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MONITORING THE QUALITY OF ROAD WORKS
A CITIZEN’S GUIDE

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PUBLIC AFFAIRS CENTRE
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This Guide represents an attempt to demystify the task of monitoring the quality of road works. It is customary for governments to leave the monitoring of technically complex works such as roads to their own experts. But the growing public dissatisfaction with road quality has highlighted the need to devise ways to monitor and get other officials as well as road users to play a “watchdog role” in the monitoring process so as to bring about greater transparency and accountability in this important area of public expenditure. Our hope is that the Guide will help make road quality monitoring a more public and open process in which all stakeholders can be involved.

The genesis of this Guide can be traced to the suggestions made by Mr. M. N. Vijayakumar, I.A.S. the then Secretary of the Hyderabad-Karnataka Development Board, to improve the technical monitoring of public works to ensure both quality and cost efficiency. This led to a series of discussions within government during which the need for a Guide listing out practical methods of quality control to be used by supervising and controlling officers became apparent. The Department of Science & Technology of the Government of Karnataka then consulted the Public Affairs Centre and eventually formulated a project under which the Centre organised workshops with experienced and committed civil works experts with the objective of putting together a Guide for monitoring the quality of public works. In the course of the two seminars organised for the purpose, experienced engineers familiar with road works in the public and private sectors interacted closely with representatives of the citizens’ groups under the overall guidance of Prof. C. E. G. Justo, a well known consultant and academic.

The preparation of the Guide is a pioneering effort for many reasons. The practical wisdom of planners and engineers regarding road maintenance is available in an easily accessible form to people both within and outside the government who have no technical background. This will greatly benefit inspecting officers who are required to periodically monitor the utilisation of budgeted outlays on road works. Within government, the Guide can be widely used by managers and supervisors in several departments; in fact it can help all those who sanction and release funds for repair, maintenance, widening and improving roads. Deputy Commissioners and Assistant Commissioners and the senior staff of special agencies like Area Development Boards can arm themselves with this Guide while inspecting road works funded under their respective schemes.

The Guide will also be a boon to local bodies, both rural and urban. Non-official members of Zilla and Gram Panchayats can use it for verifying the quality of ongoing works in their areas. Officers of such bodies, like Chief Executive Officers and Block Development Officers can also apply these methods while inspecting road works.
By closely involving non-governmental organisations and resident welfare associations in the preparation of the present Guide, the Public Affairs Centre has discovered another area in which it can be of immense use. The enthusiasm and participation of residents' associations and other concerned citizens in the present endeavor has been infectious. The common man is clearly dissatisfied with road conditions and suspicious about how the taxpayer's money is being used on public works. He is prepared to put in time and effort to monitor road maintenance and eager to be trained in the appropriate techniques. This document therefore meets a felt need of the ordinary citizen of Karnataka.

Information listed in this booklet relating to pothole repair, silting and maintaining drains and countless other matters concerning road conditions can be applied by any person who is concerned about the condition of public works and is willing to make civic authorities perform their jobs properly. The Public Affairs Centre proposes to publicise and make available the technical advice contained in this manual to all such agencies and individuals. A demonstration kit containing basic tools and equipment is also being prepared to make the Guide practicable and more effective. Participation of such groups in monitoring the quality of road maintenance could improve the performance of government offices and local bodies and increase their accountability and efficiency. We look forward to a closer co-ordination between government and civil society in this area and hope that the Guide will help make road quality monitoring a more public and open process in which all stakeholders can be involved.

It is envisaged that the Guide will continuously be revised and updated to keep pace with new methods and techniques of road construction and maintenance. The preparation of this Guide is a small but significant step in bringing government closer to the people. Nevertheless it will certainly go a long way towards the evolution of a system of "technical auditing" by certified experts, of all the infrastructure planned and built by a public agency.

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1. PREAMBLE

Construction and maintenance of roads form an integral part of infrastructure development especially in urban areas.

Excepting some minor routine maintenance, most road works are contracted out to the private sector with a tendering process. These contracts also include certain specifications which if adequately fulfilled would result in better quality roads. These specifications are framed by Ministry of Surface Transport (MOST) and Indian Roads Congress (IRC) and are adopted by PWDs, Panchayats, Municipal bodies and others.

Quality control cells do exist in many of these agencies. Since they have only advisory function related to testing for quality, supervision leaves a lot to be desired. Quality maintenance is an ongoing process and is not given enough attention because it may be politically more exciting to build something new and take credit for it than to fix or maintain an existing system.

Lack of proper planning and co-ordination between the various government agencies and illegal overloading of trucks are two other major constraints that plague road maintenance management in India. All these have contributed to the vicious circle of construction and reconstruction without proper maintenance and management.

1.1 Why citizen monitoring?

Safe and motorable roads are important for improvement in overall quality of life. Citizens and tax-payers are the ultimate users and have a right to good quality roads. Rights cannot be divorced from duties. Therefore, being vigilant is one of the important duties of citizens. It is in this context, citizen monitoring of the quality of road works which is a culmination of both rights and duties attains critical importance as only they can mount pressure for a positive change. In summary, the following factors have proved to be a stumbling block in achieving safe and motorable roads:

- Poor or lack of supervision, ignorance and unethical work practices
- The funds allotted for routine and periodic maintenance is not sufficient, in which case it’s all the more necessary to be quality conscious.
- Lack of transparency in tendering and contracting process resulting in collusion and corruption
- Flaws and loop holes in rules and regulations.
- Absence of records pertaining to construction and maintenance details of each stretch of road.

1.2 SCOPE OF THE GUIDE

The most important objective of the Guide is to provide the citizens with some information on road maintenance works and quality checks so as to strengthen citizen’s voice. The guide describes some of the standard procedures and specifications as may be provided for in the contractual/tender documents. Only those methods of routine maintenance, resurfacing and overlaying of road pavements which are most commonly being practised in this region have been covered and the coverage itself is however not comprehensive, but critical nevertheless. The specifications stated in the Guide are based on those given by MOST and relevant specifications and code of practices of IRC. The extent to which they are followed and implemented by State PWDs and local governments like Municipalities and Panchayats is a matter which merits wide spread public debate. This is precisely what the manual aims to achieve in the longer run. Imagine a situation when citizens groups all over the country become quality conscious and start demanding accountability of public work expenditure from a technical viewpoint. Only then will any positive changes occur. The guide is expected to facilitate a harmonic spirit of interaction between the citizens and the authorities in the process of evolving a system which becomes accountable to the public in a climate of mutual trust.

Though the Guide attempts to simplify the “technicalities” of road quality monitoring, it does not shy away from the same. Unless citizens educate themselves about some essential technical matters pertaining to public works expenditure, unethical practices will prevail resulting in huge wastage of public money and deterioration of quality of life. If, however, some readers find these details too complex, they may seek assistance from civil engineers or other competent persons residing in their neighbourhood to explain these relevant matters.
2. SOME BASIC INFORMATION YOU NEED TO KNOW ABOUT ROADS

ROAD CROSS SECTION ELEMENTS

The paved portion of the road meant for the use of vehicular traffic is termed carriageway or road pavement. Typical cross section of a roadway with foot paths or shoulders and drains indicating the common terms used are shown in Fig.1 and 2. (Page 7)

STRUCTURE OF PAVEMENT

The structure of a pavement is designed to support the wheel loads of the heavy commercial vehicles such as loaded trucks and buses and to distribute the load stresses through a sufficiently large area on to the soil subgrade. Based on the structural behaviour, the pavements are generally divided into two classes, viz., flexible pavements and rigid pavements. Since most Indian roads are flexible pavements, it forms the focus of the Guide. Rigid pavements mainly consist of cement concrete pavements. A flexible pavement consists of five components or layers (See Fig 3, p7). The lowest layer is i) prepared subgrade made up of soil, followed by (ii) sub base course made of granular soils and materials, (iii) Base course is made of crushed aggregates constructed in layers iv) bituminous binder course may be laid over the base course, but below the top most surfacing course on roads carrying heavy vehicles and v) the bituminous surfacing course is the top most layer which is subjected to wear and tear due to moving traffic and atmospheric factors. The top most layer requires regular maintenance so as to provide a good and safe riding surface for all classes of fast moving automobiles/vehicles. All these components combine to give the total thickness of the flexible pavement which may vary between 300 to over 1000 mm. Superior quality materials are used in the upper layers which have to sustain higher magnitude of wheel load stresses and also wear and tear due to the traffic and environmental factors.

DRAINAGE SYSTEM:

The life and performance of the road pavement very much depends upon the efficient functioning of the road drainage system. Places where there is stagnation of water, the pavement starts failing rapidly. Therefore the surface and sub surface drainage system should be properly designed, constructed and maintained in order to ensure the pavement to function satisfactorily during the design life.

SHOULDERS

Shoulders are road margins along either side of carriageway within the formation width of the roadway. The shoulders serve as side walks for pedestrians where raised footpaths are not provided and also for stopping or emergency parking of vehicles.

FOOTPATH

Footpaths are raised portions of the formation meant for safe walking of the pedestrians, usually provided in urban areas. The height of the footpath kerb may preferably be 150 to 200 mm above the pavement edge and the minimum width may be 1.5 m, which may be increased depending upon pedestrian requirements. The surface of the footpath should be maintained well so as to attract the pedestrians.

2.1. THE FOLLOWING POINTS HAVE TO BE REMEMBERED DURING MAINTENANCE OF FLEXIBLE PAVEMENTS:

i) Before resurfacing or strengthening an existing pavement, it is essential to improve the road drainage system and correct the defects of the existing pavement and its profile.

ii) Each pavement layer constructed above an existing pavement, should be of higher quality or at least of the same quality or stability value of the top layer of the existing pavement. For example, if an existing pavement surface consists of Bituminous Concrete (BC) the next layer of overlay should also be either BC or Dense Bituminous Macadam (DBM) and BC and not inferior materials.

iii) It is not desirable to construct bituminous layers using inferior materials such as Penetration Macadam (PM) or Built up Spray Grout (BSG) in place of premixed materials such as Bituminous
FIG. 1 CROSS SECTION OF ROAD WITH SHOULDERS

FIG. 2 CROSS SECTION OF URBAN DIVIDED ROAD

FIG. 3 COMPONENTS OF FLEXIBLE PAVEMENT
Macadam (BM), for use in binder course or depression filling, camber correction or even patching pot holes.

iv) Over an existing black top or bituminous surface, when another layer of bituminous layer is to be constructed it is necessary to spray a thin layer of tack coat, using a pressure sprayer (either mechanical sprayer or hand operated sprayer), at the specified rate, just before spreading the new bituminous mix. Hand pouring of tack coat through perforated cans should not be permitted. The material used for tack coat may be cutback bitumen in fluid state or heated bitumen.

v) Over an existing non-bituminous granular base course layer, before laying any bituminous layer, it is necessary to spray a cold bituminous material of low viscosity viz., either cutback bitumen or bituminous emulsion, called prime coat, and allowed to cure for about 12 hours, and over that a bitumen tack coat should be sprayed. During this curing period of prime coat, no traffic should be allowed to move on the surface.

