CHAPTER 9

FORMULATION OF ROAD MAINTENANCE MANAGEMENT SYSTEM

CHAPTER 9 FORMULATION OF ROAD MAINTENANCE MANAGEMENT SYSTEM

9.1 General

This chapter introduces the concept of an alternative management system for highway maintenance in Turkey. It looks at the organisation, staffing, materials and equipment needed to achieve this. It also looks at road works information systems which help the government to maintain the road and carry out essential works with minimum disruption to the user.

The ideas included in this chapter are based on those successfully tried elsewhere but are included for discussion and development purposes only. The future needs of Turkey and some of the employment aspects need to be looked at very carefully before any of these ideas can be developed into an implementation plan.

9.1.1 Purpose

The Maintenance Management System must be able to maximise the use of the available budget in maintaining the road and its associated infrastructure in a good condition for the road user. It should also aim to achieve the optimum life from the road pavement by carrying out routine maintenance and by ensuring good design, supervision and construction of any works. By maintaining a high quality road, travel speeds are higher and hence journey times are reduced providing a road user benefit which equates to a benefit to the national economy.

With the Winter Maintenance programme, the aim is to minimise delays to traffic on a road priority basis giving the highest priority to those roads carrying high traffic volumes which will generally give the highest level of benefit to the economy.

9.1.2 The Existing Maintenance System

The Study Team have visited many Divisions, Sub-Divisions and Workstations during their stay in Turkey particularly during the various inspection programmes. Discussions were also held with Headquarters staff to get a better understanding of the maintenance system in use. A number of points came to light during the visits and discussions as shown below:-

- The Maintenance Division carries out all the routine maintenance such as crack sealing, pothole filling and patching. For more major works such as overlay and reconstruction, the Technical Research Department becomes involved in investigating the cause of the damage, it carries out tests and designs the repair work. The Construction Department then has the responsibility through the Asphalt Division for carrying out the overlay or reconstruction works.
- There are not many engineers at the Division and Sub-Division levels.

9.1.3 The Future System

There are a number of options available to the KGM in looking to the future of Maintenance in Turkey. Consideration should be given to the fact that as the road network becomes complete, less money goes on new construction and hence more should be available for road maintenance. This requires that the maintenance system is efficient and geared up to dealing with the future demands in order to convince Ministers that more budget should be allocated to road maintenance.

To achieve the road maintenance management system for the target year 2015, it was recommended that the following steps be carried out:

(1) For the most part, continue with the present system for the immediate future.
(2) However, modify the present system as quietly as possible in order to give the Maintenance Department responsibility for all work, including overlaying and reconstruction.
(3) Decentralize decision making by transferring more responsibility to Divisions and Sub-Divisions over a period of time.
(4) Finally, move to privatization by employing private sector consultants and contractors to carry out all the maintenance functions (including inspections, design, supervision and works inclusive of winter maintenance).

(3) above would require more engineers to be moved to the Divisions and Sub-Divisions but provided they also controlled their own budgets, it would enable more decisions to be taken where the work is going on a day to day basis.

9.1.4 Programme

The Ministry must consider very carefully the options (1) to (4) above in terms of ensuring a high quality maintenance service which clearly benefits the national economy by reducing delays and disruption to traffic.

The Ministry of Public Works currently uses a Direct Labour Organisation for most of its maintenance work. This means that the labour force is directly employed by the Ministry. Major works such as overlay and reconstruction are sometimes carried out by private contractors.

With the low wage costs in the government sector, this can be a very effective strategy if it is managed well.

The concept put forward here is for a phased move towards privatisation (Option) above) and to eventually have all maintenance work managed by private sector consultants and all works carried out by private sector contractors. The target year for achieving this is 2015 with a phased change over the years.

The proposals will need to have a thorough investigation and discussion with the Ministry to ensure that savings in cost or other clear benefits to Turkey are achieved through the change.

9.2 Organisation and Staffing

9.2.1 General

All organisations need to have clear chains of command and must identify the responsibilities at all levels in order to be able to manage the efficient use of labour, equipment, materials and facilities. Wherever possible the advantage of the economy of scale should be taken in rationalising facilities and working practices.

9.2.2 Organisation and Responsibilities

The organisation chart shown in Fig. 9.2.1 shows the final arrangement and responsibilities at each level.

(1) Maintenance Department

The Director of the Maintenance Department will continue to report to the Deputy Director General responsible for maintenance. His Department will be responsible for setting policy, strategy, co-ordinating the planning of works nationally and the setting of budgets.

The Department will also set the technical standards for work.

It is important that all the above are centrally controlled to provide uniformity throughout Turkey.

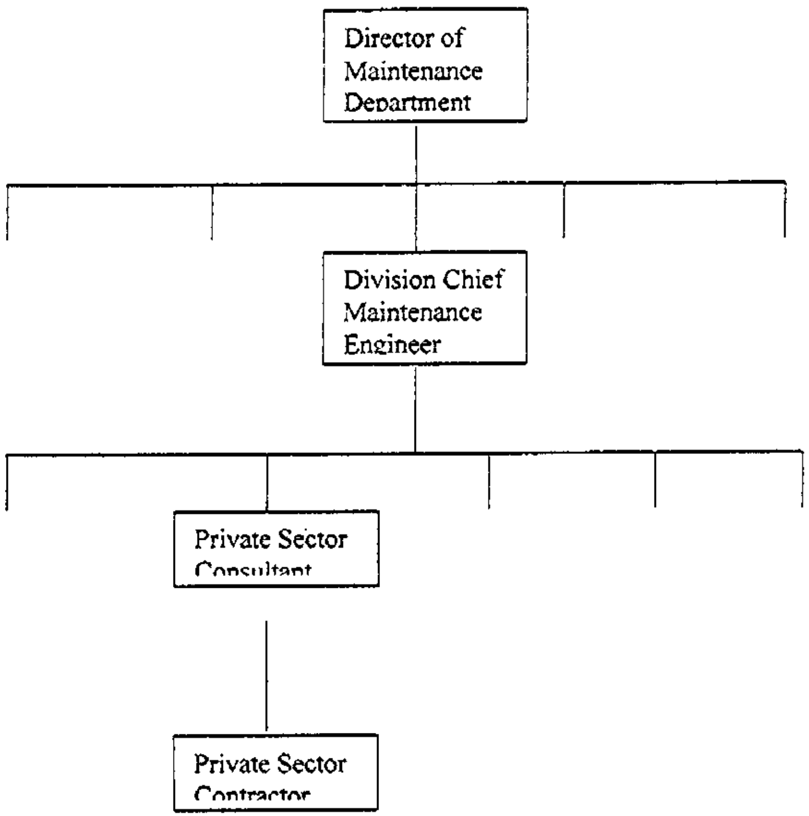
The Department will also provide advice and technical support to the Deputy Director General.

(2) Division

In the final arrangement, the Division will only have a relatively small team to let and oversee the private sector contracts. They will be responsible for monitoring performance against targets set in the contracts and for reporting back to Headquarters on performance issues.

In the period prior to privatisation, the Sub-Division maintenance teams will be divided into a 'Technical Team' performing the future role of the private sector consulting engineer and a 'Construction Team' performing the role of the private sector contractor(Fig.9.2.1).

The emphasis will be for more technical staff in the Sub-Divisions to identify and solve the problems at Sub-Division level. More engineers at this level we believe will provide a much better understanding of the pavement conditions and pavement deterioration which is crucial for selecting the correct pavement repair methods. They will still have the support of the Technical Research Department for difficult problems.



Responsibilities

Department
Policy, strategy, planning, budget
Technical standards
Advice to the Deputy Director General
Control of the Private Sector contracts

Divisions
Letting and overseeing the private sector contracts.

Private Sector Consultants
Inspections of the highway infrastructure.
Design, planning and supervision of maintenance works.
Managing the Private Maintenance Contract.

Private Sector Contractors
Routine and Winter maintenance work.
Carrying out overlay and reconstruction works.

Fig. 9.2.1 Privatised Maintenance Organisation Chart and Responsibilities

(3) Private Sector Consultant

The Private Sector Consultant and before them the 'Technical Team' at the Sub-Division will be responsible for carrying out all inspections of the highway infrastructure including roads and bridges. The combination of roads and bridges is particularly important in ensuring that wherever possible works are combined rather than having separate traffic management in operation for separate works.

They will also determine the cause of the damage, select the repair method and design the repairs. They will estimate the cost of the works, plan the works programme, instruct the private sector contractor (or 'Construction Team') and supervise the works.

They will prepare works forecasts for budget application purposes for the following year based on both short term and a 5 year rolling programme of major works, such as overlays and reconstruction.

The consultant (or 'Technical Team') will oversee the contract with the Private Sector Contractor (or 'Construction Team'). He will monitor performance, agree payments and report to the Divisional Chief Maintenance Engineer on a monthly basis.

(4) Private Sector Contractor

He is responsible for carrying out all Routine and Winter Maintenance works. The Routine works include crack sealing, pothole filling, patching and milling. They also include general cleaning of the road infrastructure and clearing debris from the road to maintain a safe passage for vehicles and so preventing costly accidents. He is also responsible for all overlay and reconstruction works.

9.2.3 Contract Matters

The size and term of the contracts need to be examined to ensure that whatever is offered to the private sector is commercially viable. It is likely that the network size will be between 500km and 1000km and the contract term will be 3 to 5 years. This scale of contract will enable the private sector to have a reasonable amount of time to develop a good commercial operation, to secure suppliers to the contract and to provide continuity of staffing and determine staffing levels for the amount of work required. These matters are always difficult to assess in the first stage of any privatisation and it is important to give a reasonable chance of success in the first stage.

In order to provide some contractual continuity for the client, it is essential that the contracts for the Private Sector Consultant and Contractor do not finish at the same time. It is preferable to extend the Consultant contract for 1 or 2 years to ensure a smooth handover to the new contractor and to continue the management in a consistent way.

Another crucial aspect of Private Sector contracts is the performance targets to be met and the penalties and liabilities of the parties to the contract. These must be considered very carefully to ensure good performance, quality of staff and workmanship. The penalties and liabilities must be sufficient for companies to take these contracts very seriously in order that the national economy benefits from good highway maintenance.

9.3 Materials and Equipment

9.3.1 Materials

It is essential that certain materials in regular use are available to the workstations. This can either be through secured contracts with private suppliers to deliver as the work demands or through limited stockpiling at workstations or Sub-Divisions and re-supply to stockpile contracts.

Weather sensitive materials must be stored in a protected environment to avoid material wastage.

Materials for emergency repair works should be stocked to avoid delays when this situation arises.

Table 9.3.1 shows a list of the recommended materials to be available.

Table 9.3.1 Materials to be Available at Maintenance Stations.

	Regions that are often affected by			
Types of materials	heavy rain	ice and snow	Fog	others
Salt and grit		✔		
Sand bags	✔	✔		
Cement	✔	✔	✔	✔
Aggregates	✔	✔	✔	✔
light reinforcement	✔	✔	✔	✔
Bitumen	✔	✔	✔	✔
Paint	✔	✔	✔	✔
cold mix	✔	✔	✔	✔
safety fences	✔	✔	✔	✔

A balance must be achieved between the amount of material stored and the cost of the storage facility. It may well be cheaper for some materials not to be stored in large quantities but to get supplies as the work demands.

For winter maintenance, it is essential to store sufficient materials to be able to achieve the target level of road clearance. The amounts stored will be based on previous experience of the local conditions and up to date weather forecasts.

9.3.2 Equipment

Table 9.3.2 shows a list of equipment to be available at the maintenance stations. It may be possible to hire in some of this equipment as the work demands rather than to retain it taking up space and requiring vehicle maintenance.

Servicing equipment and the supply of parts may also be considered in terms of private contracts to compare with the prices of maintaining equipment by more traditional methods.

Specialist equipment may be retained and owned by the KGM but leased to the Private Sector Contractor for the duration of the contract and he will take on the maintenance liability. Other equipment could be sold off to companies wishing to buy it.

Table 9.3.2 Equipment to be available at Maintenance Stations

Type of equipment	Regions that are often affected by			
	heavy rain	ice and snow	fog	others
snow ploughs		✔		
Detachable snow blades		✔		
Grader	✔	✔	✔	✔
Compressor	✔	✔	✔	✔
Portable concrete mixer	✔	✔	✔	✔
lorry mounted hoist	✔	✔	✔	✔
pickups/vans	✔	✔	✔	✔
Cars	✔	✔	✔	✔
trucks	✔	✔	✔	✔
Excavator	✔	✔	✔	✔
road sweeper/gully emptier	✔	✔	✔	✔
hand operated vibrating roller	✔	✔	✔	✔
Dowser	✔	✔	✔	✔
traffic management accessories e.g. cones, amber flashing lights, temporary works sign	✔	✔	✔	✔
pumps, hoses and accessories for water removal etc.	✔	✔	✔	✔
Assorted hand tools such as shovels, pick axes, ladder, 3-5 m tapes, etc.	✔	✔	✔	✔
Assorted personnel safety equipment such as reflective jackets, helmets etc.	✔	✔	✔	✔

Note
Equipment and Machinery may be hired or supplied by subcontractors undertaking the maintenance work.

Maintenance Depots may also be leased to the Contractor to bring in revenue to the Government. However, over time it may well be that some rationalisation of the depot locations will require some of the depots to be closed. This may present the opportunity to raise further funds through the sale of the land to developers.

9.4 Roadworks Information Systems

9.4.1 Information from the Road Users

There are many professional drivers such as truck and coach drivers who are using the road network on a regular basis. It can be beneficial to the maintenance organisation to arrange for a free telephone line to a central number where information on road condition or delays due to roadworks can be reported. This can be a considerable aid to maintenance managers as this information comes from people actually using the facility.

Similarly local residents using sections of road on a regular basis may well be able to provide useful information to assist the management of traffic at roadworks or to identify new or potential damage.

Providing a free telephone line encourages people to use the line. This may still require government staff to visit bus, coach and truck companies to explain what they would like to hear about and how they will deal with the matter. If these people can be made to feel that they would be helping the national economy and improving the road facility they are much more likely to co-operate.

9.4.2 Information for the Road Users

With regular works likely to be carried out on major roads throughout the year and with accidents and occasional emergency closures of roads, it is important to provide the road user with as much notice as possible of such work. The following information should be given where traffic delays are likely:-

- Date of the start and finish of the work or
- Closure time and likely re-opening time
- Location of works/accident/closure
- Whether traffic delays are likely to occur
- Alternative routes where practical
- The reason for the works/closure

This information should be provided to radio, television and newspapers through a regular travel information section in the paper or a special slot in the news items on radio and television. This makes the road user aware of the works and other problems and they then feel that good information is being made available to them to make choices about their journey and the route for their journey.

This can be particularly important to professional truck drivers where the overall journey time is important. If he knows there is going to be delays on his usual route, he can plan a suitable detour or use the recommended detour route and avoid the delay. This again clearly helps the national economy of Turkey by ensuring that goods and people moving around the country suffer minimum delay.

As the police are generally responsible for traffic control, such information should be co-ordinated with the Traffic Police Department.

