, all other usual tests like Marshall stability and flow, penetration and viscosity of bitumen etc. shall be carried out.

8.4   Road Test Experiments

The overall aim of road test experiment is to study the structural and functional response of a series of AC pavement structures incorporating varying thicknesses of asphalt bound layers and varying roadbed soil

(subgrade) under the action of actual fleet of trucks and temperature regime existent in Pakistan.

Specific objectives include:

(a) Evaluate the field fatigue performance of road "Test Sections" with a view to determine "Shift Factors" for the laboratory developed fatigue models (calibration).

(b) Study the rut performance of road "Test Sections" to establish "Rutting Strain Criterion" through back analysis.

(c) Develop load equivalency factors (LEF's) using the radial tensile strain and the traffic loading data collected from the road "Test Sections".

The "Road Test Sections" will be constructed as part of the widening of N-5 carriageway between the cities of Lahore and Gujranwala. The number of "Test Sections" is limited to forty-five, 91 metres (300 feet) long, separated by non-experimental transitions of 9 metres (30 feet), thus, the total length is 4.5 kms.

The "Road Test Sections" will be subjected to "LIVE" traffic, since all vehicles travelling south will become part of the "Road Test" experiment. At the "Road Test" site, the one-directional (south-bound) average daily truck traffic (ADTT) is in excess of 2500 trucks and various axle load surveys show that:

(a) the majority of these trucks are reasonably overloaded (though not as much as at few other locations in Pakistan & that is desirable considering that NHA is establishing weigh stations at various locations on N-5 for enforcing load limits - note that in Pakistan the legal load limit is 12 tons i.e., 26000 lbs. per single axle); and

(b) approximately at least 2 to 3 million ESAL's are estimated to be applied by these trucks to the "Test Sections" within one-year period.

The experimental design attempts to ensure that a sufficient number of "Test Sections" FAIL within first year of trafficking - failure is defined as 1/2 inch rut depth and/or 25% fatigue cracking of the pavement surface. The study variables include:

(a) Thickness of AC (5 levels)
(b) Subgrade strength (3 levels)
(c) AC base course mix designs (3 levels)

The goal is to collect sufficient data points within one year to allow development of preliminary pavement design relationship(s) between ESAL's to failure (25% fatigue cracking and/or 1/2 inch rut depth), thickness of AC

and subgrade strength - something similar to the Asphalt Institute pavement design curves.

8.5 PART 2 (Proposed)

In continuation to the foregoing progress will depend on continuing research, particularly in pursuit of innovation and by taking advantage of state of the art equipment available. It will also require that existing and earned knowledge about pavements regarding our own environment is implemented in practice by Paving-the-Gap. The concept of "Paving the Gap" can flourish only if National Highway Authority provides a sustained institutional vehicle for research and development. It also requires that both sides of the industry display a willingness to introduce new ideas to practice.

NHA is endeavouring to develop a country level research centre in collaboration with Japan International Cooperation Agency (JICA) which will host researchers from all over Pakistan and provide them research facilities to undertake research in the country. All efforts will be focused on pavements to begin with which will be followed by environment, highway safety and other identified subjects related to highway engineering. Subsequently, all road and bridge related research would be incorporated in the centre. To this end, the establishment of Highway Research and Training Centre (HR&TC) is well underway. Foregoing in view, NHA and the forthcoming JICA mission's will be formulating discrete planning and operational activities for the HR&TC. HR&TC is envisioned as a Centre of Excellence with its role as an Umbrella or Hub of all road research activities undertaken in the country.

A sustained research and development program by the NHA will ascertain following major advantages:

- The formulation of indigenous pavement design and material specifications for Pakistan.

- The mix design of the future projects can be improved keeping in view the widely spread rutting problem on our roads.

- The asphalt thickness may be reduced in a rational way in future road projects thus a substantial savings can be possible.

- Thus, overall cost saving may be possible in terms of better performance, extended service lives on all future projects.

- Besides delivering benefits relating to pavement design, NHA will contribute to provide high technical skills in the road engineering sector.

8.6   Objectives of Sustained R&D Program.

To establish Highway Research and Training Centre incorporating a well equipped and well organised material testing laboratory.

To group together any innovative work or experience gained by the consultants all over Pakistan registered with NHA and other agencies to provide references for future work.

Innovation and development will be the aim. In this regard an ongoing sustainable research program will be established to improve our roads. Laboratory Assistance to Field Test sections will be extended. The test sections will be implemented from south to north of the country preferably on ongoing new and rehabilitation projects.

- To devise indigenous pavement material specifications and end product specifications bringing quality to our projects.

- To devise indigenous pavement design manual for Pakistan

- To ensure proper and effective coordination for proper representation/participation of all road agencies in Pakistan. This will be useful for transfer of technology.

- To extend NHA's contribution to academia. Students from universities will acquire skills in road engineering. Professionalism will nourish in NHA.

- To train NHA officers for refining their knowledge as highway engineers.

- To establish a training centre for NHA officers and highway engineers. Smart workshops and training weeks will be formulated in this context.

- To provide technical expertise locally to inland highway agencies and internationally to countries like Afghanistan, Iran and SAARC countries.

The sustainable development in roads will give NHA new horizons and we will become opinion leaders in South East Asia and world as a whole. Benefits from our research and development program will be far reaching. NHA will extend its technical support to other countries in South East Asia which will come cheap as compared to other western states.

9. References

1.1   A Fact Book on Pakistan Transport (JAICA)
1.2   World Road Statistics 2006 (IRF-2006)
1.3   NHA Annual Maintenance Plan 2006-07
1.4   Pakistan Transport Plan Study (PTSP)
1.5   Pakistan Transport Policy
1.6   Transport Sector Plan 2006 (JAICA)