2.2 IMPROPER APPROACH OF PAVEMENT MAINTENANCE : WHAT GOES WRONG?

It may be generally noticed that some stretches of road pavement start failing earlier than the rest, though the entire length of the road was constructed and maintained under identical specifications and also subjected to almost similar traffic loads. Often the causes for early deterioration of these stretches are not identified and rectified but the full road length is again resurfaced or overlaid with a pavement layer. This is a wrong practice. In such cases, similar defects are likely to develop again on the same stretches.

i) Drainage Improvements

Among several causes, the most important cause for early failure of some stretches of road, is improper surface and/or sub-surface drainage at certain stretches resulting in stagnation of water on the pavement and/or within the pavement and the sub-grade of these stretches.

ii) Correction of defective pavement surface

A bituminous pavement surface could have developed several defects such as pot holes, cracks, ruts, depressions, loss of cross slopes, etc. at certain locations/stretches, due to various causes. But more often it is found that the overlay or resurfacing work is carried out covering-up the entire area of pavement surface including the defective areas/spots as well as relatively good surface, without properly attending to the defects, which is a wrong practice. In this case, the defects such as pot holes, ruts, and cracks will reflect on the new surface also much earlier than the anticipated service life of the pavement layer; the wrong profile such as inadequate cross slope, depressions on pavement surface causing poor riding quality etc., will develop on the resurfaced pavement also, though on a smaller scale.

iii) Water leakage from service lines

On city roads, where service lines such as pipes of water supply and sewerage system are located under the road pavements, pavement failure takes place at isolated spots due to leakage of water. Unless the leakage is effectively sealed before taking up the road maintenance works, the problem of pavement failure at these spots will continue. Shifting of these pipelines away from the carriageway is the only permanent solution. If this cannot be done, special filter drains may be constructed at potential leakage points, to drain off the water to the side drains.

iv) Cross Cutting of Pavement

Serious damages to the road pavement are caused due to cross cutting and digging of longitudinal trenches to take new service lines of water supply, sewerage, electricity and telephone lines. Lack of planning and co-ordination amongst the various agencies has compounded the problem. If such cuttings are made due to unavoidable circumstances, refilling and compaction are to be done using proper materials in layers, using suitable equipment.

v) Other wrong practices occur on the field while pavements are either being resurfaced or strengthened. These will be dealt in detail in the next paragraphs.
2.3 PAVEMENT MAINTENANCE MANAGEMENT (PMM)

Quality and durability of roads depend on an efficient PMM. PMM comes into operation after new roads are constructed and also for existing roads. It consists of the following steps:

i. Maintenance of drainage system including desilting, repair and construction of missing components/links

ii. Patching pot holes/ruts

iii. Removal of cracked portions of bituminous pavement with wide cracks and patching the same

iv. Sealing fine cracks

v. Filling up longitudinal and cross sectional trenches due to digging or road cutting for new service lines

vi) The surface level and cross slope of the shoulders and footpaths to be corrected to drain away the surface water to the side drains.

vii) Profile Correction – correction of cross slope and depressions.

viii) Relaying /resurfacing of bituminous pavements.

ix) Strengthening or overlaying of bituminous pavements.

The first six steps are operations which need to be carried out on a day-to-day basis, failing which deterioration of pavements gets accelerated. And before taking up step viii or ix, it is mandatory to check if any of /all the first seven steps are necessary and completed. The specified procedure, methods of testing and equipment is explained in Table I – a & b, Table II – a,b,c and Table III – a, b, c. PMM should be based on periodic evaluation of both structural and functional aspects of road pavements. Such evaluation should form the basis for decision regarding maintenance, resurfacing and design of overlays for strengthening at the right time, using appropriate materials. It is necessary to strengthen weak or structurally deficient pavements, with reference to increase in magnitude and number of wheel load repetitions.

Delayed PMM may lead to requirements for either rehabilitation or even reconstruction of pavement resulting in very high cost.

Most road works in urban areas like Bangalore fall within the PMM, therefore PMM forms the exclusive focus of the Guide.

3. WHY SPECIFICATIONS - QUALITY MANAGEMENT

The specifications on procedures and materials for road pavement works in India are framed by both IRC and the MOST. At the level of the State Government, it is the Public Works Department which frames the Schedule of Rates (SR) which in other words are the specifications for ensuring and maintaining quality of public works including roads. The SR draws heavily from IRC and MOST specifications. All other agencies carrying out road works mostly adopt and improvise on these specifications. There are two important considerations as rationale behind these specifications.

3.1. Water is the Enemy : Appropriate drainage system to be provided to prevent water stagnation on and within the pavement and to arrest water seepage beneath the surface.

Water is considered to be the worst enemy of roads. There are many specifications related to effective drainage of water to prevent seepage into the pavement. Ensuring cross slope of the pavement layers and the surface crack sealing and maintaining the overall drainage system are some of the important steps in this direction. It is sad to note that in normal practice these aspects are ignored particularly during maintenance of roads.

3.2. Choice of materials and construction procedure:

Most Indian roads have a bituminous layer as their surface, which is subjected to tremendous wheel load stresses. Therefore it has to be strong enough to receive this stress and distribute this evenly to the lower layers. There are many specifications to ensure proper choice and proportions of materials, thickness and density to give the desired strength. During pot hole filling, resurfacing and overlaying, unfair practices and ignorance prevails and paves the way for rapid deterioration of pavements. Deviation from the specifications are mostly seen in the following aspects: (i) rate and method of applying tack coat – pouring tack coat through perforated cans instead of spraying through sprayer or applying by hand brush; (ii) defective
size and gradation of the aggregates; (iii) less quantity of bitumen than specified; (iv) overheating or insufficient heating of the mixture of aggregates and bitumen; (v) delayed compaction; (vi) inadequate compaction and improper compacting machinery. Apart from all these, for some of the items of work, the rates given in the SR are unrealistic, to execute good quality work. Table A on page 16 gives a brief description of common types of mistakes, effects of these mistakes on the quality of pavement, whom do they benefit and who the losers and sufferers are.

4. WHAT IS MONITORING? Some tips.....

For the purpose of the Guide, monitoring is defined as watching the road works to ensure if some of the essential specifications for quality maintenance are adequately met with during road maintenance works.

When a road maintenance work starts, try and obtain the following information from the concerned Engineer of the client organisation (PWD/Municipal Corporation/Development Authority/etc)

i) The actual stretch of road ii) The items of work entrusted to the contractor iii) Type of resurfacing/overlay (PC/MSS/BC, etc.), thickness and other provisions such as camber correction, pot hole and depression filling etc. iv) Total cost of the work including other roads if any and their details. v) Details about the contractor - Name, address, telephone, fax etc. vi) A copy of the contract and specifications.

- **Be alert, vigilant and prepared**: Monitoring function calls for vigilant, alert and proactive citizen groups. The groups (CBOs, NGOs, Resident Welfare Associations) should always be alert and gather information about works being planned in their locality/ward/neighbourhood and details of the contractor. Be prepared well in advance with the necessary equipment and try and build rapport with the contractor.

- **Team work matters! Don’t forget to invite the local press**: Monitoring may yield better results if it is done as a group of at least 8-10 comprising of senior citizens, women and youngsters rather than just 2-3 people. Try and arrange for press reporters and photographers to be present when you want to begin the monitoring process.

- **Time consuming but worthwhile**: Depending on the kind of road work, monitoring process can be time consuming or even tiring but definitely an effort both interesting and worthwhile.

- **We can’t shy away from “technical” matters**: If we want safe and motorable roads, we must be willing to understand the technical aspects of pavement construction and management. Only then can we monitor the quality. The tests being advocated at different stages of this Guide are actually simple and do make a great deal of common sense. In any case, to begin with, mere observation of the different steps and questioning the contractors or officials based on those observations will itself set the trend for positive change. Before beginning the monitoring, it is better to train and orient the volunteers. Training inputs can be derived from the Guide. Try and involve the civil engineers or engineering students living in your neighbourhood.

- **Challenge with evidence**: Citizen monitoring may not ensure good quality work in all cases/situations. Citizen volunteers need to be on the streets, use the manual and question the contractors and officials about any deviations from the specifications. If they willingly comply and take corrective measures based on citizen feedback, it is an achievement. If not, report to the higher authorities and give wide publicity, or as a last step even file writ petition in the court. This questioning backed by evidence from observations and tests and coupled with wider publicity at many locations simultaneously has the potential to generate a public debate and build up pressure for positive but qualitative change.

Since the Guide is a novel experiment, its potential as a community based monitoring tool is by and large an assumption. Its advocacy potential can be concretised only if the manual is tested in different parts of the country and much interest and feedback are generated in the process.

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1 PC - Premixed carpet, MSS- Mix seal surfacing
5. THREE STAGES OF MONITORING PMM

Given below are the three stages of PMM. Either stage I, or I and II or I and III may be required depending on the deficiencies of the road pavement, traffic, etc.

5.1. Stage I – Table I a & b

1. Drainage System – cleaning , repairs
   i) Clearing all side drains (both open and closed drains), transverse/shoulder drains and culverts from blockages due to garbage, debris or silt.
   ii) Repair of all the existing drains, including resetting of stones, slabs and pointing with cement mortar.
   iii) Identification of missing links of drains and constructing these, such that the water from the road side is lead off upto the disposal points.

2. Evaluation of road pavement

3. Filling up longitudinal and cross sectional trenches due to road cutting for service lines

4. Patching of pot holes and ruts

5. Treatment of fine cracks on the surface of bituminous pavement

6. Treatment of wide or alligator cracks.

7. Profile correction – cross slope /depressions/camber

8. Foot path and shoulders- The surface of unpaved foot paths and shoulders should be trimmed, levelled and well compacted. The surface should have specified cross slope of about 4% to drain off the surface water to the side drains. If the foot path surface is paved, the paving should be properly laid to prevent differential settlement of the paving slabs/ blocks

5.1.a. Monitoring: What to check and /or measure in stage I

- Cleaning of drains/ constructing missing drains/ repairs
- Proper filling of trenches caused because of road cutting for new service lines
- Pot hole patching : rectangular shape, cleaning the surface to remove all dust and loose materials, application of tack coat using a hand sprayer and hand brush along vertical edges (not perforated cans), rate of application of tack coat, temperature of the premix, size of the aggregates and compaction using a smooth wheeled roller, or tamper when the mix is still hot
- Sealing areas of pavement surface with fine cracks
- Proper cutting and patching areas with wide or alligator cracks(procedure similar to pot holes)
- Cross slope correction and depression filling

5.2. Stage II – Table II a, b & c

Relaying /resurfacing of bituminous pavements using a thin surfacing course such as

- 20 mm thick pre-mixed carpet(PC), hot mix or cold mix including seal coat
- 20 mm thick Mix Seal Surfacing(MSS)

5.3. Stage III – Table III a, b, & c

Strengthening or overlaying of bituminous pavements with one or more thick layers, such as:

i) Bituminous Macadam (BM) of thickness 50 or 75 mm and a thin surfacing such as 20 mm PC or 20 mm MSS

ii) Bituminous Concrete (BC) of thickness of 40 mm or 50 mm

iii) BM of thickness 50 or 75 mm and BC of thickness 40 or 50 mm

iv) Dense Bituminous Macadam (DBM) of thickness 50 or 75 mm and BC of thickness 40 or 50 mm
5.3.a. Monitoring: What to check and/or in stages II and III

It is desirable that Stage II and III be initiated only after ensuring steps envisaged in Stage I are carried out fully. Recommended checks during resurfacing or strengthening with overlay are:

- Size and gradation of the aggregates
- The proportion of adding bitumen in bituminous mixes,
- Mixing temperature
- Cleaning the surface and proper application of tack coat
- Rolling temperature
- Compacting operations and adequacy of compacting operations
- Thickness of the premix after spreading and as well as the compacted thickness at centre and edges of the pavement
- Cross slope or camber of the finished pavement surface
- Not allowing traffic movement during construction and curing period
- Quality of finished surface or riding quality - depressions and undulations within specified limits.