Where necessary, detour signing should be put in place to aid the drivers in finding the alternative routes. The signing should be continuous for the complete length of the detour, particularly at intermediate junctions along the detour route, and should continue until the traffic reaches the original road.

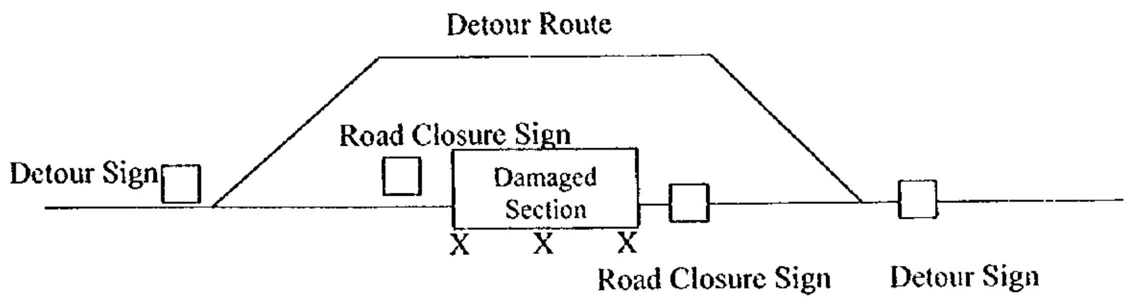


Fig. 9.4.1 Traffic Control for Detour Routes

Where the road is closed, appropriate signing and barriers must be put in place.

For road closures , Fig. 9.4.2 shows the procedure to be adopted to ensure the information is available to the road user and other agencies as quickly as possible.

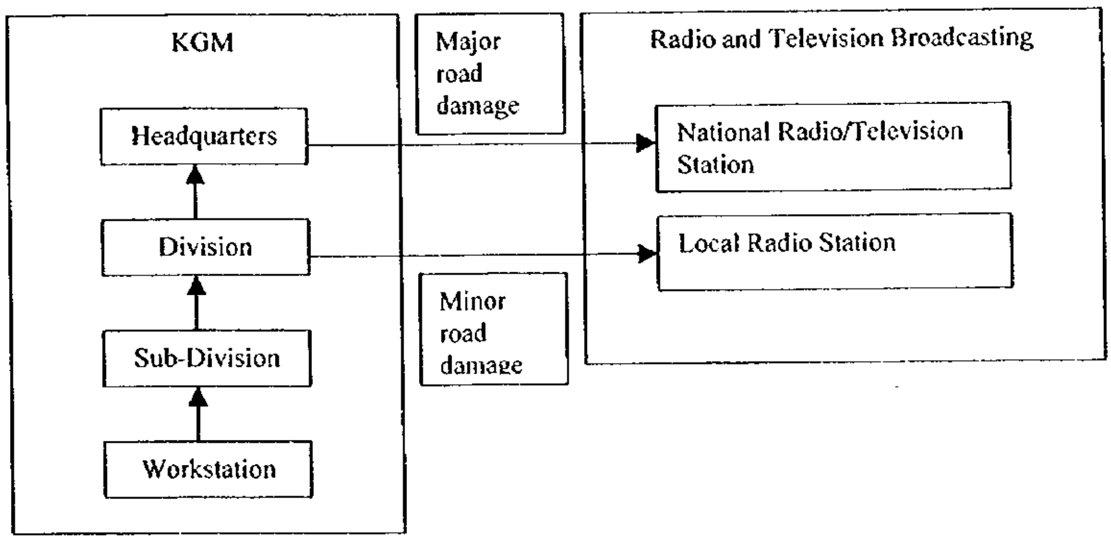


Fig. 9.4.2 Procedure for Transmission of Road Information to the Media

9.4.3 Real Time Data Collection Systems

Such systems are now in common use throughout the world to assist the maintenance manager particularly in the collection of meteorological data. During the winter season the timing of gritting and salting is critical to make the best use of the material in keeping the roads open to traffic.

With real time information systems, air and ground temperatures, snow and ice predictions can be fed to a control office minute by minute so the actual drop in temperature can be monitored and the gritting vehicles and drivers prepared. This can often prevent unnecessary gritting works or works being carried out too late both of which are ineffective and waste materials. Without the real time information the decision is left to a personal judgement on the part of the man on the spot without the knowledge of the wider picture from satellites and other relevant data available to the weather stations around the country.

CHAPTER 10

DEVELOPMENT OF MAINTENANCE MANUALS

CHAPTER 10 DEVELOPMENT OF MAINTENANCE MANUALS

10.1 General

The Maintenance Manuals have been produced for the General Directorate of Highways to assist in the continued improvement in the management of the Maintenance works on the 60.000 km of State and Provincial Roads in Turkey. They have been based on a knowledge of the existing systems, equipment, technology and budget restraints and are intended as a framework to develop common practices throughout Turkey. They have the flexibility to be changed and improved as the major maintenance issues are identified and also as more technology and equipment is made available.

10.2 Concept of Maintenance Manuals

The Maintenance Manuals comprise the following documents:-

- The Management and Inspection Manual
- The Evaluation and Repair Manual

In each case the documents have a similar structure.

Chapter 1 - provides a very brief introduction to the Manual and its objectives.

Chapter 2 - provides an overview of all aspects covered in the manual.

The remaining chapters cover the detail of the subjects included in the manual.

This set of manuals covers everything from inspecting to repairing the road and includes some ideas for the future management of all the maintenance work.

The aim of the study was to produce a maintenance system that could be applied all over Turkey today without the purchase of any sophisticated equipment. The maintenance manuals are based on a maintenance system that is easy to use and simple in terms of the equipment needed to implement it. However, the system is capable of adaptation in the event that the budget becomes available to enable the use of more sophisticated equipment and new technology.

The system applies the most suitable best practice methods from around the world taking account of the materials in use and the climate and topography of Turkey. These are tried and tested methods which have been developed over many years of experience.

Some historic data is useful in calibrating the results for the specific situation in a country and as more maintenance data is built up over the years in Turkey, the parameters given for guidance can be revised to provide more accurate information to maintenance staff. One particular aspect is the rate of deterioration of the pavement. From a knowledge of the history of repairs of the different types of pavement, a very good picture can be arrived at as to the future pattern of repair work requirements which will greatly assist in the planning and budgeting of future works. This information can also be used in economic models to refine the economic analyses carried out to compare alternative maintenance strategies.

The collection of this data using the Maintenance Database should be encouraged and an annual review of the data to pick out the trends in repair work carried out will help the maintenance managers to have a better overall feel for the future requirements.

The manuals cover the following items in accordance with the agreed scope of works:-

- pavement
- slopes
- embankments
- shoulders
- retaining walls
- side ditches
- gullies
- culverts
- snow and ice control facilities

10.3 The Management and Inspection Manual

Part A of this document is the Management Manual. This discusses some ideas on a possible alternative maintenance management system. They are not recommendations but ideas for consideration and possible discussion based on experience in other countries around the world.

Many governments have sought to move some types of government activity into the private sector generally to reduce the cost to the government as it is generally considered that the private sector will manage the works more efficiently and with less personnel. In Turkey, this question would have to be examined very carefully as it is clear that the private sector salaries for such work are much higher than the government sector and therefore some clear indication is needed that savings to the government would actually be achieved.

The manual looks very briefly at a possible organisation and distribution of responsibilities and also at data collection and distribution. It also looks at the materials and equipment requirements to deal with such a situation.

The concept is to move from the current Direct Labour Organisation (all staff employed by the government) to the use of Private Sector Consultants and Contractors to carry out the inspections, design and supervision of repair works and the actual works themselves. This could be achieved over a period of 15 years on a phased approach starting with a Pilot Study in one or two Divisions having different types of maintenance requirements e.g. one with a heavy winter maintenance programme and one with a Mediterranean climate.

Supply contracts for vehicles, vehicle maintenance and parts would have to be considered as part of the privatisation package and would need to part of the Pilot Study.

The privatisation concept needs careful study before moving forward as it is imperative to ensure that the process suits the developing situation in the country as a whole.

Employment issues would need to be addressed and changes in legislation may be required to deal with the employment matters and the possible transfer of government staff to Private Sector companies. Arrangements for normalising terms and conditions of employment are a significant hurdle. In Europe this has been covered by Europe wide legislation which although protecting the employment rights of the individual is not providing the freedom for the private sector companies to continue their business in a commercial way. Lessons need to be learned from this.

Part B of this document is The Inspection Manual. The key objective of the Inspection System, is to provide consistent and reliable data to those managing road maintenance. This will help them to make the most effective use of the available budget to keep the road and the associated facilities in a safe and sound condition for the road user and to achieve the optimum life from the road pavement.

In order to manage the maintenance of the road network, it is important to have a systematic approach to inspections. This will provide information at regular intervals to establish a thorough understanding both of the existing condition of the road and of the rate of deterioration of the various elements of the road.

Three types of inspection are proposed:-

1. Routine
2. Special
3. Detailed

The Routine and Special Inspections are visual inspections carried out on foot, supplemented as necessary by the use of basic equipment e.g. tape measure, ranging rods and camera, to assist in recording the inspections. During these visual inspections, all defects are given a ranking in accordance with the standard Damage Ranking System.

1. Routine Inspections

All elements of the road are inspected on a regular basis to identify short term repairs and the need for detailed inspections. Defects are ranked and recorded on the standard Visual Inspection Data Sheet. The frequency of inspections should be at least as often as recommended in the manual but may be varied to suit particular local conditions.

These regular inspections are important in identifying defects at an early stage and carrying out repairs to prevent the spread of a defect and the possible premature failure of the item with costly consequences.

By identifying the short term repair works such as crack sealing and pothole filling, the inspections are helping to prolong the life of the pavement provided the repair works are carried our promptly and to an acceptable standard.

2. Special Inspection

Special Inspections and Routine Inspections are identical except that Special inspections are carried out following natural disasters such as heavy rain, floods, avalanches or earthquakes, or following an accident in order to maintain the road in a safe condition for road users.

The special inspection is particularly aimed at identifying the need for emergency measures or urgent repair works to keep the road open to traffic or to reopen it in the event of a closure.

3. Detailed Inspection

The need for a detailed inspection is identified during the visual inspections.

The methods proposed have been developed to suit the existing situation within the Maintenance Department. The objective is to provide methods which can be adopted immediately without the need to purchase any additional expensive equipment.

The system is flexible in that as more money is available, new technology can be introduced to assist in the inspection and data collection process.

A detailed inspection is carried out to obtain sufficient information to establish the cause of a defect and to enable an appropriate repair method to be determined. The data collected will also assist in the design of any necessary repair work.

Standard Detailed Inspection Sheets have been developed for each inspection item to simplify the task of data recording during the survey. Each section of the sheet is filled out in turn and includes sketches and sections as well as data.

During the detailed inspection, supplementary surveys may be requested to collect additional data to assist in the evaluation of the problem and to help with any design work needed. The surveys may include core sampling, CBR tests, cross sections and boreholes.

A database has been prepared to allow all inspection and repair data to be controlled by the maintenance engineers. This will provide a useful tool to assist in monitoring the network and focusing attention on priority sections.

The database is available in Turkish and English and the screens are designed to be simple and self explanatory. There are facilities to record, add, view, edit and print the data in a range of formats to suit the needs of the managers concerned.

It is proposed that computer facilities should be available in every Sub Division to enable access to the database. In the long term, the database should be centrally controlled via ISDN or similar links to all Sub Divisions.

All personnel involved in maintenance inspections should have adequate training in all the inspection procedures, recording of data and the safety of personnel working on the road network.

Safety is considered to be a high priority in order to protect the workforce and the road user.
A number of standard Traffic Management layouts have been developed to cover the various inspection scenarios. They have been based on experience in Turkey and internationally. The objective is to keep the sign layouts simple to avoid driver confusion and to have adequate advance warning of the works in the road.

An annual inspection plan should be prepared for each Sub Division to ensure that all items are covered at the desired frequency and also to ensure efficient use of the inspection teams.

Weekly or monthly plans can then be developed from the annual plan allowing changes to suit the on site circumstances and weather conditions.

Photographs of a full range of defects are provided in the manual to assist in identification of the problems on site.

Snow and Ice Facilities are covered in a separate section of the manual as there are special requirements for dealing with these facilities.

A section is included in the manual to introduce some of the new or recent technology in use in maintenance work around the world. An Appendix on this subject is also included and covers the Profilometer, the High Speed Road Monitor, Digital Video Systems, Impulse Radar, Location Systems and the Grip Tester.

In terms of the inspection process, the methods proposed are geared at giving the inspection teams the opportunity to develop their visual inspection skills. The aim is to be able to determine the damage and repair requirements by visual inspection supplemented by supplementary surveys and tests as necessary without having to undertake too many actual measurements.

When more budget is available, it is hoped that additional Profilometers will be purchased to provide the pavement condition information to maintenance managers.

10.4 The Evaluation and Repair Work Manual

The main objective of the Evaluation and Repair Manual, is to take the information collected during the various inspections and surveys and to use the data to decide on the most appropriate repair method and when necessary, to assist in the design of the repair works.

Adopting standard methods throughout Turkey ensures that defects are assessed and repair works are carried out on a common basis. Works can be prioritised on a national basis, by Division or Sub-Division knowing that the same basis has been used for assessment.

The visual inspections provide a defect ranking. Intervention levels for various damage types are given in the manual to assist the maintenance manager in taking the appropriate course of action.

Detailed Inspections and Supplementary Surveys may be required where additional data is needed to decide on the cause of the damage and hence the correct repair method. The data collected may also assist in the design of any repair works required.

Tables showing the main causes and effects of the damage for each inspection item are provided in the manual for guidance to maintenance staff. It is important that the staff have an understanding of these aspects as it helps in the decision making process particularly where further deterioration may result from no action and also where there is a potential accident situation.

The repair methods for each inspection item are tabulated. These methods cover temporary short term and long term solutions. The methods include both basic and more advanced techniques using recent technology. The purpose of each repair is discussed and where appropriate the application and sketches of typical repairs are also included.

Flow charts to help in the selection of the correct repair method are included.

Specific design and construction matters are also discussed to provide guidance in producing a consistent quality of work throughout Turkey.

Standard traffic management layouts have been developed taking account of the best practice in Turkey and around the world. These aim to be as simple as possible in conveying the message to the road user and minimising delays whilst giving adequate protection to the personnel carrying out the maintenance work.

For pavement works, the repair works will be decided from previous experience and by using the intervention level tables as a guide. For longer term planning, we have selected the Present Serviceability Index (PSI) as the tool to be used in decisions on overlays and reconstruction works. This index is one of many developed in America and it has been well tried and tested in the conditions there. Parameters in the formula need to be adjusted to suit the in-country conditions. This will apply in Turkey where calibration should be made by measuring new road conditions or by checks against Profilometer readings. As more data is gathered over time, the accuracy of the index will improve in terms of reflecting the actual pavement conditions.

We have provided sample calculations for overlay design using the equivalent layer thickness method, also developed in America but widely used throughout the world.