6. THE SCOPE FOR ENSURING QUALITY AFTER COMPLETION OF A ROAD WORK

Thus far, we have seen how to monitor the quality of road works during the process of construction. The thrust and the approach has been preventive maintenance. However, the scope for ensuring quality after the completion of a road work is very limited. Once the food is spoilt because of faulty preparation and wrong ingredients, one cannot do much about improving the quality later. Similarly, if faults/defects are not corrected during the process of repair/construction, there is very little one can do to rectify the situation. Usually two types of testing are used to ascertain the quality of road works after completion—Destructive and Non destructive. Both, being cost intensive, laborious and complicated, are beyond the scope of the manual. Only the following aspects seems to be amenable and feasible for testing by citizens after a road work is completed. These have been described in detail in the tables:

i. Drainage

ii. Cross slope/camber

iii. Texture and Quality of finished surface—number of longitudinal undulations/depressions
7. SOME MORE CITIZENS' DUTIES IN ROAD QUALITY MAINTENANCE

Apart from monitoring and auditing, citizens also have some other important duties towards road quality maintenance.

i. Do not dump garbage into the side drains.

ii. Do not cover the drains with slab stones along the entire stretch of your house as it becomes difficult to clean the drains.

iii. When cross cutting of roads to draw new service lines or to repair the existing lines for individual households becomes necessary, ensure that the resulting trenches are refilled as specified.

iv. Debris is often dumped by miscreants on the road side, which blocks the drains, shoulders and footpaths. Report the matter to the concerned authorities. If possible, try to keep a vigil to apprehend the miscreants so as to prevent them dumping debris.

v. When constructing new house or addition to the existing house, avoid dumping material like sand, boulders, stones etc. on roads/pavements. If dumping is inevitable take adequate precaution not to damage road/pavement and not to block the drainage.

vi. Do not dig up the road for erection of pandals, private sign boards, etc.

vii. Obey traffic regulations during road construction and repair.

viii. Educate the neighbourhood and thus help the authorities to remove road humps.

ix. Refrain from encroachment of footpath, drains or roads and, if others encroach, alert the authorities immediately.
8. COSTS OF MONITORING EQUIPMENT

The complete set of equipment for tests prescribed in the Guide may cost about Rs.15,000. The digital contact thermometer with rechargeable batteries may cost almost Rs. 3,500 and that with dry cells about Rs. 1,000; the camber board may cost in the range of Rs. 3,000 – 4,000. Each individual sieve may cost about 400 - 700 rupees. Table M on P.15. gives approximate costs to acquire a set of equipment advocated in the Guide.

All those organisations concerned about accountability for public works expenditure and wastage of public money in our country due to bad governance must acquire a set of equipment. For many NGOs this may well be within their reach. Whereas for citizens groups like CBOs/Resident Welfare Associations(RWAs), the cost of acquiring equipment may be a constraining factor. Therefore it is suggested that in each municipal ward, several resident welfare associations(RWA) can come together, pool their resources and buy at least a couple of sets of testing equipment, which can be accessed (even hired on rental basis) by any RWA in that ward or from some where else at any given point in time. The RWAs and other CBOs can also approach corporate/ business/ trade bodies/Rotary / Lions clubs in their neighbourhood for sponsoring a set or two of testing equipment.
TABLE M PROVIDES A BIRD'S EYE VIEW OF ALL THE TESTING EQUIPMENT REQUIRED AND THEIR APPROXIMATE COSTS

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Type of equipment</th>
<th>Approximate cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. observations of different steps such as whether tack coat was poured using perforated cans or using a sprayer or hand brush, number of passes etc.,</td>
<td>One ordinary camera to supplement such observations (optional)</td>
<td>Citizens may already have cameras or can borrow from neighbours or friends</td>
</tr>
<tr>
<td>2. Rate of application of tack coat</td>
<td>i) Three wooden/metal boards of size 0.5x0.5 meter = 0.25 sq.m area</td>
<td>i) 3 boards Rs. 300</td>
</tr>
<tr>
<td></td>
<td>ii) A weighing machine</td>
<td>ii) Two-pan ordinary balance with set of weights – Rs. 800 or digital balance Rs. 2000 to Rs. 5000</td>
</tr>
<tr>
<td>3. Size and / or gradation of aggregates</td>
<td>i) One sieve each of size(all in millimetres)45,26.5,22.4, 20, 13.2,12.5, 11.2, 6.3, 5.6, 2.80, 2.36, 0.18, 0.09 and one of size 75 microns, pan and lid</td>
<td>i) Each sieve(45-6.3 mm size) @ Rs. 300 and smaller sieves @ Rs.400</td>
</tr>
<tr>
<td></td>
<td>ii) a stand to stack the sieves</td>
<td>ii) Rs. 300 to Rs. 1000</td>
</tr>
<tr>
<td></td>
<td>iii) a weighing scale</td>
<td>iii) Rs. 800 to Rs.5000 (same as 2-(ii) above)</td>
</tr>
<tr>
<td>4. Mixing and rolling temperature</td>
<td>One digital contact thermometer</td>
<td>Rs. 1,000 to Rs.4000</td>
</tr>
<tr>
<td>5. Thickness of PC/MSS/ BM+PC or MSS / BM + BC/ DBM + PC layers</td>
<td>i) Two screw drivers</td>
<td>i) Rs. 50</td>
</tr>
<tr>
<td></td>
<td>ii) One measuring scale</td>
<td>ii) Rs. 25</td>
</tr>
<tr>
<td>6. Cross slope or camber</td>
<td>One Camber Board</td>
<td>Rs. 3,000 to 4,000</td>
</tr>
<tr>
<td>7. Surface finish (number of undulations / depressions)</td>
<td>i) Three meter long wooden or aluminium beam or straight edge</td>
<td>Rs. 500</td>
</tr>
<tr>
<td></td>
<td>ii) One graduated scale bit or wedge scale</td>
<td>Rs. 10 to 100</td>
</tr>
<tr>
<td>TOTAL (approximate maximum costs)</td>
<td></td>
<td>RS. 10,000 to 21,000</td>
</tr>
</tbody>
</table>
TABLE A: COMMON TYPES OF MISTAKES, EFFECTS OF THESE ON THE QUALITY OF PAVEMENT, WHO DO THEY BENEFIT? WHO LOSES AND SUFFERS?

<table>
<thead>
<tr>
<th>TYPE OF MISTAKE</th>
<th>WHAT ARE THE EFFECTS?</th>
<th>WHO BENEFITS OR LOSES/SUFFERS?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Not carrying out drainage improvement works before asphalting</td>
<td>At locations where water stagnates, failure of the new bituminous layer starts early / prematurely</td>
<td>Loss to tax payer due to early failure of pavement. Note: This remains same for all the following rows in this column. Citizens/tax payers are the losers for all the mistakes committed by contractors or the concerned department.</td>
</tr>
<tr>
<td>2. Not carting away the silt and debris removed from the drains, but leaving the same by the side for several days</td>
<td>The silt and debris get back to the drains early, particularly during the next rains, making the drainage ineffective again</td>
<td>The contractor saves the cost of cartage of the silt and debris to the site of disposal</td>
</tr>
<tr>
<td>3. Not patching pot holes as per specifications</td>
<td>The pot holes develop almost at the same locations of the resurfaced/overlaid pavement, much earlier. The pavement surface deteriorates at a faster rate</td>
<td>i) The contractor saves on materials, operation cost of machines and on cost of labour ii) Poor riding surface for road users and increase in vehicle operation cost(VOC) iii) Possible cause for some accidents</td>
</tr>
<tr>
<td>4. (a) Not sealing fine cracks (b) Not cutting, removing and patching areas with wide cracks</td>
<td>The cracks are reflected on to the new surface earlier, resulting in failure of the new layer much earlier than normal life, due to entry of water into the pavement through the cracks</td>
<td>Loss to the tax payer due to early failure of pavement at these locations</td>
</tr>
<tr>
<td>5. Not cleaning the existing pavement surface thoroughly and removing all soil and dust</td>
<td>The tack coat and subsequent layer of bituminous mix do not adhere to the existing pavement layer, resulting in early failure</td>
<td>Contractor saves on labour cost on brushing/blowing and cleaning the surface</td>
</tr>
<tr>
<td>6. Not spraying tack coat at uniform rate using a sprayer, but instead pouring through perforated cans</td>
<td>Early failure of the patching/resurfacing/overlay, due to detachment and stripping through the interface, due to lack of proper and uniform binding between old and new surfaces.</td>
<td>Contractor saves only on investment/hire charge of sprayer and not on the quantity of bitumen for tack coat</td>
</tr>
<tr>
<td>7. Not correcting the camber or cross slope, particularly on roads in level stretches and low lying/valley portions</td>
<td>Early failure of pavement layer due to stagnation of water during the rains</td>
<td>Loss to the tax payer, due to early failure</td>
</tr>
<tr>
<td>8. a. Not using specified size and gradation of stone aggregates in the bituminous mixes b. Use of over-sized aggregates in bituminous mix c. Use of under-sized aggregates in bituminous mix</td>
<td>a. Considerable reduction in strength and other desirable properties of the mix resulting in much shorter life of the layer. b. When a fraction or all the aggregates used are larger than specified for the layer, there is possibility of reduction in load spreading capability of the pavement layer and also rapid damage due to increase in permeability of the bituminous layer. This can be checked using one or more square gauges prepared by bending wire c. If the fraction or all the aggregates used are smaller in size than specified for the layer, there is a possibility of reduction in stability of the mix. It is also possible for the contractor to spread the material into thinner layer of thickness than specified and hence life of pavement layer could get reduced</td>
<td>a. only marginal saving for the contractor b. A little saving in bitumen content and some saving in the cost of aggregates to the contractor c. A little increase in quantity of bitumen is required in case the compacted layer thickness is as specified and hence a little loss to the contractor on this account. But it is possible to spread the material into thinner layer and hence make considerable saving on quantity of mix. For example, it is possible to spread 20 mm MSS to even 10 mm thickness, if under-sized aggregates are used.</td>
</tr>
<tr>
<td>9. Using lesser quantity/proportion of bitumen while mixing</td>
<td>Inferior mix and lesser pavement life</td>
<td>Direct benefit /saving to contractor</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>10. Over heating during mixing in hot mix plant (above 160 degree C)</td>
<td>The bitumen starts losing desirable characteristics and finally gets burnt without sufficient binding action and required flexibility, resulting in early failure of the pavement layers.</td>
<td>Contractor does not save anything</td>
</tr>
<tr>
<td>11. Heating the mix to lesser temperature in hot mix plant (less than 140 degree C)</td>
<td>Mixing is not efficient and the aggregates are not uniformly or fully coated with bitumen leading to early failure. Compaction temperature may be lower resulting in poor compaction and early failure of the layer.</td>
<td>Marginal saving to contractor towards heating/fuel costs</td>
</tr>
<tr>
<td>12. Delayed compaction resulting in lower compacting temperature than specified (less than 100 degree C)</td>
<td>Inadequate compaction and hence lesser strength, more voids and earlier deterioration of pavement. Also inferior riding quality of surface</td>
<td>i) No saving to contractor ii) Higher VOC and poor riding comfort to road users</td>
</tr>
<tr>
<td>13. Inadequate compaction due to improper rolling/improper compacting equipment/lesser number of passes</td>
<td>Inadequate compaction and hence lesser strength, more voids and earlier deterioration of pavement. Also inferior riding quality of surface</td>
<td>i) Saving to contractor; ii) Reduction in life of the layer iii) Higher VOC and poor riding comfort to road users</td>
</tr>
<tr>
<td>14. Unsatisfactory surface finish with undulations and depressions due to improper workmanship, improper machinery (paver &amp; roller)</td>
<td>Riding surface is not good causing discomfort and increase in VOC. Stagnation of water at depressions during rains, resulting in early failure of pavement</td>
<td>i) Some saving to contractor on cost of equipment and labour ii) Increase in VOC and discomfort to road users iii) Early failure at locations of water stagnation.</td>
</tr>
<tr>
<td>15. Carrying out bituminous pavement works during rainy season when the pavement surface is not fully dry (except patching of pot holes which can be carried out even on slightly wet surface, using cationic emulsion both for tack coat application as well as for preparation of premix)</td>
<td>The new bituminous layer does not develop proper bonding with the existing surface due to presence of moisture and hence the new surface may get detached early. If it rains during-asphalting work, water gets into the mix during compaction, causing early deterioration; also the compaction temperature falls too low.</td>
<td>i) No saving to the contractor ii) Early failure of the layer, resulting in loss to the tax payer.</td>
</tr>
</tbody>
</table>
### Stage I -> Table I - a