CHAPTER 11

SLOPE DESIGN

CHAPTER 11 SLOPE DESIGN

11.1 General

Slope works play a very important role in preventing road disasters and in stabilizing cut or embankment slopes. Slope design should take account of the soil and topography, and should utilize previous slope design experience.
Slope protection is divided into two types. One is vegetation and the other is made of concrete. Currently vegetation works are used to reduce construction cost and to enhance the environment. However, if it is very difficult to use vegetation, concrete structures are a suitable countermeasure.
Water is the key threat to slope stability and so all slopes must be protected from surface and ground water effects. An adequate drainage system must be designed to maintain stable slopes and protection during construction must be considered.

11.2 Present Situation of State Highway in Turkey

The JICA study team carried out visual and detailed inspections of the State Highways during their visits to Turkey. The Study Team found several types of slope damage.

11.2.1 Design Matter

The damage type and related causes of the damage are shown in Table 11.2.1

Table 11.2.1 Major Causes of Damage Related to Design Issues

Major Causes of Damage on Cutting slope	Damage Type
· slope gradient too steep · lack of drainage system · lack of berm and berm ditch	Landslide
· steep slope gradient causes Rock-fall	Rock Avalanche
· poor quality materials · lack of bearing capacity of structure.	Slope Protection collapse
· slope too steep · poor quality materials · lack of drainage system on slope	Cracking
· slope too steep · poor quality materials · no protection of slope surface · lack of drainage (runoff water, spring water and seepage water)	Erosion

Major Cause of Damage of Embankment slope	Damage Type
· water between natural ground and fill material · slope too steep · lack of berm and berm ditch · lack of bearing capacity of lower layers	Slip
· poor quality fill materials · washing out underneath embankment by river water	Collapse of Slope Protection
· slope too steep · lack of drainage system · no protection, no vegetation on slope surface · runoff water, spring water and seepage water · weathering surface of slope	Erosion

The causes mentioned above mostly originate from the design. By using the specified design manual, a more complete design can be produced avoiding slope damage.

11.2.2 Construction Matters

The Table 11.2.2 shows the major causes of damage related to construction matters for each damage type.

Table 11.2.2 Major Causes of Damage related to Construction matters

Major Cause of Damage on slope	Damage Type
· lack of proper compaction of surface allowing slope to crack · poor construction methodology	landslide, collapse of slope protection

The JICA Study Team believe that most of the observed slope damage is as a result of poor

supervision of construction.
The JICA Study team would like to recommend that the method of supervision of construction currently used by KGM should be reviewed and improved.

11.2.3 Maintenance Matters

The Table 11.2.3 shows the major causes of damage related to maintenance matters for each damage type.

Table 11.2.3 Major causes of Damage related to Maintenance Matter

Major Cause of Damage on slope	Damage Type
· lack of inspection frequency · no precise inspection method · no precise prevention method · no precise repair or restoration method	any type of damage

The JICA Study Team has provided an Inspection and Maintenance Manual to give a comprehensive maintenance method to make a maintenance plan and this should be used as a framework to prepare a maintenance plan to carry out and supervise maintenance work.

11.3 Slope Design

11.3.1 Survey

A survey shall be carried out at the site and the findings of the survey shall be utilized in designing the slope. The survey consists of three types; a soil and geological survey; a topographical survey; a hydrological survey. The objectives of the site surveys are as follows;

- confirm the stability of the slope
- define the influence of the circumference (Rock avalanche, Landslide, flush flow etc.)
- confirm the difficulty of excavation(stiffness of in-situ soil)
- confirm the ground water level and drainage capacity after construction
- assessment of in-situ soil whether good quality for fill material
- confirm the strength of in-situ soil and bearing capacity

Table 11.3.1 shows the typical survey option for designing slope.

Table 11.3.1 Survey for design slope

Survey type	Survey Type	Results
Soil and Geological Survey	Borehole	- soil type - N value (Standard Penetration Test) - RQD (Rock Quality Designation) - Ground water level - Stratification structure
	Laboratory test (soil and rock)	- soil and rock properties - strength of soil and rock - cracks, joints in rock
Topographical Survey		- Cross section - Plan
Hydrological Survey		- Surface water survey - Drainage survey - River survey

(1) Soil and Geological Survey

The Table 11.3.2 shows application of soil and geological survey items.

Table 11.3.2 Application of Soil and Geological Survey

Survey Item \ Survey Method		Boring	Auger Boring	Test Pit	Sounding	Soil Test	Rock Test	Move-ment Survey
Soil/Rock Properties		O	□	□	+	O	O	
Geological Structure	Stratification Structure, Fault, Fracture Zone, etc.	□						
	Crack, Joint	O		□			□	
	Weathering	O	+	□			+	
	Thickness of Top Soil	O	O	O	□			
	Unconformity, Discontinuity	O		□	□			
Strength of Ground		□		□	□	O	O	
Strength of Embankment Material						O		
Properties of Embankment Material		□	□	□		O		
Condition of Groundwater Level		□	+	□				
Vegetation	Soil Hardness					□		
	Soil Material					O		
	Fertility of Soil					□		
	Composition of Soil Grading					O		

Note: O Most Applicable
□ Applicable
\+ Supplemental

The outline of each soil and geological survey method explains as follows;

- Borehole: The purpose of Borehole is to collect information on the underground soil/rock at the site by boring a hole into the ground. Then, by the observation and laboratory testing of the soil/rock samples, the physical properties, strata information, etc. of the soil/rock are determined. Information on groundwater level and sliding surfaces in the case of landslides can also obtained using Boreholes.

- Auger Boring: The main purpose of auger boring is to examine only the properties and conditions of top soil using simple boring methods.

- Test Pit: A test pit aims to observe soil directly by excavating a pit that can accommodate an investigator.

- Sounding: Sounding is generally applied to standard penetration test (S.P.T.)

- Laboratory Test: The purpose of a laboratory test is to obtain information on a soil's engineering properties via laboratory testing. Samples for the test are usually collected by Borehole. Information on the applicability of vegetation work can also be determined by laboratory test.

- Rock Test: The engineering properties of rock are examined by laboratory tests using samples collected by boring.

- Movement Survey: This survey aims to detect the movement of a slope, and provides their information on the location of sliding planes, detection of their movement, etc. A tiltmeter and extensometer are commonly used for these purposed.

(2) Topographic Survey

Topographic survey items in accordance with the types of anticipated damage are shown in Table 11.3.3

Table 11.3.3 Topographic Survey Items

Type of Damage	Survey Method	Survey Items
Cut slope erosion	Plane table survey	- Entire affected area
	Cross-section survey Measurement of size	- Entire affected area - Cavity
Rockfalls	Plane table survey	- Entire affected area
	Cross-section survey Measurement of size	- Entire affected area - Remaining boulders / rock
Collapse of embankment	Plane table survey	- Entire affected area
	Cross-section survey Measurement of size	- Entire affected area - Damaged portion
Road flooding	Cross-section survey Level survey	- Entire affected area - Along road

For topographic survey, the objectives and utilization of survey results are as follows;

- Topographic Survey; In order to make a drawing of a plan and a cross section, topographic survey shall be carried out. The drawing should be based on making a plan for the construction method, and is used to calculate the quantity of the work.

(3) Hydrological Survey

Suitable survey methods to collect hydrological information at the anticipated damage locations are shown for each type of damage in Table 11.3.4

Table 11.3.4 Hydrological Survey Items

Type of Damage	Survey Method	Survey Items
Cut slope erosion	Precipitation survey	- Catch basin concerned
	Surface water survey	- Water runoff, seepage
Rockfalls	Precipitation survey	- Catch basin concerned
	Surface water survey	- Water runoff, seepage
Collapse of embankment	Precipitation survey	- Catch basin concerned
	Survey related to drainage capacity	- Affected area
	Riverflow survey	- River concerned

The outline of each hydrological survey method is described as follows;

- Precipitation Survey: Consists of a site survey and data collection. A site survey collects information on past rainfall and flooding from witnesses living nearby a damaged spot. Regarding data collection, statistical data on precipitation in the area shall be collected at the Meteorological Agency (DSI).
- Surface Water Survey: Collects information on surface water flow and the track of surface water flow on the site.
- Stream Flow Survey. Collect data on river flows and study the following items.

/ high water level at the time of flooding
/ velocity of river flow
/ river discharge
/ condition of riverbed

11.3.2 Slope Gradient

Slope gradient is one of the important factors in road disaster prevention. The slope gradient should be based on soil type as follows;

- the under layer soil properties of cutting slope
- and fill material of embankment

In designing cutting slopes, the following points should be considered carefully;

- how to discharge the runoff water, underground water and road surface water
- how to acquire the information on the dip of the rock, scale of weathering,
- fear of landslide and collapse

Table 11.3.5 shows standard cutting slope' gradient and Table 11.3.6 shows standard embankment slope gradient. Using the table simplifies the decision on the design slope gradient but care must be used in selecting the correct in-situ soil type..

If the slope height is more than 15 meters, a 1 ~ 2.0m wide berm and berm ditch should be constructed.
When surface water runs off onto a slope, the velocity of the surface water flow goes up and increases scouring of the toe of the slope. The construction of a berm and berm ditch will reduce the velocity and prevent the slope from scouring, and the berm can be used for inspection and maintenance access.

Table 11.3.5 Standard Cut Slope Gradient

Soil Type			Height of Cut	Slope Gradient(h:v)
Rock		Hard		0.25 : 1 ~ 0.5 : 1
		Soft		0.33 : 1 ~ 1.0 : 1
Gravel (GW,GP)		Hard	~10m	1.0 : 1
			10m~15m	
		Loose	~10m	1.5 : 1
			10m~15m	
Fine Particle Sand and Gravel(GM)		Hard	~10m	1.5 : 1
			10m~15m	
		Loose	~10m	2.0 : 1
			10m~15m	
Sand(SW,SP)	SW	Hard		1.0 : 1
		Loose		1.5 : 1
	SP	Hard		1.5 : 1
		Loose		2.0 : 1
Fine Grain Soil (ML,CL)		Hard (N=20)	~9m	1.5 : 1
			9m~15m	2.0 : 1
		mid hard (N=10)	~5m	1.5 : 1
			5m~9m	2.0 : 1
			9m~15m	2.0 : 1 ~ 3.5 : 1
		soft (N=5)	~5m	1.5 : 1
			5m~9m	1.5 : 1 ~ 3.0 : 1
Coarse Grained Soil (SM,SC)		hard (N=20)	~7m	1.0 : 1
			7m~15m	1.5 : 1
		mid hard (PI<10, N<10)	~7m	1.5 : 1
			7m~13m	1.5 : 1
			13m~15m	2.5 : 1
		soft (N=5)	~5m	1.5 : 1
			5m~9m	2.0 : 1 ~ 2.5 : 1
			9m~15m	3.0 : 1 ~ 3.5 : 1

Note: Assumes no ground water effects.

Table 11.3.6 Standard Embankment Slope Gradient

Embankment Material		Height of Cut	Slope Gradient (h:v)
Rock		10m~20m	1.0 : 1
Gravel – Sand	GW , (GP, GM), SW	5m~15m	1.5 : 1
	GC	5m~15m	2.0 : 1
Sand	SP	~10m	2.0 : 1
Silty, Clayey Sand	SM, SC	~15m	2.0 : 1
Clay	ML, CL	~ 9m 10m~15m	2.0 : 1 1.5 : 1
		9m~13m	2.5 : 1
	MH-CH	~10m	2.0 : 1
		11m~13m	2.5 : 1

Note: Assumed no ground water effect.

11.3.3 Cause of Slope Damage

The cause of slope damage can be put into the following two categories.

(a) Natural Ground Condition

- Soil or Rock type (Scale of weathering)
- Soil or Rock Formation (Layer, Dip, Crack)
- Underground Water, Nature (Vegetation)

(b) External Affect

- Artificiality (Excavation works etc.)
- Rainfall, Snowfall, Water Affects (Freezing and thawing)
- Earthquake

Slope collapse caused by the above reasons can be divided into the following three representative types;

(a) Rock Avalanche, Erosion, Top Soil fall (small scale landslide)
This damage is caused by having too steep a slope gradient and the chances are that this would occur soon after construction.

(b) Top Soil Slide
If damage (a) progresses much more, a top soil slide may occur. The slide occurs due to a combination (a) and (b), natural ground condition and external affects.

(c) Landslide or large scale collapse
In comparison with (a) and (b), this damage is a longer scale and long term issue. We can observe that the cause of damage is related to a complicated soil formation.

11.3.4 Countermeasure for Slope damage

Weathering and eroding of the cut slope starts as soon as the construction is finished. Therefore, countermeasures ought to be carried out to keep it in a sound condition.
In the case of (a), vegetation is a useful countermeasure, but if the case is (b), concrete crib or shotcrete is mostly used and retaining walls or ground anchors are also used.
The countermeasure needs to be installed during construction.

11.4 Construction Method

11.4.1 Cutting slope

The method used will depend on the natural soil type in the cutting. More details of construction methods will be in the Maintenance and Repair Manual.

(1) Earth Slope

If the in-situ soil is earth or weathering rock, the cut slope must follow a specified slope grdient shown in this section because of the risk of collapse.
The construction method for earth slopes is shown below.

- use excavation machinery and stop around 20 to 30 cm away from the finished surface
- finishing of the slope surface is by manual labour, however, a small excavator is more efficient.
- a bulldozer with blade is also useful to cut moderate slopes.

(2) Rock Slope

When designing rock slopes, the slope gradient is decided and it is necessary to plan the construction of countermeasures to protedct traffic from rock avalanches.
Before designing the rock slope, a rock survey and topographic survey are required to define the properties of the rock or to get information of the circumference.
When making decisions on countermeasures for rock slopes, care must betaken to consider the life span or limitation of the countermeasure.
The countermeasure will effect road traffic, if it collapses.

The representative countermeasure for rock slope is shown below;

- cutting
- removal of unstable rock
- concrete support
- wiring
- rock-bolt
- weep hole
- shotcrete
- cribwork
- stone riprap wall
- prevention wall
- anchoring

The construction method for rock slopes is as follows,

If the in-situ soil is mostly soft rock which is easy to remove by manual labour, workmen shall be used to excavate the rock using a pick or breaker as shown in Fig. 11.4.1 If the cutting face is made up of hard rock, a drilling machine is used to make holes and low power dynamite is used. However, where the scale of earthworks is large, dynamite will generally be used.

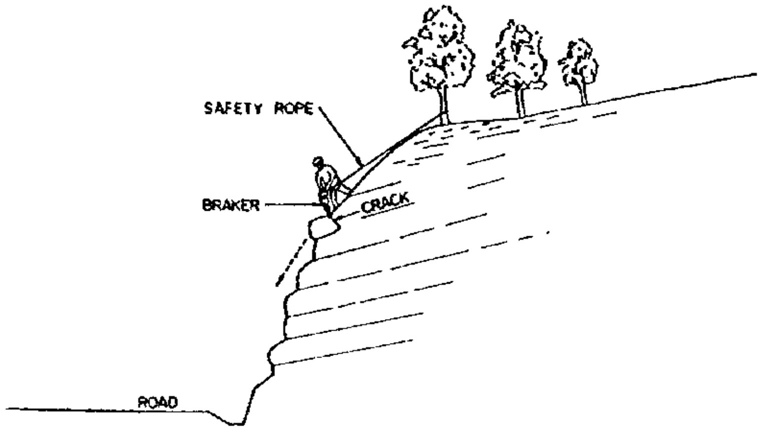


Fig. 11.4.1 Construction Method for Rock Slope

11.4.2 Embankment slope

(1) Procedure for Construction of Embankment slopes

At the time of constructing the embankment slope, the material must be compacted in layers 20 to 30 cm thickness to avoid collapse due to scouring.

- First, bench cutting will be carried out, to improve the adhesion between the in-situ soil and the fill material if the original ground has a steep gradient, the method of bench cutting is shown in Fig. 11.4.2.

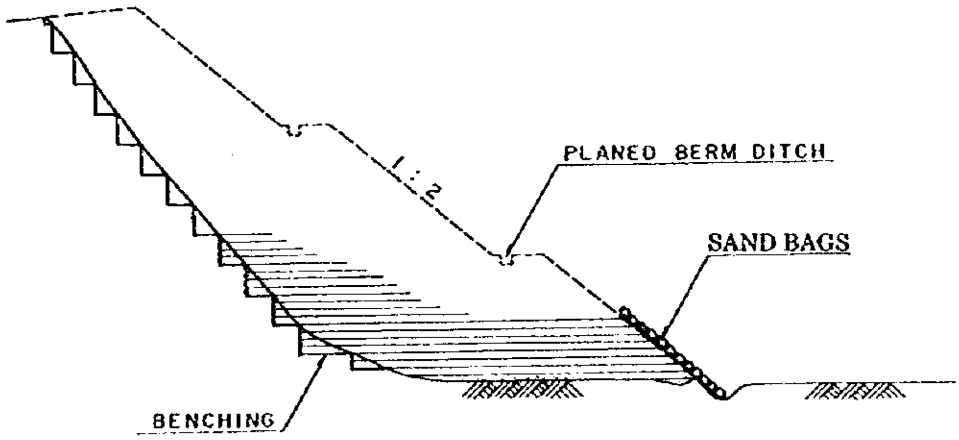


Fig. 11.4.2 Benching and Filling in Embankment

- The thickness of the filling layer will be 20 to 30 cm.
- When constructing an embankment, the interval and width of berm, and the slope gradient between berms should be designed and constructed to be the same as the existing slope.
- The standard gradient, berm width, and the height between berms of the filled portion of a fill slope are determined by the slope's geology as shown in the section on Slope Gradient.
- Based on past experience, embankment slopes with berms should be less than 20m in height. If this condition can not be satisfied, the embankment slope materials, berm width, slope gradients between berms, and structural work, etc. to be applied, should be reconsidered from the design.
- In the case of filling an embankment, large -scale compaction equipment, such as that shown in Fig. 11.4.3 must be used. However, smaller equipment may be used where space is limited.

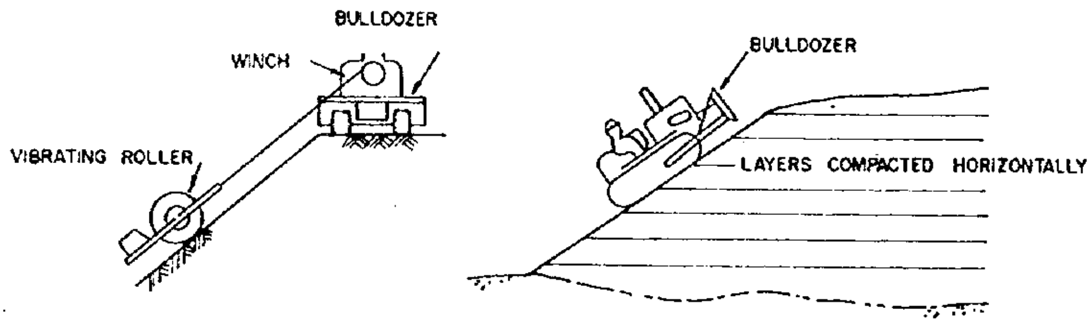


Fig. 11.4.3 Slope Compacting Work

- When filling is being carried out on sloping ground, containing groundwater, a drainage layer will be included in the construction of each layer as shown in Fig. 11.4.4

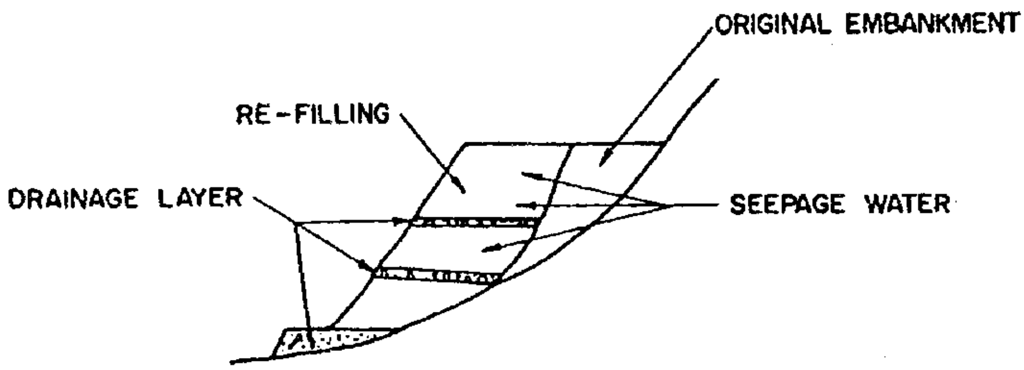


Fig. 11.4.4 Berm Drainage Layer for Refilling a Fill Slope

- To protect an embankment slope from erosion and weathering, the condition of the slope should be confirmed at the design stage and a countermeasure such as surface drainage, subsurface drainage, vegetation, or structural work selected.

CHAPTER 12

DESIGN OF DRAINAGE SYSTEMS

CHAPTER 12 DRAINAGE DESIGN

12.1 General

Drainage plays a significant role in maintaining the road structure as shown below.

- To secure slope stability
- To maintain the pavement condition
- To protect concrete structures
- To assist in the safety of road traffic
- To prevent problems for third parties

The highway drainage system is a key element in providing a safe facility for the road user and in achieving a full design life from the road pavement. Surface water can create road accidents and water entering the pavement can quickly cause deterioration in the strength of the pavement and so reduce the pavement life.
The JICA Study Team propose that much more attention should be given to the drainage system on the state roads.
Fig. 12.1.1 shows the different types of drainage associated with road projects.
The design engineer should consider the plan, profile and cross-section of the road to ensure that the drainage facility works efficiently.

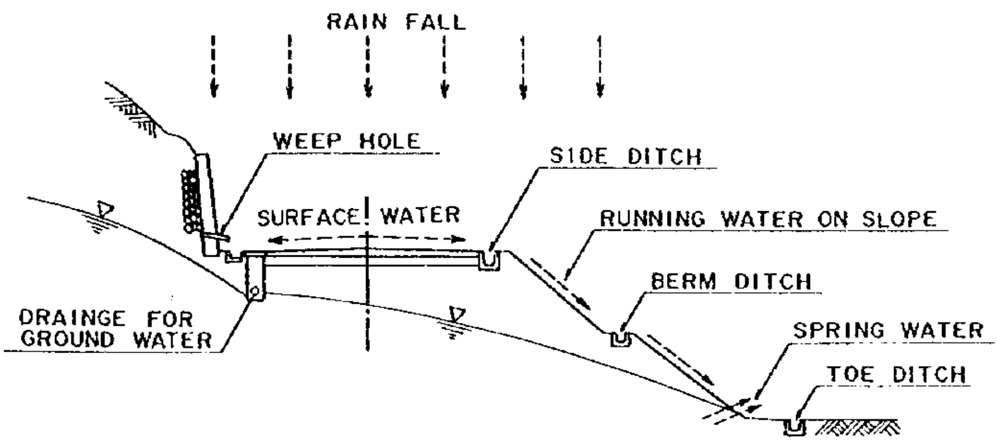


Fig. 12.1.1 Road Drainage System

12.2 The Existing Situation of State Roads in Turkey

The JICA Study Team carried out visual and detailed inspections of the State Roads during their visit to Turkey. Several types of drainage damage were observed which can be classified as shown in the following sections;

12.2.1 Design Matters

Table 12.2.1 shows the cause of damage related to design for each damage type.

Table 12.2.1 Major Causes of Damage related to Design

Major Cause of Damage	Damage Types
· lack of drainage system · lack of cross section area of water flow · unsuitable type of structure · lack of preliminary site inspection	- Collapse - Accumulation of debris

The causes mentioned above are all design related. The JICA Study Team recommends that KGM introduces a systematic design method which should resolve these design problems.

12.2.2 Construction Matters

Table 12.2.2 shows the causes of damage related to construction for each damage type.

Table 12.2.2 Major Causes of Damage related to Construction

Major Cause of Damage	Damage Type
· poor quality of concrete · poor foundations · unsuitable structure type · poor quality of construction · poor materials	- Collapse - Accumulation of debris

Many of the defects observed by the JICA Study Team result from poor quality of construction. By improving the quality and method of construction supervision and control of contractor's work, maintenance costs will be reduced providing budget savings to the Ministry.

12.2.3 Maintenance Matters

Table 12.2.3 shows the causes of damage related to maintenance for each damage type.

Table 12.2.3 Major Causes of Damage related to Maintenance

Major Cause of Damage	Damage Type
· lack of frequent inspection · no precise inspection method · no precise prevention method · no precise repair or restoration method	all damage types

The JICA Study Team has provided Inspection and Maintenance Manuals to give KGM a comprehensive method for maintenance work.

12.3 Drainage Design

12.3.1 Drainage Type

Generally the drainage divides into four into types. Each type of drainage is shown below;

- Surface Drainage

The drainage is to discharge the surface water which comes from rainfall or snowfall. Also the slope drainage is used to maintain slope stability.
The Fig. 12.3.1 shows the surface drainage system and construction.
The surface drainage is made up of numerous horizontal and vertical sections that cut up and only true for slopes or open ground down the entire length of the area collecting water.

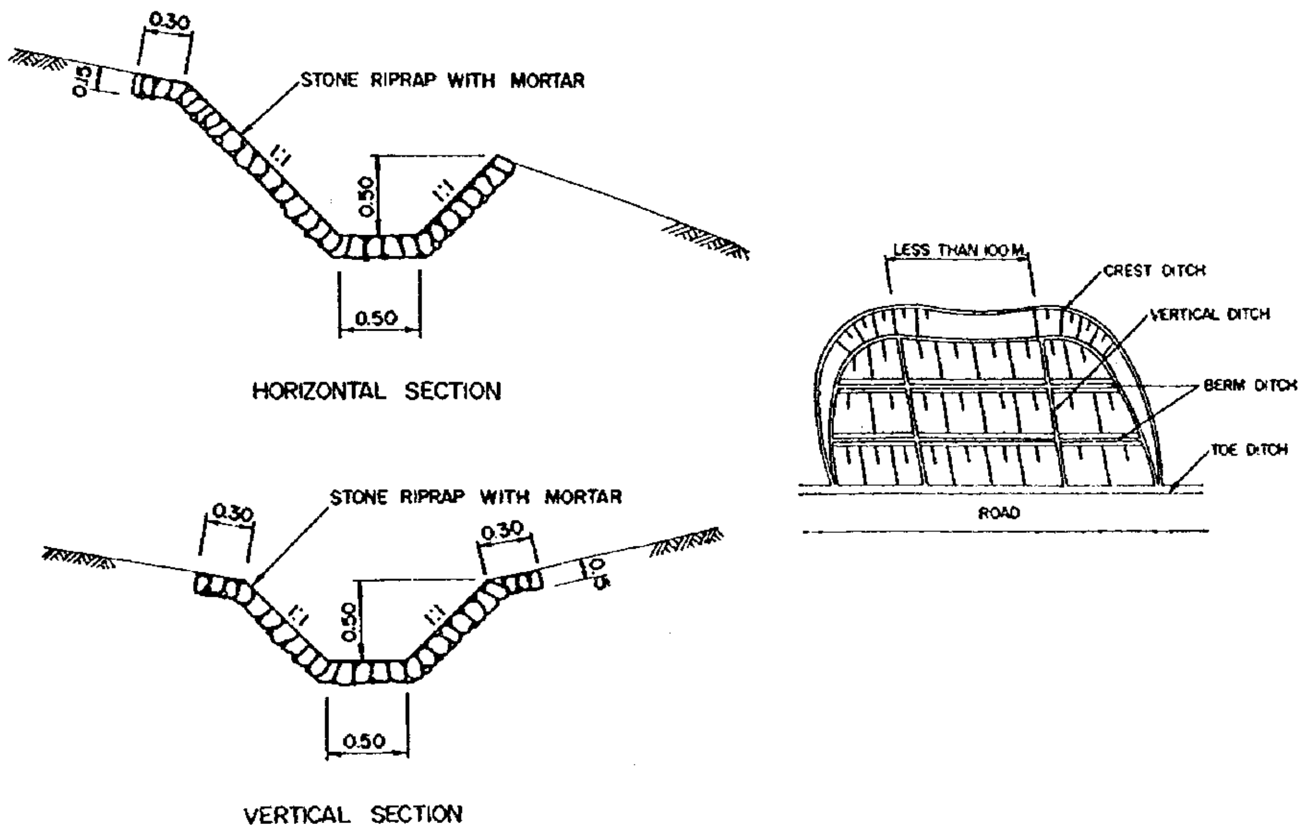


Fig. 12.3.1 Surface Drainage

■ Slope Drainage

The drainage shown in Fig. 12.3.2 is to collect the runoff water on cut and embankment slopes, and also to discharge the seepage water from the slope to maintain slope stability.

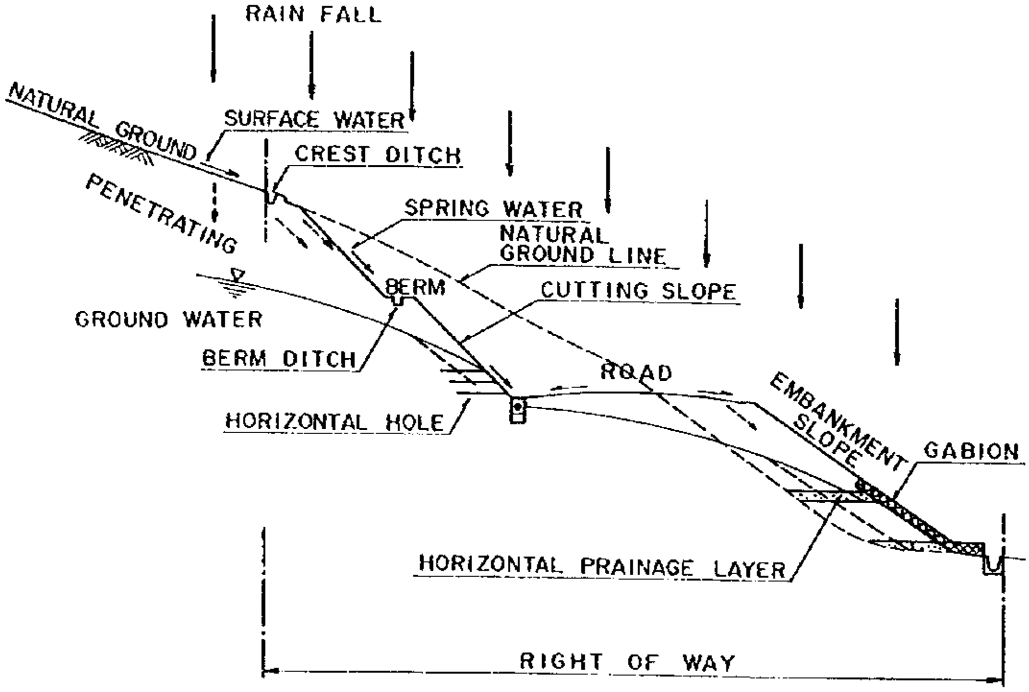


Fig. 12.3.2 Slope Drainage

■ Structure Drainage

The drainage is to prevent the road structure from being affected by water. Fig. 12.3.3 shows typical drainage for structure.