<table>
<thead>
<tr>
<th>Type of Road Works</th>
<th>Standard Procedures/Specifications (as given in Contractual/Tender Documents)</th>
<th>How and What to Check/Monitor</th>
<th>AIDS / Tools</th>
</tr>
</thead>
</table>
| 1. Drainage System | Water is said to be the enemy of roads. Before taking up any pavement maintenance or improvement works, or even before the start of the rainy season it is essential to check and maintain the drainage system. It includes identification of deficiencies in surface and subsurface drainage system, maintenance of existing drainage system and construction of additional drainage facilities. It is necessary to ensure that water does not stagnate on the pavement surface and along the edges of the carriage way, especially at low lying areas and valley portions of the road. Maintenance works consist of clearing all drains, removal of silt, debris etc., from longitudinal and cross drains, correcting the cross slope of pavement surface, shoulders and footpath and filling up of all the depressions on the pavement. | • Check if the drains are cleared of silt, debris and garbage before any road repair work begins. The silt and debris removed from the drains should be carted away and dumped in identified dumping places on the same day and should not be stacked by the side of the roads/drains.  
• Checking the functioning of the drainage system (camber, shoulder drains, longitudinal and cross drains) by spot inspection during rains especially in valley portions of the road and low lying areas. | ➞ A camera to supplement visual observations  
➢ Sieves of size 20 mm, 12.5 mm, 6.3 mm and 75 microns  
➢ A square wooden or metal board of size 0.5m x 0.5m |
| 2. Patching pot holes and ruts | | | |
| Note: Patching of pot holes can be done with cold mix also, using cationic bituminous emulsion, for tack coat and also for pre-mixing. This work using emulsion can be done even when the surface is slightly wet, during rainy season. | 2.1. The loose materials from the pot hole are removed (see fig.4, page 22)  
2.2. The area around the pot hole is marked in the shape of a rectangle or square, beyond the existing periphery of the pot hole with loose materials  
2.3. The marked area is cut or trimmed using either jack hammer or chisel, or pick axe such that the edges of the rectangle are cut vertical up to the depth where the lower layer is stable without loose material  
2.4. The area is thoroughly cleaned with compressed air or brush to remove all dust and loose particles  
2.5. If the exposed bottom area to be patched is a bituminous layer, a tack coat of bituminous material may be directly applied. | Observe and insist on steps 2.1 to 2.4.  
➢ The tack coat is to be uniformly sprayed and pouring through perforated cans should be avoided as far as possible. Insist on either a sprayer or the least, a hand brush. Insist on compacting  
➢ To check the rate of application of tack coat, take a square board of size 0.5x0.5 m and find its weight. Place the board on the surface to be applied with tack coat. Remove after application and measure the weight again. The increase in weight of the board should be 125 to 175 g. | ➞ A camera to supplement visual observations  
➢ Sieves of size 20 mm, 12.5 mm, 6.3 mm and 75 microns  
➢ A square wooden or metal board of size 0.5m x 0.5m |
2.6. If the exposed surface is non-bituminous aggregates, prime coat of cut back bitumen is applied before application of tack coat.

2.7. The tack coat material may be either hot bitumen or cutback grade -3(RC-3/MC-3) applied at a rate of 5.0 to 7.0 kg per 10 sq.m area.

2.8. The vertical edges of the sides of the area to be patched should be painted thoroughly with hot tack coat material, using a brush.

2.9. The bituminous premixed material to be used for refilling pot hole may either be i) hot mix of well graded aggregates of size 20 or 12.5 mm and downwards with 4-10% fines passing 75 micron sieve or ii) cold mix of open graded materials passing 20mm sieve and retained on 6.3 mm sieve; this is premixed either with cut back bitumen or bitumen emulsion. When open graded mix is used, the top surface should be finished with a seal coat, unless this is to be covered with a bituminous surfacing course immediately.

2.10. The premix is to be placed in layers of 50-100mm loose thickness and each layer compacted using small vibratory roller or vibratory plate or tamper or at least rear wheels of a loaded truck.

2.11. The final finished surface of the patched surface should be in conformity at the same level of adjoining area and humping is not allowed.

⇒ Check the size of the aggregates: For hot mix, the aggregates should be well graded with all the aggregates passing either 20mm or 12.5mm sieve, and smaller size of aggregates with 4-10% of aggregates passing through 75 micron sieve. The hot mix is to be prepared in a mini mixing plant at 150°C(plus/minus 5°C) and be laid and compacted before it cools down to 90–100°C. For cold mix, check the size of the aggregates - they should pass through 20 mm sieve and be retained on 6.3 mm sieve; after compaction of this open graded cold mix a seal coat type A or B (see table II –b, P.26) is to be applied on the top of each patched area, in case another layer of resurfacing or overlay is not being constructed immediately.

⇒ Observe if the mix is uniformly coated with bitumen, if not it indicates inadequate heating of the mix, which will result in poor compaction.

⇒ A pan balance and set of weights or a digital balance of capacity 10 kg and an accuracy of 1g.

⇒ A thermometer.
### STAGE I ➔ TABLE I - b

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/ TENDER DOCUMENTS)</th>
<th>HOW AND WHAT TO CHECK/ MONITOR</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
</table>
| 3. Treatment of surface with fine cracks and medium cracks | This is only a temporary measure to prevent entry of rain water from the cracked surface and resultant rapid deterioration of pavement. Fine cracks of width less than 1.0 mm and medium cracks of width 1.0 to 3.0 mm may be sealed by application of Fog Seal, which consist of  
  - Cleaning the surface  
  - Light application of bituminous emulsion uniformly through a distributor or pressure sprayer at a rate of 0.5 to 1.0 litre per sq. m and allowing to set for about one hour, without allowing traffic movement on the surface  
  * Alternatively, Type A or Type B seal coat may be applied (See Table II-b, P.26) | 1. Observe whether the surface was cleaned  
2. Check whether the rate of application of bituminous emulsion was at a rate of 0.5 to 1.0 litre per sq. meter. The increase in weight of 0.5x0.5 square board should be about 125 to 250 g.  
3. Only a pressure distributor or hand sprayer shall be used and use of perforated can shall not be allowed  
4. Observe whether the bituminous emulsion was allowed to cure for at least one hour with out traffic movement | You can supplement your observations with photographs taken when the work is going on  
⇒ 0.5mx0.5m square board  
⇒ A weighing machine |
| 4. Treatment of surface with Wide or Alligator Cracks |  
- Areas of bituminous pavements with wide cracks of width more than 3mm and deep cracks in the form of alligator cracks should be identified and marked, in rectangular shape.  
- The cracked bituminous surface should be dug to rectangular shape such that the edges are vertical up to the crack depth, similar to preparation for pot holes  
- All loose materials be removed and the surface is cleaned  
- The prime coat and /or tack coat are to be sprayed on bottom surface using a hand sprayer and not perforated cans and vertical sides to be painted using tack coat of hot bitumen or heated cut back bitumen or cold bituminous emulsion using hand brush  
- The premix either open or dense graded is to be spread and compacted in layers similar to patching of large pot holes. If open graded mix is used, a seal coat is to be applied on top surface, if resurfacing or overlay construction is not taken up immediately | Follow the same steps as given for pot holes in Table I - a page no. 19, col.3 sl.no. 2.1 | A Polaroid camera to supplement visual observations  
⇒ Stack of sieves of size 20 mm, 12.5 mm, 6.3 mm and 75 microns  
⇒ a square wooden or metal board of size0.5mx0.5m.  
⇒ A weighing machine |
5. **Profile Correction Course (PCC)**

Note: *When the maximum depth of PCC is less than 40 mm, the PCC need not be done separately in which case it becomes integral part of overlaying.*

| 6. Refilling the trenches due to cross sectional cutting and digging for new service lines | The Profile Correction includes filling up depressions of pavement surface and building up the cross slope of the pavement. It is desirable to provide a cross slope of 2% or 1 in 50 on straight stretches of black top pavements to effect drainage of surface water from road pavements.

**1. Depression Filling:** The depressions on the black top surface are cleaned and tack coat is applied at a rate of 2.5 to 3 kg/10 sq metre area. The bituminous premix is spread and rolled in layers of compacted thickness 50-75mm. (fig 5, P 22)

**2. Correction of Camber:** The correction of Cross slope or camber may be done using a bituminous premix. The procedure is same as depression filling. The premix is spread and rolled to obtain required grade and camber of 2.0%. The cross slope is to be checked by a camber board. (fig. 6a-b, P 23)

| Camber Board |
| By using a camber board, check the cross slope after correcting for camber. It should be 2%. Refer fig no. 6a-b & 7 on page 23 for more description |

Note: There is no specification or standard practice for this item of work. Please refer the annexure on page no.43 for recommended procedure for refilling the trenches due to cross sectional cutting and digging for new service lines. |
FIG. 4 PATCHING OF POT HOLE

FIG. 5 PROFILE CORRECTION AND DEPRESSION FILLING
FIG. 6 CHECKING CROSS SLOPE USING A CAMBER BOARD

i. Place the camber board perpendicular to the edge of the road pavement with the hinged edge towards the centre line of the road (or towards the median of divided road).

ii. Raise the free end of the upper/movable arm of the camber board till this arm is made horizontal when the lower arm or beam is resting on the pavement surface. When the bubble of the spirit level attached to the upper arm comes to central position, this upper arm will become horizontal.

iii. Note the cross slope of the graduated vertical scale, given as a percentage or as gradient.

FIG. 7 CAMBER CORRECTION

FIG. 8 UNDULATIONS AND DEPRESSION
### RESURFACING OF BITUMINOUS PAVEMENTS

#### STAGE II ➞ TABLE II - a

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL / TENDER DOCUMENTS)</th>
<th>HOW TO CHECK OR AUDIT</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin bituminous layers are mainly meant to improve the riding quality of an existing bituminous surface and to serve as a thin wearing coat. The most commonly used types of resurfacing are - Premixed Carpet - PC and Mixed Seal Surfacing - MSS</td>
<td>❖ Preparation of existing pavement surface to be re-surfaced consisting of (a) patching pot holes, ruts and areas with wide cracks. (b) sealing medium and fine cracks (c) profile correction including camber correction and depression filling. ❖ Cleaning the surface of dust, soil etc. Application of bitumen tack coat at a rate of 2.5 to 3.0 kg per 10 sq. m. area or prime coat and tack coat, where necessary.</td>
<td>Test the size of the aggregates using the sieves of size i) 22.4 mm and 11.2 mm and ii) 13.2 mm and 5.6 mm sieves Test the temperature of the hot mix—must range between 140 – 150 degree C Observe if the mix is uniformly coated with bitumen, if not it indicates inadequate heating of the mix and/or presence of dust coating the aggregates which will result in early failure</td>
<td>Sieves of size 22.4 mm, 13.2, 11.2 and 5.6 mm Digital contact thermometer</td>
</tr>
<tr>
<td>I. PC - 20 mm thick premixed carpet including seal coat using hot bituminous mix</td>
<td>Size of the aggregates (stone or metal): Two sizes i) passing sieve size – 22.4 mm and retained on 11.2 mm sieve and ii) passing 13.2 mm and retained on 5.6 mm sieve Mixing of the two sizes of stones in the ratio of 2:1 The two sizes of stone aggregates are taken in the ratio of 2:1. Mixing of the aggregates and hot bitumen is done in a hot mix plant such that uniformly coated aggregate-bitumen mix is discharged from the plant and whose temperature ranges from 140 to 150° C.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Spreading:**
The mix is spread to an average loose thickness of about 27 mm over the prepared surface to the desired grade and camber and rolled so as to obtain average compacted thickness of 20 mm.

**Compaction:**
This involves rolling over the mix using 8-10 ton tandem-wheel roller. Rolling to begin before the mix cools down to 110-120 °C and completed before it cools to 100 °C (or 90 °C at the lowest). Usually 4 to 6 passes of rolling operation may be required and rolling must be continued until no roller marks are seen on the surface after each roller movement.

**One “pass” of rolling:** It involves movement of the roller along the longitudinal edge up to the full length to be compacted at a time. On the next movement, the roller may be moved towards the centre and again run parallel to the edge such that there is an overlap of about half the roller width, with regard to the first run. Thus the roller may be run backwards and forward at a uniform speed until the roller reaches the centre (longitudinal) line which is the highest point in an undivided road. Same thing to be repeated for the other side of the centre line, starting the rolling from the other edge. These prescribed set of movements back and forth from the two longitudinal edges till the roller reaches the central line constitutes one “pass”. The normal practice observed is treating a mere single “run” as a pass. Therefore in real terms, only one or two passes are done to save costs on operation of the roller and labour. Also less compaction with lesser materials results in more apparent thickness. **On divided roads with central median, there is single cross slope and hence the rolling starts from the outer edge (which is on a lower elevation) and proceeds towards the highest level along the edge of the median.**

- Instead of the specified size of stone aggregates, if smaller size aggregates only are used, it is possible for the contractor to spread the mix to a thinner layer which is not desirable.
- When contractors use material in quantity lesser than what's specified, they could resort to delayed compaction which may still result in specified thickness, which is not desirable.
- Observe the number of roller “passes”.
- Insist on the rolling operation to be completed before the PC mix cools down below 100 degree centigrade or at least 90 degree Centigrade in the case of PC construction. Measure the rolling temperature.
- Prevent the delay in rolling as the mix cools down fast.
- Check for roller marks during the last pass. If found, insist on more rolling.
- Test the thickness after compaction but with in a few hours by piercing a screw driver into the PC layer at different locations and measure the thickness of the layer using a scale. The average should be 20 mm at various locations across the road pavement.

- Digital Contact Thermometer
- Screw driver and a measuring scale
## RESURFACING OF BITUMINOUS PAVEMENTS (Contd...)

### STAGE II ➔ TABLE II - b

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ NORMS/SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/TENDER DOCUMENTS)</th>
<th>HOW TO CHECK OR AUDIT</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC - hot bituminous mix Contd.....</td>
<td>Application of seal coat: The compacted layer of open graded surface should be covered with a seal coat as soon as possible, even before the surface cools down and before opening the road surface to traffic movement. Delay could result in entry of water during even light showers and possible damage. There are two types of seal coats. Type A – liquid seal and Type B – a premix of hot bitumen and fine aggregates or sand. <strong>Type A seal coat</strong> consists of spraying hot bitumen at a rate of 9.8 kg per 10 sq.m area followed by uniformly spreading aggregates of size passing 11.2 mm and retained on 2.36 mm size sieve at a rate of 0.09 cu.m/10sq.m area and rolling with 8-10 t tandem roller. Hand pouring through perforated can should not be allowed. <strong>Type B seal coat</strong> consists of hot mix of fine aggregates of size passing 2.36 mm and retained on 0.18 mm sieve and 6.8 kg bitumen premixed in a hot mix plant and applied at a rate of 0.06 cubic metre per 10 sq. m area uniformly spread and rolled.</td>
<td>⇒ Observe if the seal coat either type A or B is applied before the PC cools down to atmospheric temperature or it is opened to traffic movement. ⇒ Check the rate of spraying bitumen for type A seal coat. The increase in weight of a square board of size 0.5m x0.5 m should be 245 g. ⇒ Check the size of the aggregates using appropriate sieves respectively for Type A or B seal coat, which ever is the case.</td>
<td>Sieves of appropriate size for Type A or B seal coat. 11.2, 2.36, 0.18 mm sieves  Weighing balance</td>
</tr>
<tr>
<td>Quality of the finished surface:</td>
<td>Check the number of depressions by placing a 3 metre wooden or aluminium beam longitudinally on the finished surface along the middle of each traffic lane. With the beam still on, using a graduated scale bit or wedge scale measure the depth of the largest depressions. Repeat the same 100 times along the chosen line to check the number of depressions along a continuous stretch of 300 metre length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camber and the number of undulations indicate the quality of finished surface.</td>
<td>Using a camber board check the cross slope, at intervals of 10 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undulations/depressions: Under a 3.0 m long straight edge, the maximum number of depressions of size 4 mm and 7 mm should not exceed 20 and 2 respectively in a road length of 300 m. (see figure 8, page 23)</td>
<td>3 meter long wooden or aluminium beam and a graduated scale bit or wedge scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camber: the Camber is to be checked using a camber board so that the cross slope is 2% or 1 in 50 (see fig. 6a-b &amp; 7 page 23)</td>
<td>camber board</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
II MIX SEAL SURFACING (MSS)

It consists of 20 mm thick compacted layer of graded aggregates, premixed with specified quantity of bitumen in a hot mix plant laid over a prepared surface. The MSS is preferred to PC as only one set of operation of spreading and rolling is involved. Also, mechanical paver can be used for spreading and so the surface finish and riding quality will be superior than the PC layer. The gradation of aggregates, mixing temperature and compacting temperature are to be controlled. However, the choice between MSS and PC would also depend upon technical factors.

There are two types of MSS mix – Type A and Type B mix which vary in terms of gradation and size of the aggregates and the quantity of bitumen binder per sq. m area. The type of mix is decided considering certain technical factors. The specified gradation is given below:

<table>
<thead>
<tr>
<th>Sieve size, mm</th>
<th>Type A Mix</th>
<th>Type B Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.20</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>11.20</td>
<td>100</td>
<td>88-100</td>
</tr>
<tr>
<td>5.60</td>
<td>52-88</td>
<td>31-52</td>
</tr>
<tr>
<td>2.80</td>
<td>14-38</td>
<td>5-25</td>
</tr>
<tr>
<td>0.09</td>
<td>0-5</td>
<td>0-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quantity of aggregates per 10 sq. m. area</th>
<th>0.27 cu.m</th>
<th>0.27 cu.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of bitumen binder per 10 sq. m. area</td>
<td>22 kg</td>
<td>19 kg</td>
</tr>
</tbody>
</table>
Description of type A mix of table A:
Gradation for type A mix consists of four sizes of aggregates. 100% of the mix of aggregates must pass through 11.20 mm sieve, 52 to 88% should pass through 5.6 mm sieve, or in other words, the proportion of size range 5.6 to 11.2 mm will be 12 to 48 percent of the total graded aggregate mix. Similarly 14 to 38% should pass through 2.80 mm sieve while only 0 to 5% should pass through 0.09 mm sieve. Read gradation of type B mix in the same way.

Testing the size and gradation of aggregates: (For Type A mix)
Stack the sieves of sizes 0.09, 2.8, 5.6 and 11.2 mm over the pan, in the ascending order of size, one over other. Collect a representative sample of 1 kg of the aggregate mix and place it into the top sieve of size 11.2 mm and shake and vibrate well the set of sieves. Measure the weight of the mix retained on each sieve. All the aggregates should pass through the top sieve of size 11.2 mm. If part of the aggregates is retained on this sieve even after shaking and vibrating, this portion of aggregate is over sized. Find the weight of the portion of aggregates retained on the next sieve of size 5.6 mm. If this is 120 to 480 g, the proportion of aggregates of size 5.6 to 11.2 mm is satisfactory. Similarly check the proportion of aggregates of size 2.80 mm and 0.09 mm. The same procedure may be followed for testing the size and gradation of the aggregates for Type B mix.

It must be noted that the size and gradation of the aggregates should be checked at the site of the hot mix plant, before mixing with bitumen.

REFER TABLE II - C (P.30) FOR CONSTRUCTION AND MONITORING STEPS
## RESURFACING OF BITUMINOUS PAVEMENTS (Contd...)