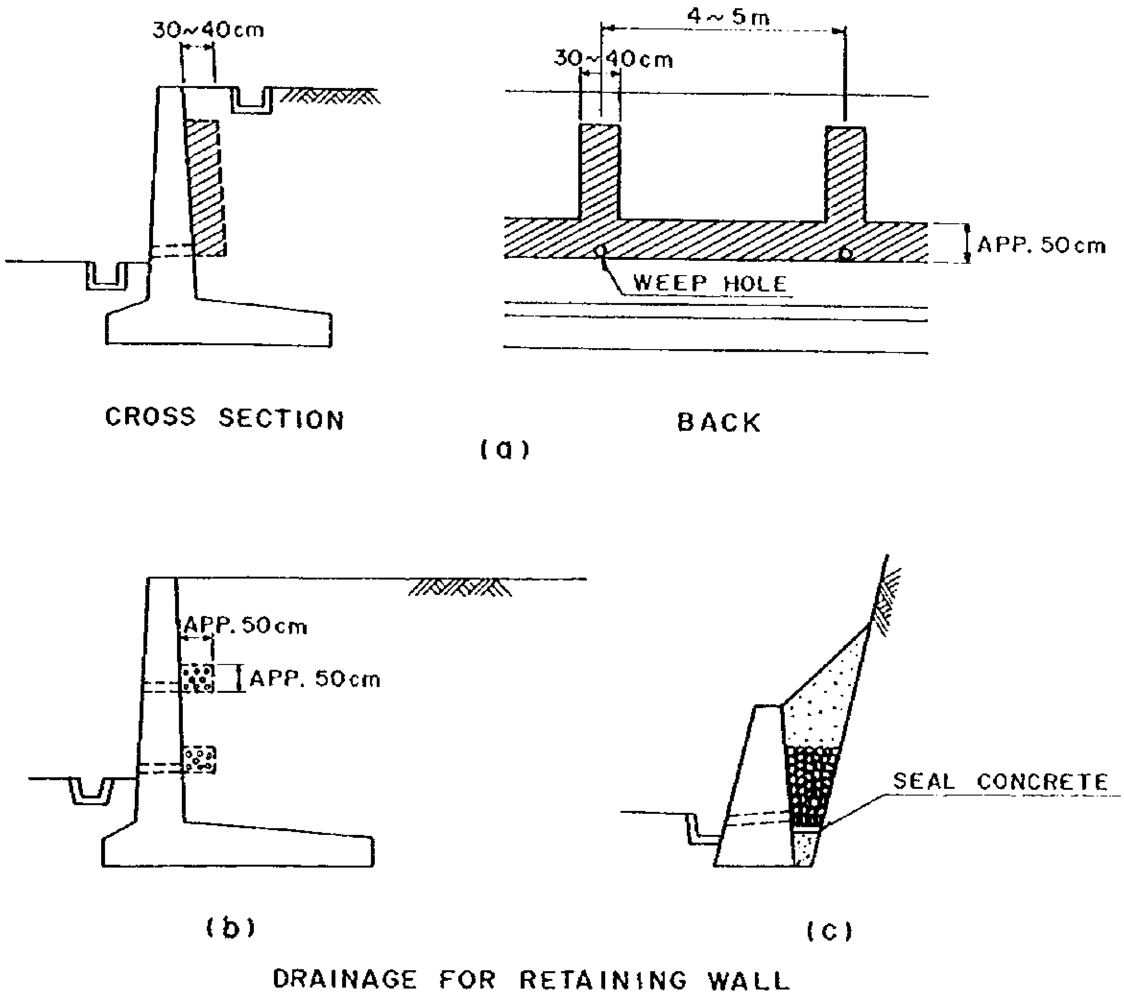


Fig. 12.3.3 Structure Drainage

■ Underground Drainage

The drainage is designed to lower the ground water level, to collect and discharge water that reaches the pavement from the slope or adjacent land. It also prevents water penetrating the pavement from the sub-grade. Examples are shown in Fig 12.3.4.

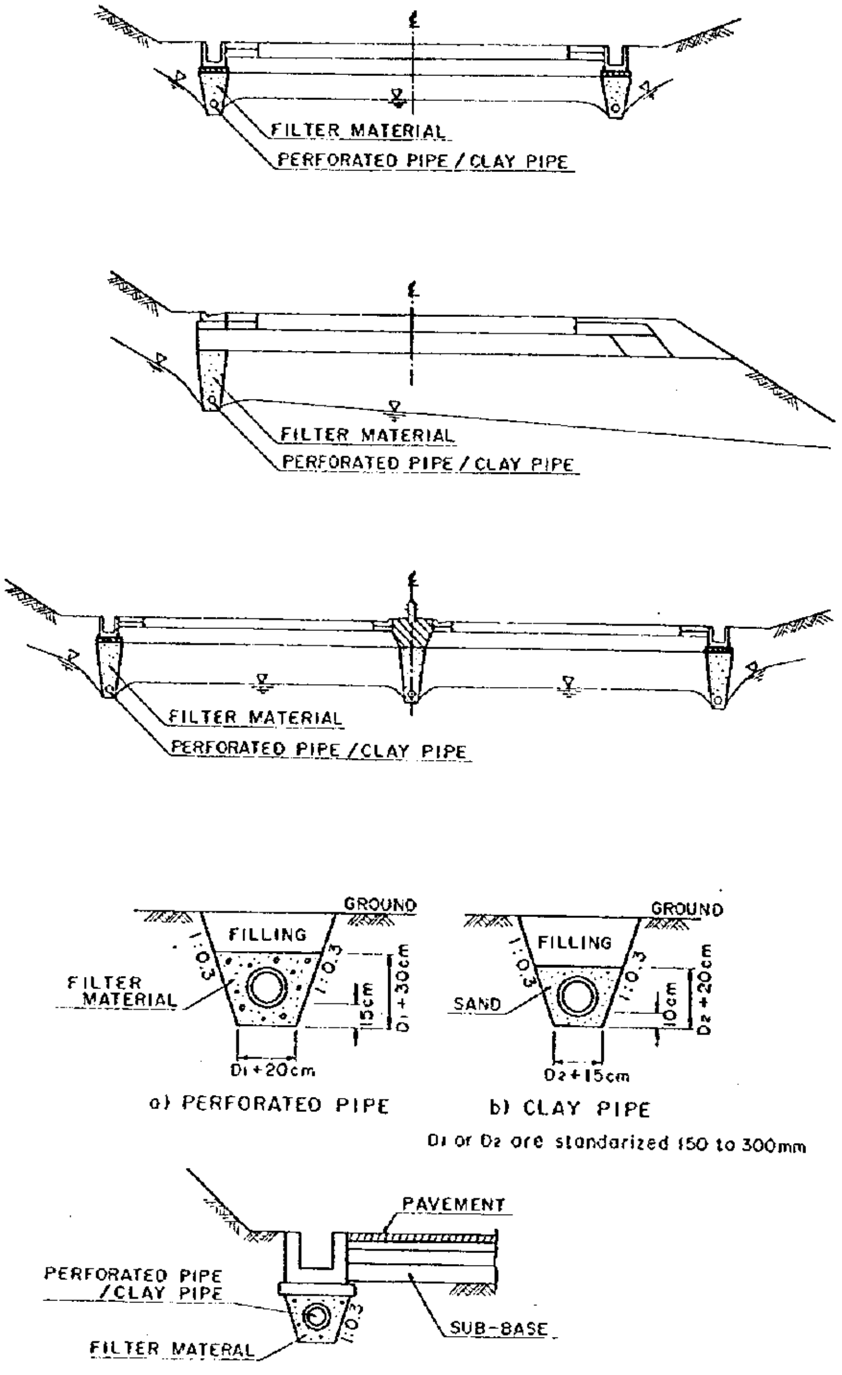


Fig. 12.3.4 Underground Drainage

12.3.2 Survey

A survey shall be carried out, and the findings of the survey shall be utilized in designing the drainage. The survey items are shown in Table 12.3.1

Table 12.3.1 Survey Items

	Survey Items	Result
1	Weather Information	• examination of discharge volume • drainage system as constructed • countermeasure for freezing • control of snow and ice removal
2	Topographic	• examination of discharge volume • define the underground water
3	Soil and groundwater	• countermeasure for freezing • drainage system as constructed • apply to slope and underground drainage system • countermeasure for freezing • control of snow and ice removal
4	Existing drainage system	• examination of discharge water • plan of new drainage system

The outline of each survey described as follows;

■ **Weather Information**
Weather information is used to decide on the structural type and extent of the drainage system. Information shall be collected in the area on rainfall, snowfall, temperature and humidity.

■ **Topographic and Site survey**
Generally the topographic survey shall be carried out to get the cross section of the road, and the site survey is used to get information for planning the drainage system.

■ **Soil and groundwater survey**
The soil survey shall be carried out to define the soil type and properties. Information on groundwater can also be taken from the results of Borehole and soil sampling.

12.3.3 Calculation of Discharge Volume

This chapter briefly describes the drainage calculation method. For more details of the design method, refer to the design guide line produced by KGM .

When calculating the discharge capacity and deciding on the type and size of a culvert, the regional rainfall characteristics must be available.
KGM is using the Rational Formula for working out the maximum discharge flow. This formula is commonly used for calculating discharge flow for small catchment areas(25-35km^2).

The Rational Formula is shown below;

$$QV = \frac{1}{3.6} \times A \times K \times I$$

QV = maximum flow depending on the frequency which is adopted for the design
A = catchment area of rain-fall (km^2)
K = runoff coefficient, percentage of flow which runs
I = rainfall intensity within time of concentration (mm/h)

- Catchment area: the area of land (km^2) from which water would flow to the structure being considered. The area can be marked on a contour plan and measured using a planimeter.

- Runoff coefficient: This can be taken from the Table 12.3.2 below for the appropriate site characteristics.

Table 12.3.2 Runoff Coefficient

Site Characteristic	K values(%)
sowed area	10-40
orchard	15-40
pine forest	25-50
leaved forest	35-60
rolling pasture	40-65
flat naked surface	50-70
rolling naked surface	60-80
steep naked surface	80-90
in permeable	90-95

- Rainfall intensity within time of concentration (mm/h): Collection time is the time taken for rainfall to reach the structure under consideration from the farthest point in the catchment area. After reaching to structure, water running into the structure reaches its maximum level.

The rain-fall value is taken from rainfall-Intensity-time-frequency which is shown in Fig. 12.3.5 published by the General Directorate of DSI. For state highway culvert calculations, the maximum 1 hour rain-fall for 10 and 100 years is used. Using these rainfall values, maximum flow for 10 years shall not exceed the structure height by 20cm and the maximum flow for 100 years shall not exceed the embankment level.

- Site surface water: The running time of rainfall is the time taken to travel from the farthest point in the catchment area to the stream bed. We obtain the distance from 1/25000 scaled maps. The surface water speed is obtained from following table.

Grade of site(%)	speed (m/sec)
up to 2	0.008 - 0.15
2-4	0.15 - 0.21
more than 4	0.21 - 0.30

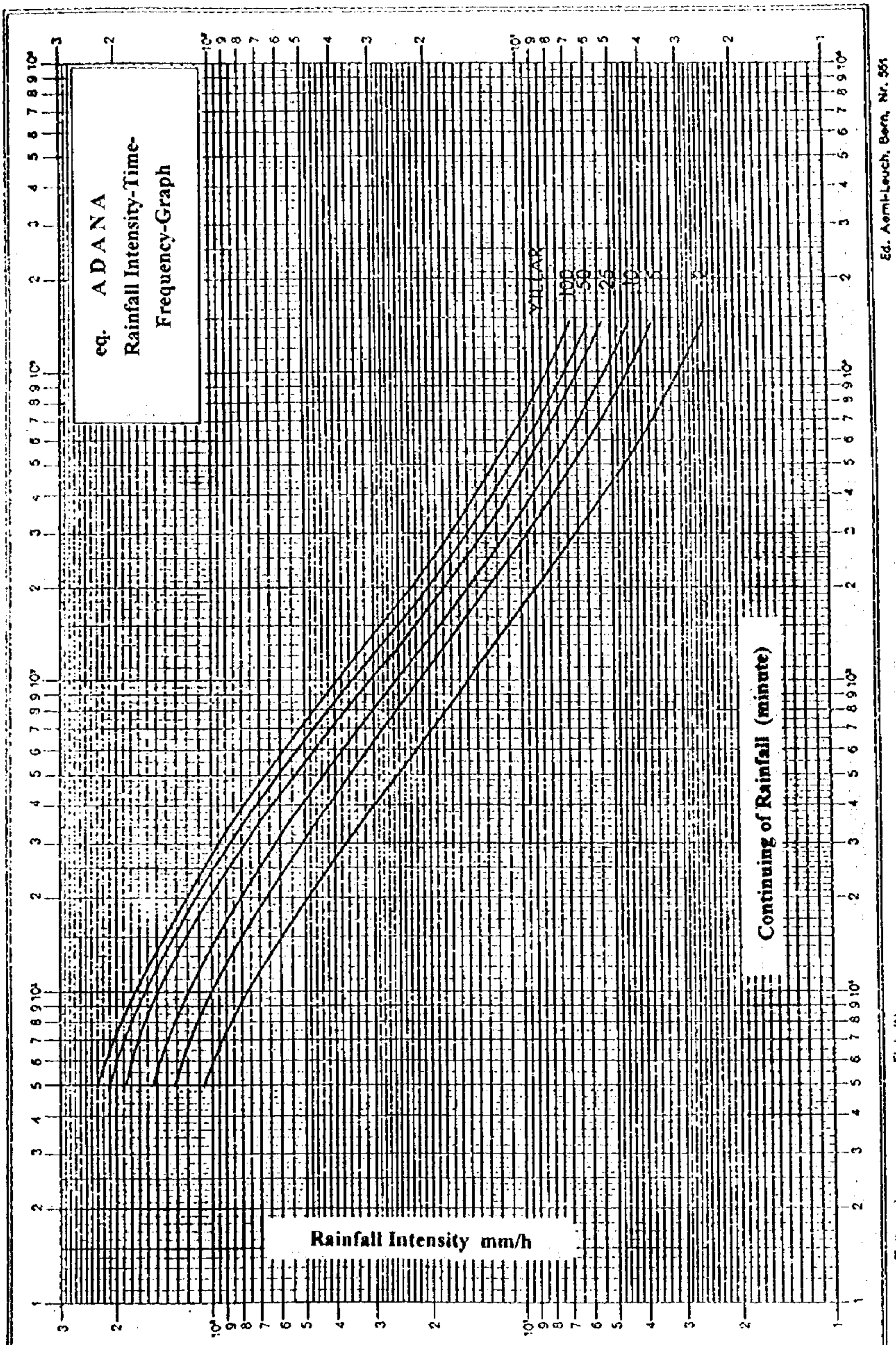


Fig. 12.3.5 Rainfall Intensity-time-frequency

12.3.4 Calculation of Allowable Discharge Capacity

After calculating the discharge volume, the drainage capacity must be checked. The drainage capacity can be calculated from the available cross section area of water flow, and the average velocity of the water flow. This method is called the Manning method. The formula is made up of a Roughness Coefficient of Drainage, Hydraulic Gradient, Hydraulic Radius and Length of Wetted Perimeter.