### STAGE II

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ NORMS/SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/TENDER DOCUMENTS)</th>
<th>HOW TO CHECK OR AUDIT</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
</table>
| **II. Mix seal surfaced** | Construction steps:  
  - Preparation of existing pavement surface to be re-surfaced consisting of (a) patching pot holes, ruts and areas with wide cracks. (b) sealing medium and fine cracks (c) profile correction including camber correction and depression filling.  
  - Cleaning the surface of dust, soil etc.  
  - Application of bitumen tack coat at a rate of 2.5 to 3.0 kg per 10 sq. m. area or prime coat and tack coat, where necessary using a sprayer.  
  - Preparation of hot mix of aggregates and bitumen in a mixing plant (mix temperature 145-155°C)  
  - Transporting the mix to site and spreading on site using a paver finisher, to an average loose thickness of about 27 mm and desired cross slope.  
  - Compaction (also refer table II –a., p. 25) using 8-10t tandem roller with overlap of 50% roller width and 4 to 6 passes or until there are no roller marks and completion of rolling operation before the temperature falls below 100°C. |  
  - Insist on using a sprayer for application of tack coat. Using perforated cans should not be allowed  
  - Test the rate of application of tack coat – Take a 0.5 m x 0.5 m square metal board. Weigh the board and note the weight. Place the board on the surface to be applied with tack coat. After application of the tack coat, remove the board and weigh again. The increase in weight of the board should be in the range 63 to 75 g. Any value lower than this should be immediately brought to the notice of the concerned authorities.  
  - Test the size and gradation of the aggregates as explained in page no.28, using Table B  
  - Measure the mixing temperature using a digital contact thermometer which should be in the range of 145 –155°C  
  - Observe if the mix is uniformly coated with bitumen, if not it indicates inadequate heating of the mix or presence of dust which will result in early failure  
  - Observe and insist on 4-6 passes in the prescribed way or until roller marks disappear. Prevent any delay in compacting operation.  
  - Measure the rolling temperature of the mix. It should be carried out when the temperature is in the range 120 to 100°C. Rolling should be completed before the temperature falls to 100 degree C |  
  - Wooden/metal board of size 0.5 X 0.5 m for measuring the quantity of application of tack coat  
  - A weighing machine  
  - A stack of sieves of appropriate size and  
  - Digital contact thermometer  
  - Camber board  
  - 3 metre long wooden or aluminium beam and graduated scale bit or a wedge scale  
  - a screw driver and a measuring scale |

---

*Wooden/metal board of size 0.5 X 0.5 m for measuring the quantity of application of tack coat.*

*A weighing machine.*

*A stack of sieves of appropriate size.*

*Digital contact thermometer.*

*Camber board.*

*3 metre long wooden or aluminium beam and graduated scale bit or a wedge scale.*

*a screw driver and a measuring scale.*
Surface finish for MSS, number of undulations of 4 mm not to exceed 20 and of 7 mm not to exceed 2 per length of 300 m, under 3.0 m straight edge. Cross slope should be 2%.

Opening to traffic only after the full layer cools down to surrounding atmospheric temperature.

Test the thickness after compaction but within a few hours by piercing a screw diver into the MSS at various locations and measure the length using a scale. The average value should be 20 mm.

Measure the cross slope using a camber board at intervals of 10 m. (Fig 6a-b & 7, page 23)

Measure the number of undulations using a 3 metre long wooden or aluminium beam (refer table II-b, page 27 for testing procedure & fig. 8, p.23)
STRENGTHENING OF BITUMINOUS PAVEMENTS:
STAGE III

It is the last and the most cost intensive step in the pavement maintenance management. It involves construction of an overlay of thickness ranging from 40 mm to (75+50) or 125 mm. Delayed overlaying will result in extensive damages to the existing pavement including cracking and will necessitate either rehabilitation or even reconstruction of pavement resulting in very high cost. The choice of the type and specifications of overlay materials depend on scientific assessment of various factors. The three most commonly used methods of constructing an overlay in India are

I. Bituminous concrete (BC) : Compacted thickness 40 mm or 50 mm and

II. Bituminous Macadam (BM) : Compacted thickness 50 mm or 75 mm, followed by BC or MSS or PC

III. Dense Bituminous Macadam (DBM): Compacted thickness 50 mm or 75 mm, followed by BC

Specifications for the BM mix:

BM is used as a binder course. The following tables provide the specified gradation for BM mixes: While IRC has suggested three gradations each for 75 mm and 50 mm BM overlay, MOST has suggested total two gradations only, for BM with 3.0 – 3.5% bitumen content by weight of mix. Grading is read as percentage passing by weight of aggregates through sieves of different sizes.

TABLE C Bituminous Macadam

<table>
<thead>
<tr>
<th>Sieve size, mm</th>
<th>Grading I for 75 mm BM</th>
<th>Grading II for 50 mm BM</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>26.5</td>
<td>75-100</td>
<td>100</td>
</tr>
<tr>
<td>22.4</td>
<td>60-95</td>
<td>75-100</td>
</tr>
<tr>
<td>11.2</td>
<td>30-55</td>
<td>50-85</td>
</tr>
<tr>
<td>5.6</td>
<td>15-35</td>
<td>20-40</td>
</tr>
<tr>
<td>2.8</td>
<td>5-20</td>
<td>5-20</td>
</tr>
<tr>
<td>0.09</td>
<td>0-5</td>
<td>0-5</td>
</tr>
</tbody>
</table>
Procedure for testing the size and gradation of aggregates for BM:

The size and grading of the aggregates should be checked at the site of the hot mix plant, before mixing with bitumen.

Follow the same procedure of testing the size and grading of the aggregates as for MSS given on page No. 29

Method of constructing BM overlay

(see Table III-a page 34)

Method of constructing DBM overlay

DBM is a high quality bituminous mix to be used as strengthening or as a binder course, preferably over an existing thick black top surface or over a BM layer. The mix for DBM has to be designed strictly as per specifications, fulfilling the specified stability or strength, flexibility, voids etc. The mix design should be got done in a well equipped lab, using the actual aggregates collected at the site of hot mix plant. Refer table III-b, page 36, for construction and monitoring steps

Method of constructing BC overlay:

BC is the highest quality of the bituminous mixes used as a strengthening and surface course. The specifications should be precisely followed and the mix design should be got done in a well equipped lab, using the actual aggregates collected at the site of hot mix plant. Refer table III-c, page 37 for construction and monitoring steps

NOTE: Both DBM and BC are methods beyond the scope of the Guide. Therefore they have not been dealt in detail. Nevertheless, Table III-b & c, page 36-37, give some description of the procedure for BC and DBM and it is suggested that citizens can monitor/observe those aspects which are simpler and amenable for citizen testing.
# STRENGTHENING OF EXISTING BITUMINOUS PAVEMENTS

## STAGE III ➞ TABLE III - a

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ NORMS/SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/TENDER DOCUMENTS)</th>
<th>HOW TO CHECK OR AUDIT</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
</table>
| 1. Bituminous Macadam of thickness 50 mm or 75 mm | The construction steps for BM are given below:  
(i) Preparation of existing surface including patching, sealing, profile correction, and cleaning the dust  
(ii) Application of 2.5 to 3.0 kg bitumen tack coat per 10 sq. m area by sprayer  
(iii) Preparation of BM mix in hot mix plant and transportation to site. The minimum bitumen content suggested for BM is 3.5%. The mixing temperature is 145°C - 155°C  
(iv) Spreading to desired loose thickness (about 25% more than required compacted thickness) to desired cross slope and grade using a mechanical paver, preferably a senser-paver  
(v) Compaction- (refer table II a, p.24 for more details of rolling operations using 6-10 t static roller with 4-6 roller passes ). It is desirable to use a tandem vibratory roller with gross weight 8 t (adopting a vibration of 0.3 to 0.4 mm amplitude and 50 to 60 Hz. frequency). In this case two passes each of rolling in three types of rolling operations to be applied; initial rolling without vibration, intermediate rolling with vibration and final rolling or finishing without vibration to obtain good results. Rolling may be carried out when the temperature of the mix is 120 to 100°C. | What to test or measure:  
1. Check whether the following preparatory steps were followed: drainage repair/cleaning; patching pot holes and areas with wide cracks; crack sealing; profile correction; cleaning the surface of dust and soil  
2. Application of bitumen tack coat – check the quantity of bitumen tack coat per 10 sq.m area using a 0.5m x 0.5m metal or wooden board as described in Table II - c, p. 30. Insist on application of tack coat using a sprayer and not through perforated cans.  
3. Check the gradation and size of the aggregates for BM using a stack of appropriate sieves as described on page No. 18. Check the mixing temperature of aggregates and bitumen using a digital contact thermometer. The temperature should be in the range of 145 – 155°C. Observe if the mix is uniformly coated with bitumen, if not it indicates inadequate heating of the mix, which will result in poor compaction.  
4. Check the rolling temperature and ensure rolling to be completed before temperature of the mix falls below 100 degree centigrade. | ✦ Wooden/metal board of size 0.5m X 0.5 m for measuring the quantity of application of tack coat  
✦ A stack of sieves of appropriate sizes to measure size and gradation of the aggregates  
✦ Digital contact thermometer to measure mixing and rolling temperatures  
✦ Camber board to measure cross slope  
✦ 3 metre long wooden / aluminium beam and graduated scale bit or wedge scale for measuring size and number of undulations |
(vi) Checking cross slope – it must be 2%

(vii) Surface finish. The maximum permissible undulations of 4 mm and 7 mm are 40 and 4 in a 300 m stretch, under 3 m straight edge.

(viii) The BM layer should not be opened to traffic or exposed to rains. A surfacing course of BC or MSS or PC or atleast a seal coat should be applied, preferably the very next day, if this to be opened to traffic.

5. Observe whether adequate roller "passes" were conducted for each of the three kinds of rolling operation. After completion of rolling operation, check if the roller marks are visible. If yes, insist on further rolling till the marks disappear.

6. Check the surface finish for the specified number and size of longitudinal undulations (depressions) as described in Table II -b, p.26 and fig.8, P.23

7. Check the cross slope using a camber board at intervals of 10 m - cross slope should be 2%. (fig 6a-b & 7, p.23)

8. Insist on allowing the traffic movement only after the layer cools down to atmospheric temperature and another layer of surfacing course is constructed.
# STRENGTHENING OF EXISTING BITUMINOUS PAVEMENTS