The following formula is used for calculating discharge capacity;

$Qc = A*V$
Qc = Discharge capacity (cubic meter/ second)
A = Available cross section area of water flow (square meter)
V = Average velocity of water flow by Manning formula (meter/second)

As indicated below, the allowable discharge capacity for the cross section of a waterway for drainage facilities must be greater than or equal to the discharge volume.

$$Qv <= 0.8Qc$$

where,
Qc : allowable discharge capacity at culverts
Qv : discharge volume of culverts

The surplus drainage capacity shall be considerable to allow debris to accumulate, except that clogging up by debris is taken into account in deciding that the water level of a culvert should only reach 80% of its height. .

12.4 Temporary Drainage System

Temporary drainage systems are an indispensable facility to perform skillful road construction. If temporary drainage is not planned and designed for the construction phase, serious problems may occur which could delay the construction. The design engineer should consider and plan the need for temporary drainage at the design stage.

The permanent drainage system should be installed as soon as possible during the construction to control groundwater levels keeping the sub grade free of water, and to prevent surface water running down cutting slope.

The Fig. 12.4.1 shows the drainage for constructing an embankment and Fig. 12.4.2 shows the temporary drainage which allows the runoff water to discharge during the construction of the cutting slope.

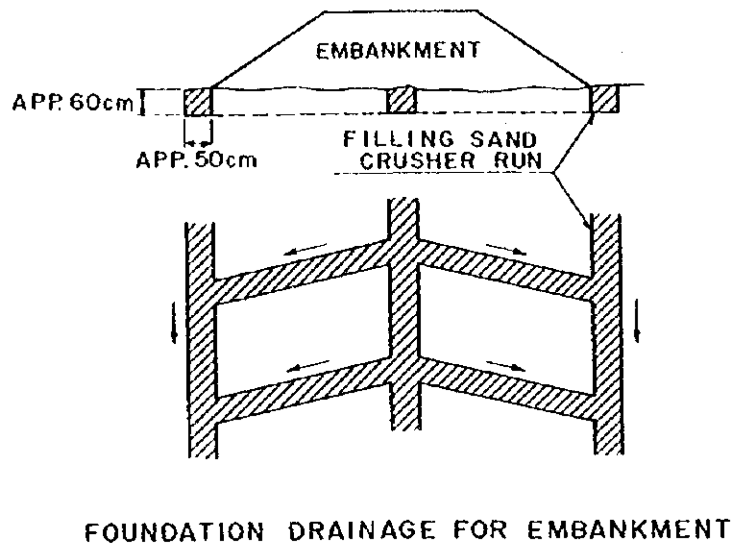


Fig. 12.4.1 Drainage for embankment construction

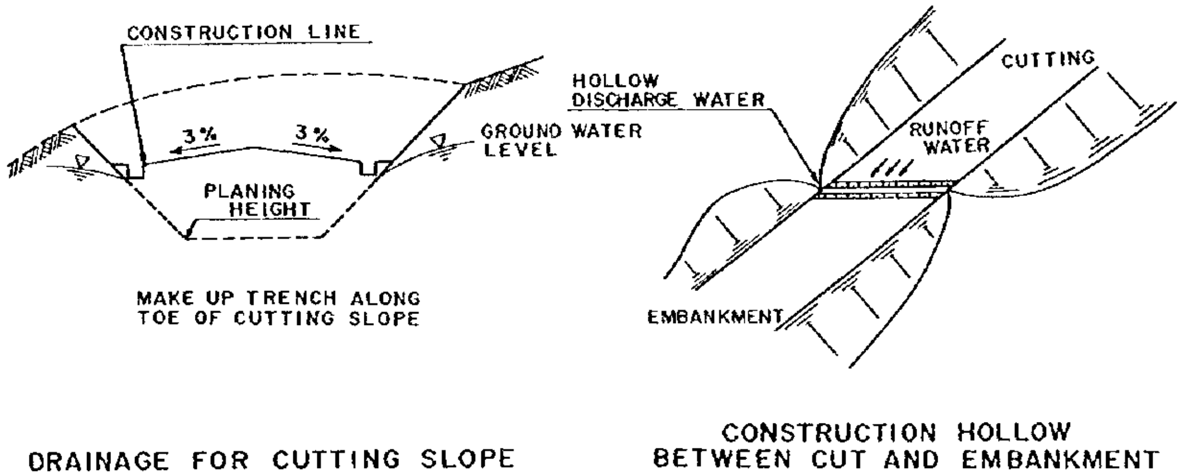


Fig. 12.4.2 Drainage for Construction Cutting Slope

CHAPTER 13

DESIGN OF SNOW AND ICE CONTROL FACILITIES

CHAPTER 13 DESIGN OF SNOW AND ICE CONTROL MEASURES

13.1 General

This section sets out the information and advice needed for the design of winter road management and snow and ice control facilities on both state and provincial roads in Turkey.

13.2 Purpose of Design

The purpose of this design is to protect the drivers' safety and maintain the road traffic movement in winter season.

KGM is responsible for the reduction of snow and ice hazard, which threatens the driver's safety and obstructs the traffic movement, by adequate selection of possible and effective preventive measures, taking local conditions into account, including such works as:

(1) Improvements in safer driving through driver education
(2) Collection of weather and road surface information and the provision of this to the users of road
(3) Control of traffic

13.3 Preparatory Survey for Design

It is advisable that the inspection of winter road conditions is made by patrol on a regular basis. The frequency should be determined after consideration of the local meteorological, topographical and traffic conditions.

Inspection items are as follows;

(1) Weather conditions,
- What are the present local weather conditions?
- How are the local weather conditions changing?

(2) Road surface conditions,
- At which section is the road surface covered with snow, ice or water?
- How thick is the snow, ice or water on surface?
- How is the surface condition changing?

(3) Traffic conditions,
- How is the traffic movement?
- Are vehicles equipped with chains?
- Is any vehicle in trouble on the road due to bad surface conditions?

13.4 Service Level

Both state roads and provincial roads are classified into three categories of service level for winter road maintenance as shown below:-

1st level	: Road which must always be kept passable Open 1-lane for 2-lane road, 2-lanes for 4-lane road as the minimum requirement
2nd level	: Road which is kept passable as much as possible
3rd level	: Road which is excluded from winter maintenance

The classification of each road must be revised every year, taking a hard look at the influence of it being impassable when considering the seasonal variation of traffic density. In general, elements to be taken into account for the classification are as follows:

(1) Importance of road	Traffic density Alternative routes available, Road networking Access to public facilities Bus route
(2) Meteorological Conditions	Return periods of snow depth Return periods of daily snowfall amount Return periods of maximum/minimum temperatures
(3) Disasters and Accidents	Frequency of snow drift, avalanche, surface freezing Frequency of car accidents and their causes
(4) Road Structure	Width of carriageway Width of sidewalk Width of snow removal Roadside conditions Line forms, traverse slope
(5) Capacity of maintenance	Snow Removal Ice Control

13.5 Design of Snow and Ice Control Measurements

13.5.1 Snow Removal Operation

(1) Principal Procedure

The purpose of snow removal for winter road maintenance is to ensure that the road is safe, that is, to eliminate slippery and hazardous winter conditions and to allow an acceptable flow of uninterrupted traffic under inclement weather conditions

The principal procedures of the snow removal operations are shown in Fig. 13.5.1. The basic operation is "Removal of New Snow Deposits" and "Removal of Packed Snow". It is desirable that new snow is displaced before it is packed.
When there is heavy snowfall, a quick start and speedy displacement is important.

1. Removal of New Snow Deposits(Snowplowing)

↓

2.Removal of Packed Snow (Snowplowing)

↓

3.Widening

↓

4.Transportation and Disposal

↓

5.Snow Removal of Special Sites

Fig. 13.5.1 Principal Procedure of Snow Removal

(2) Snow Removal Equipment

Various types of snow removal devices and their roles are summarized in Table 13.5.1.

Table 13.5.1 Snow Removal Equipment and its Role

Equipment	Removal of New Snow Deposits	Removal of Packed Snow	Widening	Transporta -tion and Disposal	Snow Removal at Special Sites
Blade Plow	O		O		
Blade Plow with Side Wing	O		O		
Truck Grader	O	O			
Motor Grader		O			
Rotary Plow (Snow-blower)			O	O	O
Loader				O	O

The majority of snow removal devices fall into two categories, Blade plow (displacement plow), and rotary plow (snow blower). The relationships between the various types of equipment design in those categories are depicted in Fig. 13.5.2. The blade plow of front-mounted one-way fixed type is the most commonly used snow removal device. Rotary plow of drum type is also commonly used to displace deep and hard snow.

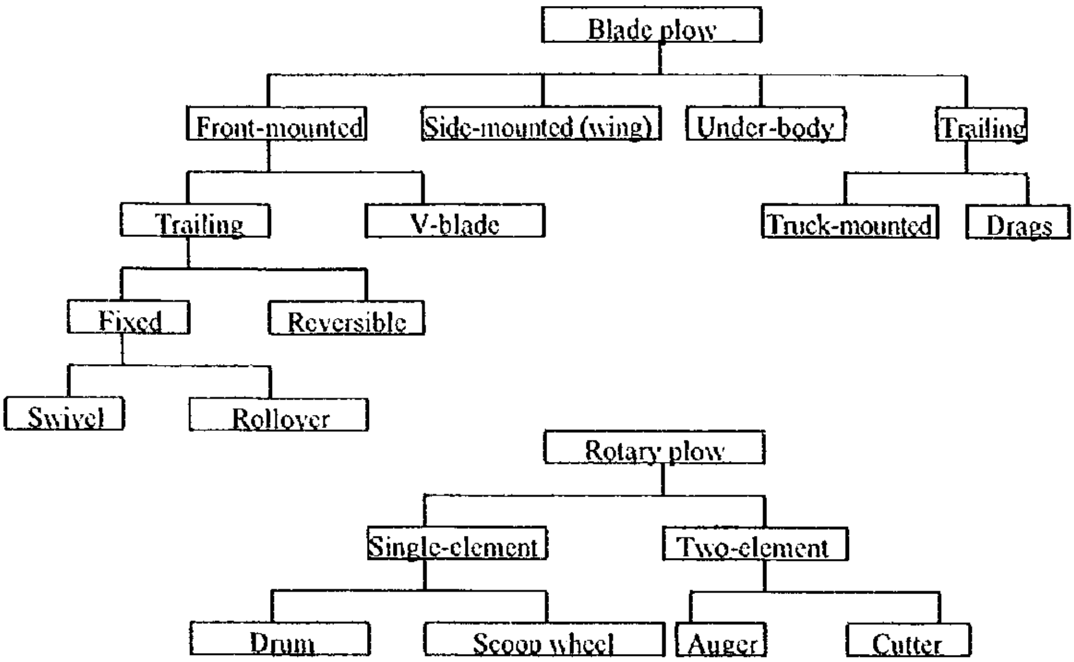


Fig. 13.5.2 Relationships between Various Types of Equipment Design

(3) Snowplowing

It is important to have a clear policy that is easily understood; the technique used for multi-lane roads should be clearance by lane.

Due to differences in local weather conditions, snow depth, snow wetness and road topography, it is difficult to be precise on the order of lane clearance. Also, local traffic densities and movements vary from day to day and even within in a day, and may affect lane clearance priorities.

In prolonged, heavy snowfall the priority will be to maintain a single lane open. In the majority of cases this will be the more heavily trafficked right lane (lane 1) and the first operation will be to plow snow from lane 1 to the shoulder, with clearance of outer lanes continuing as conditions improve.

Irregular windrows caused by plowing passes, especially those that weave from one lane to another, are dangerous, as they may tempt drivers to overtake by squeezing into the partly cleared lane. Lanes should be completely cleared, and the windrows of snow remaining should form a smooth and continuous lane without sudden encroachments into the cleared path.

Speeds of plowing vehicles should be regulated, particularly at features such as under-bridges where snow could be thrown over the bridge parapet and adjacent reserve where snow could be pushed onto the other road.

The aim is to clear all lanes as soon as conditions permit. Clearance work shall therefore proceed continuously, since a pause during a snowfall could lead to a build-up, which would take a disproportionately long time to clear. Packed snow, glazed by the wind, can be particularly difficult to remove.

Care must be taken to avoid damage to road surfaces, road studs, roadside furniture and structures. At road works, traffic management equipment must not be disrupted. An accumulation of plowed snow creating a ramp adjacent to safety fences and concrete barriers should be avoided.

(4) Snow-blowing

Heavy snowfall, drifting and plowing operations may result in a build up of snow on the road and shoulders. Snow blowers are particularly suited to clearance of blockages and to remove accumulations from the shoulder and road where snow may be safely directed onto the verge (or possibly a wide central reservation).

13.5.2 Ice Control Operation

(1) Purpose of Ice Control

The purpose of ice control for winter road maintenance is to ensure that a roadway is safe, that is, to eliminate slippery and hazardous winter conditions and to allow an acceptable flow of uninterrupted traffic under inclement weather conditions.

Ice control aims to improve the co-efficient of sliding friction.

(2) Measures and Effects

The most widely adopted measure for ice control is the application of salt and other chemicals, which makes snow and ice melt. To be more exact, it makes the freezing point lower. The application of salt and other chemicals produces the following effects;

- Anti-icing to prevent water on the road surface from freezing
- Anti-snowpacking to prevent snow on the road surface from being packed by tires by weakening the bond between the snow particles and also between the pavement surface and the snow on it
- De-icing to make ice on the road surface melt
- De-snowpacking to soften snow on the road surface packed by tires by weakening the bond between snow particles

Fig.13.5.3 shows the increase with time in the coefficient of sliding friction of a road surface, initially covered with 0.6cm of packed snow, following the application of sodium chloride and a 3 : 1 mixture of sodium chloride and calcium chloride.

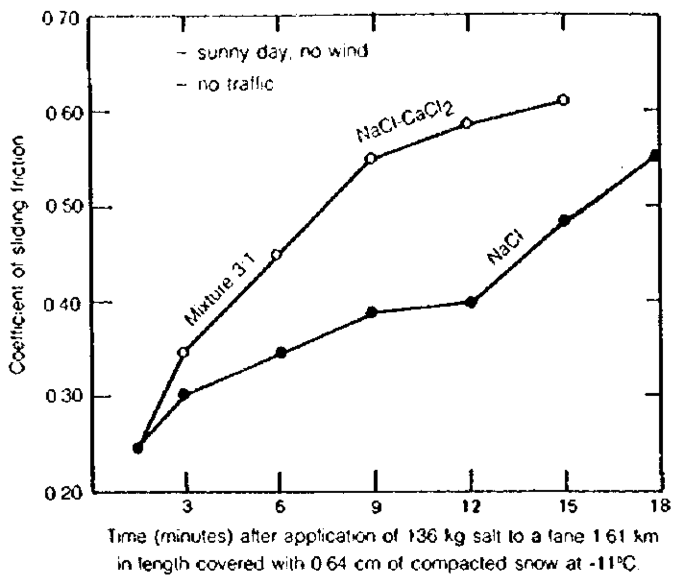


Fig. 13.5.3 Increase with time in the coefficient of sliding friction of road surface

The coefficient increases with time because of the increase in the amount of snowmelt, and as a result, the traction increases.

Another measure is the application of abrasives, which increases the coefficient of the sliding friction between tires and the road surface. This produces the effect of Physical improvement of the traction of tires running on a slippery road surface.

As the traction increases, the stopping distances of a vehicle decreases. Table 13.5.2 illustrates the decreases in stopping distances if an icy surface is sanded or the ice or snow surface is melted by salt to provide a wet surface.

Table 13.5.2 Effect of sanding and salting on the stopping distances

Road Condition	Stopping Distance	%
Icy Road at −1℃	143 m	100
Sanded Surface at −1℃	55 m	38
Bare Wet Surface after Salting	20 m	14

The mixture of salt and abrasives is also commonly used on a slippery road, expecting the combined effect of de-icing and physical improvement of tire traction.

(3) Precautionary treatment

Anti-icing and anti-snowpacking are effective with less spread rate (amount of chemicals per area) than de-icing and de-snowpacking. To be most effective, chemicals should be spread before ice forms, or after the snowfall has started, but before snow starts settling on the road. Anticipating these conditions, and reacting correctly, depends on a mixture of local knowledge and experience, good weather forecasts, and the awareness of the current condition of the road (i.e. Is it wet or dry ; is previous treatment sufficient?). It is recommended that KGM makes effective use of the weather forecasting service in the near future.
The success or otherwise of the operation depends greatly on the good judgement of those

who decide whether to treat or not. Good weather forecasts are essential, but local topographic features or other factors may have to be considered in reaching a decision. It does however take time to acquire this kind of local knowledge, and therefore continuity of staff is important. The decision will depend on many factors but, if the road surface temperature is predicted to fall below plus 1℃, a precautionary treatment should normally take place unless :

- No moisture is on or is expected to be on the road ; or
- There is sufficient residual chemical on the road to deal with the expected conditions.

Road inspections should confirm residual treatment levels and other information about the road surface condition.

Elevated section of roads, including bridges, and sections lying in low ground or where the topography channels wind-borne cold air, are more prone to freezing and may need special attention.

Spread rates for a precautionary treatment should be 10-20 g/m^2 for salt except in the following circumstances :

- If freezing conditions are expected after rain, salt should be spread at 20-40 g/m^2 according to the amount of moisture present and temperature expected. Unless freezing conditions coincide with rainfall, treatment should be delayed as long as possible to reduce loss of salt by run off.
- If continuous snowfall is forecast, salt should be spread at 20-40 g/m^2 according to the anticipated severity of the snowfall. It is essential that enough treatment is applied before the snow starts to stick to the road as the treatment will melt the initial snowfall and provide a wet surface beneath subsequent snow making the work of snowplows much easier.

(4) Treatment of Settled Snow and Ice

- If ice has formed, salt for de-icing should be spread at up to 40 g/m^2, depending on the amount of ice present and the temperature, to ensure a rapid melt. Particular attention should be paid to lengths of road which are known to be susceptible to 'run-off' water from verges or central reserves. Although the road itself may be dry, accumulation of snow may melt, run onto the road and then re-freeze.
- Snow accumulation exceeding 30mm in depth is best removed by plowing. Each pass of the plow should be supplemented by salt spread at 20 g/m^2 to prevent the remaining snow from compacting and to aid disposal by traffic and subsequent plowing.
- It is important to monitor air temperature and if the temperature drops,to increase spread rates, up to 40 g/m^2 if necessary. Vehicle mounted thermometers can be misleading. Proprietary ice sensors placed at roadside sites, or thermometers at suitable open sites in compounds, or similar systems are a great help for such decisions.
- Even light snowfalls may call for plowing where local drifting has occurred, or to remove snow not dispersed by traffic. This may occur where the traffic is reluctant to use lanes 2, or at night when the traffic is light.
- During prolonged falls of snow, plowing should be continuous to prevent build-up and be supplemented by simultaneous salting at a rate of 20-40 g/m^2.
- If snow reach 120 mm, or when tackling drifts, or when working on gradients, it may be better to plow without spreading, as the weight of the treatment load will aid vehicle traction. As soon as the situation is under control, spreading should be resumed. Use of a snowblower may also be considered for removal of deep snow.

- Plowing or snowblowing is not practical in built up areas. Repeated applications of chemicals for de-icing can remove heavy accumulations, but this type of treatment is not otherwise recommended, as it is likely to provide an unacceptable surface for traffic. In this case consideration shall be given to the use of a snowblower with the snow being directed into an accompanying lorry, followed as soon as possible by salt spreading at 20 g/m^2. The formation of packed snow and ice should be rare if other recommendations are followed. If it does occur, provided it is no more than 20 mm thick and the air temperature is above minus 5℃, removal is possible by using successive treatment of salt at 20-40 g/m^2.
- Great care must be taken as the use of chemicals for de-icing or de-snowpacking on the snow/ice can result in an uneven and slippery surface. If there is any danger that the surface will be unacceptably slippery, then the addition of abrasives should be considered.
- Reversion to the initial treatment technique shall be made as soon as possible since abrasives don't contribute to the removal of snow/ice and may block drains and gullies on thawing in the sections where they exist. Abrasives shall not be used on structures where there is any danger of blockage of drains.

(5) Treatment in Sustained Low Temperatures

For each degree drop below minus 5℃, the amount of salt needed to maintain the equivalent melting effect increases by about 14g/m^2. But where traffic is reasonably heavy, little or no increase is needed until sustained temperatures fall below minus 10℃. When sustained temperatures do fall below minus 10℃, one method that has proved to be effective is the addition of calcium chloride mixed with 4 parts of salt. Calcium chloride is expensive and difficult to store however as it absorbs moisture freely.

(6) Summary of Spread Rate

The spread rate of salt described above are summarized in Table13.5.3.

Table 13.5.3 Summary of Principal Treatment for Settled Snow and Ice

Road surface Conditions	Treatment		
	Effect	Salt spreading	Plowing
Wet	Anti-icing	10-20 g/m^2	Not possible
Continuous snowfall forecasted	Anti-snowpacking	20-40 g/m^2	Not possible
Ice formed	Anti -icing	20-40 g/m^2 for rapid melting	Not possible
Moderate snow	Anti-snowpacking	20 g/m^2 to supplement plowing up to, 40 g/m^2 if temperature falling	Required (depth must exceed 30mm)
Prolonged snowfall	Anti-snowpacking	20-40 g/m^2 to supplement plowing	Continuous (without salting if necessary to aid traction)
Hard packed snow/ice	De-packedsnow/ice	Successive treatments at 20-40 g/m^2 (supplemented by abrasives if necessary)	Not possible

(7) Spreading Techniques

Purpose built winter maintenance vehicles offer the opportunity to achieve a substantial saving in labor costs. In particular, the use of powered systems to control spreading eliminates the need for a second man in the cab during precautionary treatment. The use of a driver and mate shall be restricted to snowplowing and to other occasions when conditions are hazardous, (e.g. when precautionary or emergency treatment is required on particularly isolated stretches of road, when difficult manoeuvres are unavoidable or when visibility is poor). In compounds and depots where hoppers are provided, the drivers can load vehicles.

To be effective, salt should be spread evenly and at rates that suit the prevailing or expected conditions. Care should be taken to ensure that spread widths are neither too wide nor too narrow. The treatment should be spread by automatic machines, the controls of which shall be calibrated and clearly marked for distinct rates of spread, up to a maximum of 40 g/m^2. Higher spread rates are unnecessary, wasteful, and environmentally harmful and shall be avoided.

Crosswinds can affect the distance that treatment is spread and to compensate it may be necessary to spread from a lane upwind (if appropriate) from that normally chosen. In exceptionally strong winds it may be necessary to undertake a second treatment run with the spreader set asymmetrically into the wind.

Due consideration should be given to traffic conditions and the timing of winter maintenance operations. Wherever possible without detriment to the effectiveness of treatment, precautionary salting should be undertaken in off-peak periods when disruption to traffic and to proper distribution of the salt will be minimized. If precautionary treatment in heavy traffic is unavoidable it may be necessary to seek Police assistance or to consider treatment in two runs (to ensure proper distribution of the salt).

Care should be taken at roadworks that in addition to areas currently being trafficked, all other areas likely to be opened to traffic are treated. Traffic management equipment, including cones and cylinders, may disrupt distribution of salt; contraflow systems should be treated in both directions.

(8) Routes

However well vehicle operational routes are planned, a certain amount of wasteful duplication (dead mileage) is inevitable because of network complexities and the siting of compounds and depots. Dead mileage should be kept to a minimum, but first condition shall always be given to the need to achieve the required treatment time.
Routes should be reconsidered whenever major road works may affect the winter maintenance operation.

15.5.3 Snow Drift Control Facilities

(1) Basic Principle of Snow Drifting

There are three major factors governing the formation of drifts :

- Snowfall Amount and Snow Properties
- Wind Speed and Wind Direction
- Terrain (including obstacles) over which the windblown snow is carried

As each factor is extremely variable, it is difficult to predict the amount of drifting that will occur at a given site without the aid of field observations taken over a number of years.

The physical properties of snow, particularly the cohesion of its surface, determines the ease of drifting. If thawing and subsequent re-freezing of the surface forms the hard crust, the individual snow grains will be firmly cemented. Wind action itself is a compacting mechanism, creating, after some hours, a surface capable of withstanding velocities that would ordinarily drift loose, fresh snow. This implies that most drifting occurs when snow is falling or during the first day or so immediately following the end of the snowfall. Once snow accumulates into drifts it tends to remain until it melts.

Snow accumulation depends on the shape of the obstructions, their number and wind speed and direction so that the general patterns shown in Fig. 13.5.4 are at best approximate guides to what can be expected in nature. The effect of embankment slope on the amount of drifting is well exhibited in Fig.13.5.5.

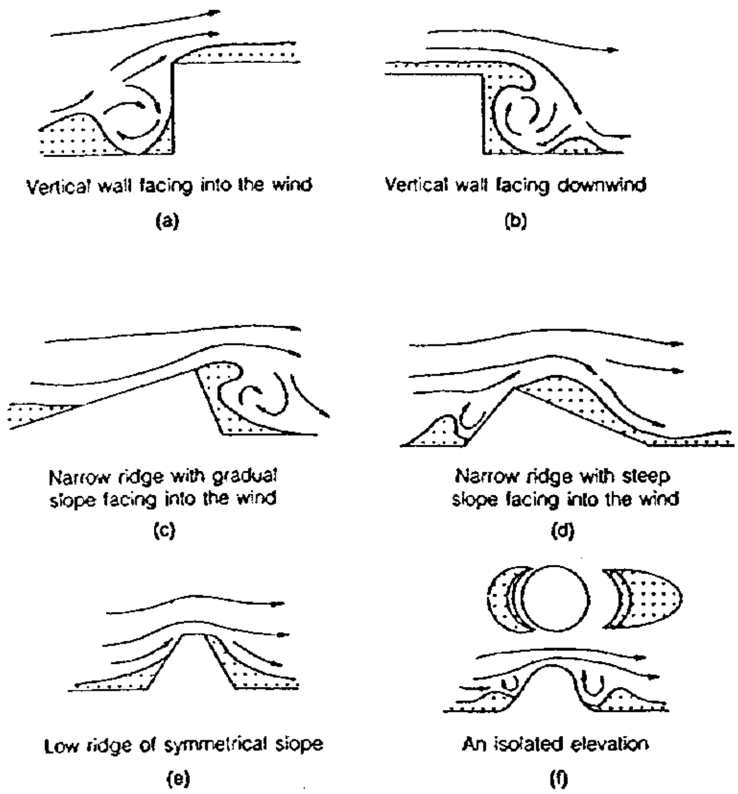


Fig. 13.5.4 Accumulation of Drifting Snow Caused by Some Typical Obstacles

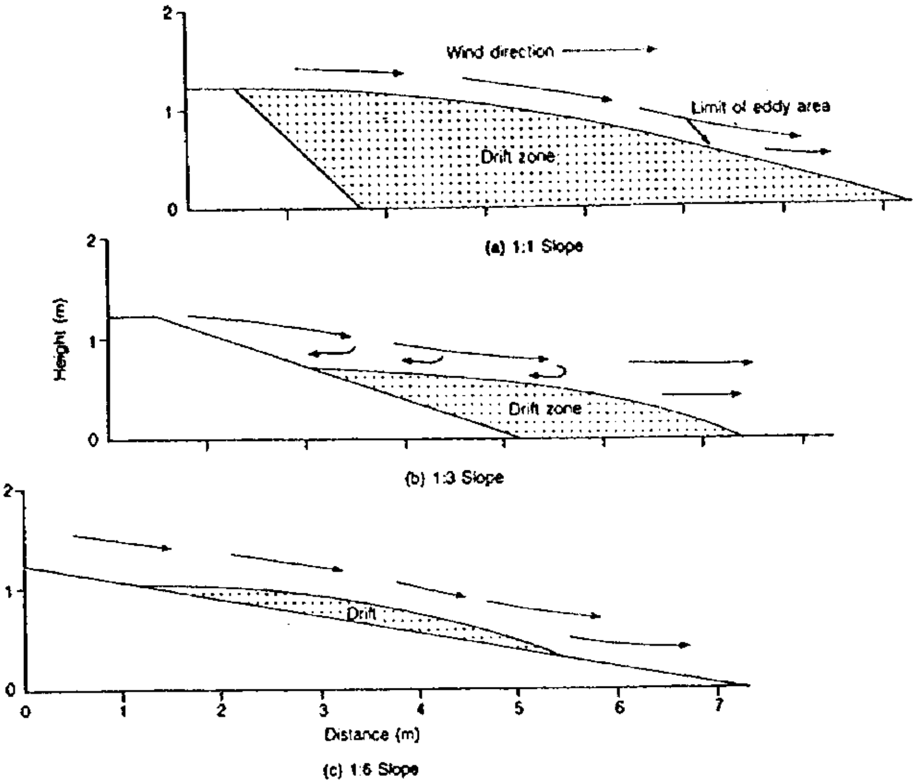


Fig. 13.5.5 Effect of Embankment Slope on the Amount of Drifting

(2) Types of Snow Drift Control Facilities

Facilities to control snow drift widely adopted at present are :

- Living Tree Fence
- Snow Fence
- Snow Shelter

(3) Living Tree Fence

The objective in planting (we don't plant deed frees!!) trees is to cause the snow to be deposited before reaching the area to be protected (road). Hedges and rows of trees provide effective protection and help to beautify the landscape.