**STAGE III ➞ TABLE III -b**

<table>
<thead>
<tr>
<th>TYPE OF ROAD WORKS</th>
<th>STANDARD PROCEDURES/ NORMS/SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/TENDER DOCUMENTS)</th>
<th>HOW TO CHECK OR AUDIT</th>
<th>AIDS / TOOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Dense Bituminous Macadam (DBM) of hickness 50 mm or 75 mm</td>
<td><strong>Note:</strong> This is a high quality bituminous mix to be used as a binder course, preferably over an existing thick black top surface or over a BM layer. The mix for DBM has to be designed strictly as per specifications, fulfilling the specified stability or strength, flexibility, voids etc. The construction steps for DBM are given below: (i) and (ii) as in BM (table III – a, P.34) (iii) preparation of DBM mix strictly as per specified gradation of aggregates and bitumen content as given in the mix design (usually in the range 4.25 to 5.25%), in a hot mix plant at 145°C – 155°C. (iv) as in BM (v) Compaction to be in three rolling operations; the intermediate rolling may be done using vibratory roller or 15-25 t pneumatic tyred roller. (vi) Checking of camber (2.0%) and surface finish. The maximum permissible undulations of 4 mm and 7 mm are 20 and 2 in a 300 m stretch, under 3 m straight edge. (vii) DBM layer should be provided with a high quality surfacing course such as BC layer</td>
<td><strong>What to test or measure:</strong> 1, 2, 3, 4, 5, 6, 8 as for BM – Table III – a, P.34 The gradation Table and mix design including bitumen content, to be strictly followed. 7. Note the specified number of undulations, are less than BM. 9. The DBM surface may be temporarily be opened to traffic, after a curing period of 8-12 hours after compaction</td>
<td>The mix design should be got done in a well equipped lab, using the actual aggregates collected at the site of hot mix plant.</td>
</tr>
<tr>
<td>TYPE OF ROAD WORKS</td>
<td>STANDARD PROCEDURES/ NORMS/SPECIFICATIONS (AS MAY BE GIVEN IN CONTRACTUAL/TENDER DOCUMENTS)</td>
<td>HOW TO CHECK OR AUDIT</td>
<td>AIDS / TOOLS</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>3. Bituminous Concrete of thickness 40 or 50 mm</td>
<td><strong>Note:</strong> This is the highest quality among bituminous mixes used as a strengthening and surfacing course. The mix should be designed and the specifications precisely followed. The construction steps for BC are given below: (i) to (vi) as in DBM, except that under (iii) the optimum bitumen content for BC mixes may be in the range, 4.75 to 5.75%. Also it is desirable to make use of lime powder or Portland Cement (2 to 3% by weight of aggregate) as a filler material and an antistripping additive at some locations. (vii) BC layer of thickness 50 or 40 mm should be laid preferably over a DBM binder course, or at least over a BM layer.</td>
<td>What to test or measure: 1 - 8 same as DBM, Table III-b P 36 9. The BC layer is a surfacing course and may be opened to traffic after the full depth cools down to atmospheric temperature; preferably a curing period of 8-12 hours may be allowed after compaction</td>
<td>The mix design should be got done in a well equipped lab, using the actual aggregates collected at the site of hot mix plant.</td>
</tr>
</tbody>
</table>
9. Citizen Monitoring & Evaluation of Quality of Road works in Bangalore - A Field Experiment

This section is an attempt to provide a glimpse of the campaign launched by the Public Affairs Centre (P A C) in Bangalore, to demonstrate the advocacy potential of the Guide. While there is no doubt that there may be other exciting possibilities, the P A C experiment is only suggestive of the kinds of citizen intervention possible at the city level. The neighbourhood group approach to citizen monitoring of the quality of road works remains to be explored.

The Context: Municipal Bonds Road Project

Under the Municipal Bonds Road Project (MBRP) of Bangalore, it was envisaged to take up 250 km. of arterial and sub-arterial roads for comprehensive improvement over a period 15 months between January 1, 1999 and March 2000. The Bangalore Mahanagara Palike (BMP) had raised Rs. 125 crores by floating municipal bonds for this purpose. The road works were allocated to ten contractors under various packages and consultants had been appointed to carry out detailed studies, designs and supervision of road works. The P A C campaign was launched in May 1999 when some works on the MBRP had already commenced. Since then, a sample of thirteen road works, with at least one each from the works of ten contractors have been inspected with cooperation from the BMP and reports submitted for follow-up action. As field inspection and reporting is a time consuming activity and since time was a major constraint only a sample of works were chosen for inspection based on the assumption that field inspection of a particular work of a given contractor will have positive spill-over in the subsequent works of that contractor.

Objectives of the Field Experiment

- to field test the practicability and reliability of the guide
- to explore the advocacy potential of the guide
- to strengthen BMP's efforts to achieve high quality roads under the ongoing Municipal Bonds Roads Project (MBRP) and of the annual road maintenance works

Preparatory Phase:

1. Constitution of a Citizens Panel for road quality monitoring and evaluation comprising of eleven eminent experts, retired technocrats and citizen activists who were appointed by the P A C on an honorary basis. (See cover page 3 for details)
2. Collecting the list of road works, details of contractors and the technical specifications for road works proposed under the MBRP
3. Developing a format for reporting the field observations (Annexure 2 and 3, P.45-47)

Interim Phase:

After the field inspection of the first three works, a meeting was arranged with the Commissioner of the BMP and his team to appraise them of salient observations and defects and to enlist their co-operation and participation for the Panel's activities thereafter. The meeting was successful in eliciting a very positive response from the then Commissioner and the Panel was assured of full cooperation from the BMP, the contractors and the consultants in terms of providing all the relevant information and participation in the field inspections to be followed henceforth. With this, the field inspections by the Panel almost gained an official status. Following this meeting in June:
Seven more road works were field inspected over the next four months.

Four or five days prior to every inspection, the Commissioner, Chief Engineer and the Executive Engineer were intimated and requested to arrange for the presence of the respective contractor and the consultant at the site.

The selection of a particular road work was based on the extent of progress made on items like drainage, footpath patching of pot holes and cracks and profile correction. Emphasis was always on completion of works on these components before taking up resurfacing or strengthening of pavements.

Efforts were also made to ban resurfacing and strengthening of pavements owing to the fact that it was the monsoon season in Bangalore.

After every inspection, separate reports for each road work was formulated by consolidating the observations made by each Panelist in the field investigation data sheet. The final reports were submitted to the BMP officials, contractors and the consultants for action on the points raised in the report.

Some of the key strategies during this phase were:

- the Panel’s friendly attitude but independent action
- field inspection and meaningful interaction with engineers on the site
- motivating and persuading the contractors on the site
- rigorous follow-up visits

As no response with regard to the action taken based on the reports were forthcoming even after completion of the first round of field inspection of ten road works, the second meeting with the commissioner and his team along with the consultants and the contractors was organised in October 1999. An interim report summarising the salient observations was presented in the said meeting. Yet again, the response was very encouraging. The chief Engineer (Projects) invited the Panelists to participate in the monthly project review meetings and the fortnightly inter-agency co-ordination Committee meetings and assured of prompt action taken reports. Annexure 2 is a typical periodical report and several such reports were consolidated to prepare the summary interim report.

Critical factors and positive signs in the Interim Phase:

- Emphatic co-operation from the BMP Commissioner and his team and prompt presence of the consultants, BMP engineers and contractors at the site during field inspections

- Evidence of a sense of fear amongst the contractors: During one of the field inspections, a particular contractor who had ‘obtained’ an unsigned “letter of appreciation” from the local residents welfare association profusely thanking him for excellent quality work, produced the letter as a defensive evidence when the Panel questioned him on the poor quality work. The same contractor has been reported to have performed better in one of his subsequent works in terms of adherence to technical specifications. This is one of the instances of positive spill-over referred to in the earlier part of this report.

- Acquisition of new camber boards by contractors and the BMP: During the field inspections the Panel noticed that some contractors (of national repute) and even the BMP engineers were using out-dated camber boards to measure the cross slope. Following a demonstration of its portable and easy-to-use camber board by the Panel at the site, it was reported that both the contractors and the BMP engineering department have acquired similar camber boards.

- Redesigning of a particular stretch of the road work: An entire stretch of the road of one of the pre-qualified contractors was redesigned following the field inspection report by the Panel.
The Conclusive Phase:

Soon after the second meeting of the Panel with the Commissioner and his team in October 1999, a new State Government was instituted and a new Commissioner assumed charge of the Bangalore Mahanagara Palike. Since then, many reform measures have been initiated. With particular reference to road works, the following are worthy of mention here:

- The then Chief Engineer (Projects) was divested of his charge of the MBRP on the grounds of serious lapses
- Competent engineers have been posted on deputation from other Government undertakings to the BMP
- Plans are afoot to strengthen and upgrade the quality control cell in the BMP
- The post of the Engineer-in-Chief for the BMP has been filled, the request for which was long pending before the State Government.

Meanwhile, the Panel submitted a comprehensive file containing all the field inspection reports, a copy of the Citizens Guide and the interim report to the Commissioner and other key officials. Subsequent to some of the changes mentioned above, the Panel undertook field inspection of three new works and follow-up inspection of another three. The Superintending Engineer (Projects) and the concerned Executive Engineers were present during these inspections. For the first time, the Panel also received an official letter from the new Chief Engineer (Projects) acknowledging the usefulness of the contribution being made by the Panel.

At the time of drafting this report, the Panel is eagerly awaiting a meeting with the new Commissioner and his team to discuss its concerns regarding the quality of road works and to plan strategies for future action.
10. GLOSSARY OF KEY TERMS

1. **Aggregates**: The crushed rock or stones of hard variety, of different sizes used for construction of pavements.

2. **Bitumen**: The binding material, derived from the distillation of petroleum. It is called asphalt or bitumen and is used for asphaltling/construction of bituminous pavements.

   Bitumen is in a semi-solid state at normal atmospheric temperature. By heating the bitumen to a temperature of about 150 degree C, it is brought to a sufficiently fluid state so that it can coat heated aggregates or be sprayed through a pressure distributor.

3. **Cut back Bitumen**: The bitumen mixed with a lighter petroleum derivative like kerosene or naptha, in order to make it fluid at lower temperatures or even at atmospheric temperature (to avoid requirement of heating). The actual bitumen content in a cutback may be 60 to 80% and the remaining portion is diluent.

   By choosing an appropriate type and grade of cutback bitumen, it is possible to spray it through a pressure sprayer or distributor without heating or by slight heating. Also cut back can be used to prepare a cold mix with aggregates for road maintenance works.

4. **Bituminous Emulsion**: It is a two phase system in which bitumen is dispersed in fine globules and is kept in suspension in water and stabilised by means of suitable emulsifying agent. The actual bitumen content in an emulsion is 40 to 60% and the remaining portion is water.

   The bituminous emulsion is stored in air tight containers and can be used for spraying or to prepare a cold mix with aggregates. One special advantage is that bituminous emulsion tack coat and cold mix can be used during wet weather conditions or when the surface is not dry.

5. **Prime Coat**: The first application of low-viscosity liquid bituminous binder (such a cut back or emulsion) over an existing porous or granular pavement surface is called prime coat. The main object of applying prime coat is to plug the capillary voids of the porous surface and to bind the loose mineral particles of granular pavement surface and to prepare the same before the application of the tack coat.

6. **Tack Coat**: The application of liquid bituminous material either over an existing black top/impervious pavement surface or over a porous surface already treated with prime coat, just before spreading a layer of bituminous mix is called tack coat. Tack coat may be applied by spraying hot bitumen or cut back(in cold or slightly heated form) or emulsion, at the specified rate. However it is not desirable to spray emulsion and immediately spread a bituminous mix over that, before allowing the water in the emulsion to evaporate.

7. **Bituminous Macadam(BM)**: A pre-mix of aggregates of specified size range and gradation and bitumen laid and compacted to a layer thickness of 50 or 75 mm and used as a superior layer of the base course or as a binder course of flexible pavement, above the base course. The BM mix is generally open graded with more voids and hence should not be exposed as a surface course; this layer should invariably be followed by a surfacing course(thick or thin).

8. **Fog Seal**: A light application of bituminous emulsion, over an old pavement surface(after cleaning), to increase the binder content of the surface or to seal fine surface cracks.
9. **Seal Coat**: A seal coat is used to seal the surface of a relatively porous or pervious surface and to make it more impervious so that the surface water does not easily enter into the pavement. Two types of seal coats are usually adopted.

Type A seal coat or liquid seal coat consists of an application of a bituminous material (hot bitumen, cut back bitumen or emulsion), covering the same with a layer of aggregates (of size range 2.36 to 10mm) and rolling with light roller.

Type B seal coat or sand-bitumen pre-mix seal coat consists of mixing fine aggregates and bitumen binder, spreading and rolling with light roller.

10. **Pre-mixed Carpet (PC)**: PC consists of open graded aggregates pre-mixed with bituminous material, spread and compacted, followed by application of Type A or Type B seal coat. PC forms a 20 mm layer of thin surfacing or wearing course.

11. **Mixed Seal Surfacing (MSS)**: MSS consists of a fairly dense graded aggregates heated and premixed with hot bitumen, spread and compacted to form a 20 mm layer of thin surfacing or wearing course.

12. **Dense Bituminous Macadam (DBM)**: DBM consists of hot pre-mix of dense graded aggregates and bitumen spread and compacted to a layer of thickness 50 or 75 mm over a good base course such as BM, to form a binder course. DBM mix is to be carefully designed and constructed to high specifications and standard

13. **Bituminous Concrete (BC)**: BC consists of a hot premix of dense graded aggregates and bitumen spread and compacted to a layer thickness of 40 or 50 mm over a good binder course of DBM or BM to form a strong surfacing course. BC mix is to be carefully designed and constructed to high standards, being the highest quality among given types of bituminous mixes.

14. **Undulations/unevenness**: A good pavement surface has to be finished as a plain or even surface. However due to several deficiencies during construction, undulations or unevenness are formed, resulting in inferior riding quality. The unevenness may be checked using a straight edge in terms of classified undulations. It is also possible to measure undulations in a cumulative scale called "Unevenness or Roughness Index" in mm per km length of road using equipment such as 'Bump Integrater'.

15. **Depressions**: Some portions of pavement surface deform or settle more than the adjoining area, forming a depression. Depressions on pavement surface adversely affect the riding quality. Presence of undulations and depressions on pavement surface not only results in poor riding quality for automobiles, but also increase the vehicle operations cost. Depressions also permit stagnation of water resulting in pot hole formation and early failure.

16. **Cross Slope and Camber**: On straight road stretches, the road surface is given a double cross slope of about 1 in 50 or 2.0%, with the centre line raised to a higher level with reference to the edges in order to drain off the surface water from the centre of road pavement towards the edges. This cross slope is called camber. On divided roads, a single cross slope is provided sloping down from median towards the edge, in each carriageway.

At horizontal curves, the pavement surface is provided with a single cross slope with the outer edge at higher level with respect to inner edge. This cross slope is called super-elevation or banking and helps safer negotiation of the curve at high
speeds and also allows the surface water to drain away towards the inner edge of the road pavement.

17. **Patching:** The pot holes are cut to shape, loose materials removed, refilled with appropriate materials and compacted as per the specifications. This process is called patching of pot holes. Patching may also be done by removing isolated areas of pavement surface with wide cracks.

18. **Profile Correction:** A pavement surface may form depressions and undulations along the length of road or on the cross-section deviating from the plane surface. When the depth of the correction required is 40 mm or more, these depressions are filled with a bituminous pre-mix and compacted. The correction of longitudinal undulations or depression filling and the correction of cross profile including camber correction are termed profile correction. If the profile correction is made properly, the deformed surface of road pavement is restored and thereafter the resurfacing or overlay layer can be spread and compacted to uniform thickness.

19. **Resurfacing:** Laying of a thin layer of surfacing or wearing course such as PC or MSS is called resurfacing. This resurfacing layer covers up minor defects of the existing surface and improves riding quality, but does not add to the strength of the pavement structure.

20. **Overlay:** Laying of one or more thick pavement layers such as BC, (BM+MSS), (BM+BC) or (DBM+BC) in order to increase the structural stability of the pavement is called overlay. However the overlay should be constructed before the surface course of the existing pavement gets badly damaged with medium and wide cracks, etc.

21. **Rehabilitation:** If the existing surface course of a pavement has been badly damaged, it forms a weak layer and hence it is desirable to remove this weak layer before providing overlays for strengthening. This process is termed rehabilitation. Delay in strengthening a pavement could lead to requirement for rehabilitation. However instead of carrying out proper rehabilitation if the overlay is directly constructed over the badly damaged surface, the life of the overlay will get reduced considerably.

22. **Reconstruction:** If the pavement maintenance works such as pot hole patching or strengthening works are considerably delayed and the damages extend to lower layers of base course/sub-base course, it becomes necessary to remove all these layers and to reconstruct the entire pavement, layer by layer resulting in considerably higher cost.

**ANNEXURE 1 TO TABLE I –b**

**REFILLING THE TRENCHES DUE TO CROSS SECTIONAL CUTTING AND DIGGING FOR NEW SERVICE LINES:**

In city roads, particularly the ones which are going to be newly constructed, introduction of duct system for accommodating water/electricity/sanitary/telephone lines, can prevent the cross sectional cutting and digging for service lines. Since there is no specification or standard practice for this item of stage I, the following procedure is recommended. As the trenches are seldom refilled and compacted properly by those who dig these, it is essential or desirable to follow the steps given below:

a) If the refilled material is firm and has got compacted, dig and remove all the materials from the trench up to a depth of 0.35 m. Fill with a layer of sand or crusher stone dust and compact with a plate vibrator, to a thickness of 105 mm. Lay graded,
crushed hard aggregates of size 50 mm to 10 mm, to a loose thickness of about 100 mm and compact with a roller or a plate vibrator to a thickness of 75 mm and repeat the second layer of 75 mm thickness, using same material in the same way. Apply prime coat and tack coat and lay a BM layer of compacted thickness 75 mm followed by MSS layer of compacted thickness 20 mm as given in Table III-a, P.34 and Table II-c, P. 30 respectively. If it is not possible to use an ordinary roller for compaction, a small vibratory roller or plate vibrator may be used.

b) If the refilled material is loose, dig and remove the material from the trench up to a depth of 0.5 m. Fill in two or three layers of sand or crusher stone dust of total compacted thickness 180 mm. Lay three layers of graded crushed stone aggregates of size 50 mm to 10 mm, each of compacted thickness 75 mm (total 75 X 3 = 225 mm). Apply prime coat and tack coat and lay Bituminous Macadam of compacted thickness 75 mm followed by MSS of compacted thickness 20 mm, as mentioned in (a) above.

REFERENCES:

2. All Relevant Specifications and Code of Practices of Indian Roads Congress.
ANNEXURE 2 – Sample format for recording field observations

Public Affairs Centre

CITIZEN MONITORING AND EVALUATION OF ROADS IN BANGALORE UNDER THE MUNICIPAL BONDS PROJECT

FIELD INVESTIGATION DATA SHEET

Date : 5 June 1999

Name of the Evaluator : 
Name of the Contractor : 
BMP Zone : WEST 
Details of the work in progress : length..........................

Location.............................

ITEMS OF WORK - FIELD OBSERVATIONS

1. DRAINAGE
   a. Clearing the existing side drains and culverts
   b. Creating the missing links of drainage up to the point of disposal
   c. Have the removed material been carted away to the disposal site
   others:

Conclusions:

2. PATCHING / FILLING
   a) i) Pot hole filling ii) Cracked Area iii) Cross ruts iv) Trenches
   b) was the patched or the filled portion covered with seal coat in the case if strengthening of the pavement with bituminous overlay was not taken up immediately

3. PROFILE CORRECTION
   a) Cross Slope b) Depression Filling

4. REMOVING AND RESETTING THE KERB STONES

5. ASPHALTING
   i) Rolling temperature ii) Thickness of the layer iii) Camber correction iv) Quality of the finished surface

Other Comments

45
ANNEXURE 3- PAGE 1 SAMPLE FORMAT FOR REPORTING THE FIELD OBSERVATIONS

PUBLIC AFFAIRS CENTRE - CITIZEN PANEL FOR MONITORING AND EVALUATION OF THE QUALITY OF ROAD WORKS

Field inspection on 17 July 1999 (Saturday) of .......... road to .......... Road: Total Length of the road: 2.85 km, Ward numbers - 64, 58, 57, Name of the Contractor: ..........; Consultants: .......... Stretch of the road inspected: A length of 500 metres starting from .......... to ..........

Participants: Members of the P A C Citizens Panel; .......... the Contractor; Chief Engineer (Projects), BMP; Executive Engineer (projects), BMP; representatives of Consultants; and others

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>COMPONENT OF THE ROAD WORK</th>
<th>SUMMARY OF THE EVALUATIVE OBSERVATIONS</th>
<th>ACTION TAKEN BY CONSULTANTS/ CONTRACTOR/BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DRAINAGE IMPROVEMENTS</td>
<td>1.1. Side drains: Desilting done along this road; but the side drains from side roads leading to drains on this road have not been cleared; also debris and garbage have been dumped and hence at present the drains are partially filled up by silt, debris and garbage at some stretches</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2. Cross drains: There are no proper cross drains to drain-off water coming from two side roads, sloping towards this road. Note: Even the consultants seemed to have omitted this item of work</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3. Shoulder drains: The existing shoulder drains have not been provided at locations where water stagnates.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4. Covered drains: The stone slabs of the covered portion of drains have not yet been properly fixed and pointed, after desilting. The masonry work at some locations of the drains have not been repaired.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5. At the lowest point (valley) of the road, the residents complained that the flood water would get into their houses. The adequacy of drainage at this location should be reviewed by the consultants and relief provided</td>
<td></td>
</tr>
</tbody>
</table>

Signature: Convenor - P A C Panel

Date:
ANNEXURE 3- PAGE 2 FOR REPORTING THE FIELD OBSERVATIONS

PUBLIC AFFAIRS CENTRE - CITIZEN PANEL FOR MONITORING AND EVALUATION OF THE QUALITY OF ROAD WORKS

<table>
<thead>
<tr>
<th>SL.NO</th>
<th>COMPONENT OF THE ROAD WORK</th>
<th>SUMMARY OF THE EVALUATIVE OBSERVATIONS</th>
<th>ACTION TAKEN BY CONSULTANTS/ CONTRACTOR/BMP</th>
</tr>
</thead>
</table>
| 2.    | FOOTPATH IMPROVEMENTS       | i) The existing granite slabs at some locations of the foot path near the bus stops have not been removed and reset properly. They have remained untouched.  
  
i) The earthen surface of existing foot paths have not been trimmed to proper level and camber and compacted.  

iii) The debris and soil along the footpath near .... Road junction has not yet trimmed and removed.  

Note: Also new debris is still being dumped on the foot path and road side, by miscreants. |
| 3.    | ROAD PAVEMENT               | a) At some stretches, reflection cracks have started appearing, as found under partially wet condition of the road surface. These cracks are likely to widen resulting in failure within the next one or one and a half years. Obviously the main cause for the early deterioration of the strengthened road pavement is due to improper patching of areas on existing pavement surface with wide cracks and potholes.  
  
b) The surface texture at several locations of new Bituminous Concrete(BC) surfacing is open graded. The causes for this could be i) improper gradation and /or delayed and improper compaction after the mix had cooled down  
  
c) At some locations patching has been done after the surface was damaged. The damage has been caused due to cross cutting made by other agencies and also due to water leakage from water/surface pipes.  
  
d) The Camber provided is generally as per the design |
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