Species should be low growing, dense near the ground, frost resistant and adapted to a wide range of soil and climatic conditions. By the end of winter the hedges may be covered with deep snow, therefore the individual trees and shrubs must be able to carry the load.

The main disadvantages in using trees and hedges are that they require several years to grow and once planted are not easily moved to correct for any errors made in the initial site selection and orientation. Hedges need not be higher 2.5m.

(4) Snow Fence

The most common method of snow drift control is with snow fences. Because the snow-carrying capacity of the wind is approximately proportional to the cube of its speed even small reductions in speed will produce substantial deposits of snow. A snow fence is designed to reduce the wind speed, therefore causing snow to deposit. Normally, places where drifting occur are known from experience, or in the case of new installations, have been observed during the first few years. Without this information the effectiveness of a snow fence will be uncertain. It is placed upwind of the area to be protected and oriented perpendicular to the direction of the snow-carrying wind so that snow is deposited in front of and behind it.

Various types of snow fences and configurations of snow deposits are exhibited in Fig. 13.5.6. The sloping type of fence is rarely used because it reduces the effective height.

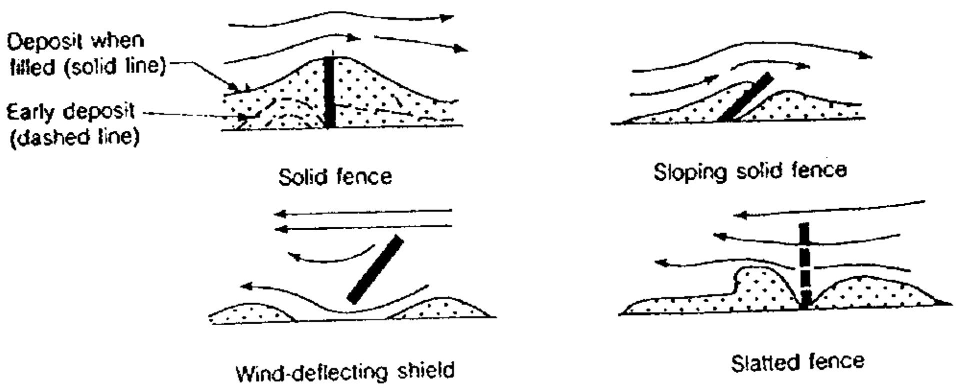


Fig. 13.5.6 Accumulation of Snow at Various Types of Snow Fences (Rickhter, 1945)

Economics, availability and space limitations determine the type of materials and arrangement used for fences. Because the wind pressure is less on the slatted fence, it can be fabricated from lighter material. Vertically slatted fences are the most common. Since a solid fence or wall produces a shorter deposit on its leeward side than on its windward side, it is most suitable when space is limited. The major disadvantages of solid fences are the high cost of materials and the need for a strong foundation.

The expected depth of snowfall and the quantity of drifting snow associated with the snowfall are decisive factors in selection. Observations of the conditions under which drifting occur must be made. If drifting occurs when the snow is shallow the required fence height will be substantially less than that if drifting only occurs during and after heavy snowfalls. For areas with light to moderate snowfalls fence heights between 1.2 and 1.8m are usually sufficient. Even in places of heavy drifting two parallel rows of relatively low, inexpensive slatted snow fence may be more economical than one high fence that is more expensive to construct.

The base of the fence should lie above ground level. A ground gap tends to produce vortices immediately in front and behind the fence preventing filling in or choking at least until the deposit reaches the bottom of the fence; the gap also reduces the potential of the fence to rot due to moisture. The size of the gap will vary with the type of fence and amount of snow. Some authors recommended a gap about one-seventh the height of the fence, i.e., ~17cm for a 1.2m fence may be recommended.

The smaller the density ratio (the ratio between the solid area and the total area of the fence), the longer and shallower the drift. The maximum collecting capacity of an open fence occurs for a density ratio between 40 and 60 percent. The density of an open fence might be the most important factor in determining the volume of snow deposited. Tests in the field and in wind tunnels have demonstrated that the slat arrangement (vertical or horizontal, slightly inclined) or material (wood, metal or other) is not important.

The optimum distance of the fence from the object or area to be protected will vary with wind and snow conditions. In practice, unless better information is available, an open fence should be placed upwind at a distance from the object of fifteen to twenty times its height.

Fig.13.5.7 shows the relationship between fence density and distance of the fence from the protected area as given ; e.g., a fence with a height of 2m and a density of 50% should be approximately 26m from the protected area. In practice, other factors such as land ownership or building location often determine the siting of a fence.

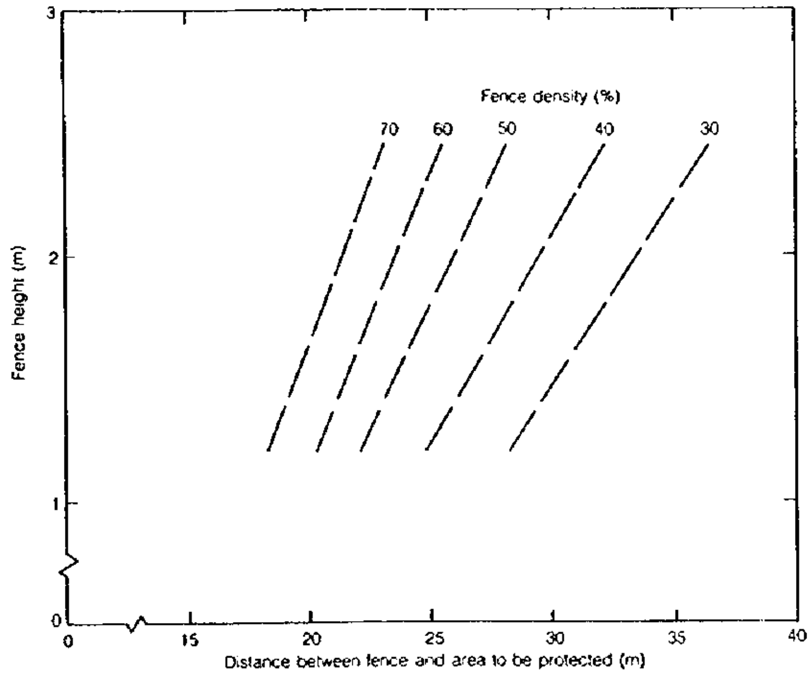


Fig. 13.5.7 Relationship between Fence Height, Fence Density and Distance between Fence and Area to be Protected

Since the length of the deposit formed behind a solid fence is about ten times the height of the fence, this distance should be maintained between the fence and road. When a solid fence is longer than the width of the road to be protected and closer than five times its height, a strong eddy occurs between the fence and the road so that this space is usually snow free. It could be easily filled, however, if the wind direction was oblique rather than perpendicular.

As a general rule if the wind-blown snow originates from more than one direction, which is frequently true, several protective fences may have to be installed. In regions where large quantities of drifting snow can be expected, snow fences are arranged in rows, at a recommended separation of about 10 times their height. Some basic row arrangements are presented in Fig. 13.5.8. The arrangement selected depends on the prevailing wind direction and its expected variation. Other factors such as available space, soil condition, and the depth of snow also must be considered. The first arrangement will rarely give satisfactory results ; field observations of the shapes of the deposits are necessary before the best locations can be selected.

Tall fences are more efficient than short ones in trapping snow. The reduction in wind speed behind the fence increases with its height. Since most of the blown snow is transported in a shallow layer adjacent to the ground or snow surface, the reduction of wind speed in this layer is responsible for the increase in catch rather than the capture of additional snow in the higher layers.

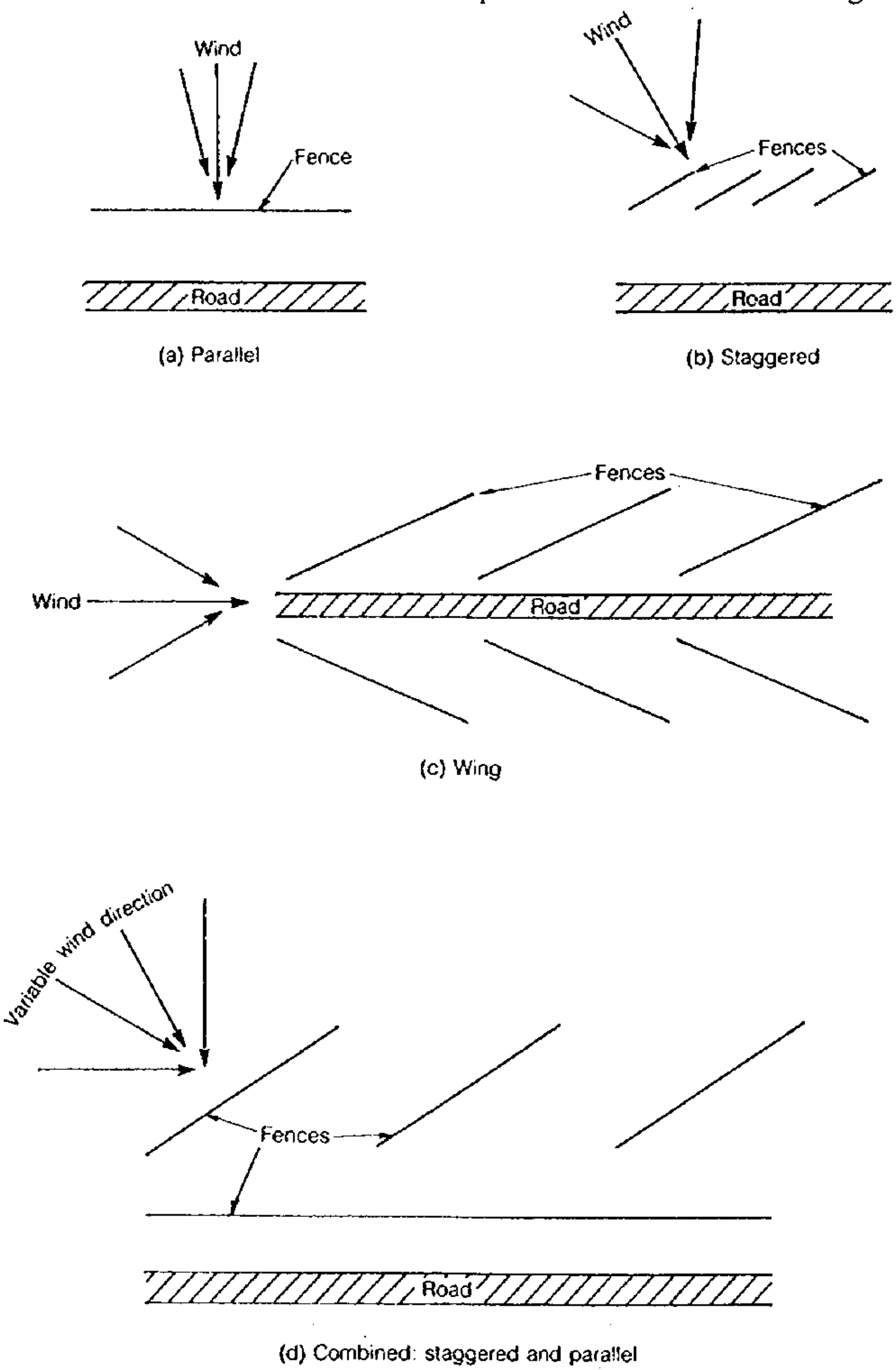


Fig. 13.5.8 Basic Arrangements of Snow Fences (1950)

13.5.4 Avalanche Control Facilities

(1) Basic Principles of Snow Avalanches

Because the snow deforms readily under its load resulting in settlement, creep, and glide, additional tensile and compressive stresses appear at anchor points such as rocks, trees, and flat parts of the terrain. Failure occurs when the stress exceeds the strength at some point. Stresses in a snowpack are increased by the weight of additional snowfall or the accumulation of drifting snow, but a decrease of strength most frequently results from a rise in temperature. After the snow has failed at one point this causes a rupture to propagate over a wide area.

The variation in creep velocity along a slope produces different tensile and compressive stresses in the snow as shown in Fig. 13.5.9. It is important to identify zones of high stress because snow fractures and starts an avalanche at places of high tensile stress.

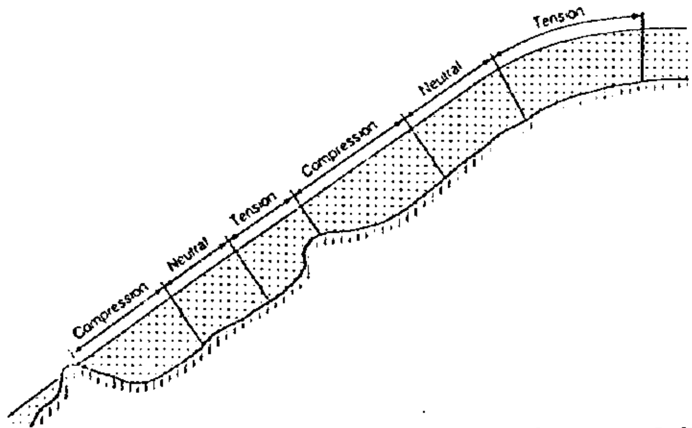


Fig.13.5.9 Stress Distributions Developed under Creep and Glide Deformation

The dislodged snow usually accelerates rapidly on a steep slope and, as it moves downhill, breaks delicately balanced snow and the terrain. During the initial state of movement the snow has a gliding and rolling motion which becomes turbulent and the material is pulverized.

If the snow is dry, the fine particles mix with the air to form a powder. The component that follows the ground is known as a flowing avalanche; that carried by the turbulent air motion, a powder avalanche. Often both forms are present. A drop in the terrain may cause all the snow to mix with air producing a pure powder avalanche.

On a steep slope an avalanche may attain a high speed and exert great pressures on obstacles in its path, thereby becoming destructive. As the slope of the terrain decreases the avalanche decelerates and finally stops.

An avalanche path is the specific locality in which a snow mass moves. It is generally divided into the starting zone at the top where the snow initially breaks away, the runout zone at the bottom where the snow decelerates and stops, and the track that connects the starting zone with the runout zone. On the track, the speed of the avalanche may increase, remain steady, or decrease, however, its mass remains more or less constant. Often there is no clear separation between each part.

Minimum inclines of around 25 degrees are required to initiate avalanches and maintain their

Minimum inclines of around 25 degrees are required to initiate avalanches and maintain their motion. The runout zone begins where the angle of the slope drops below this minimum value and can usually be recognized by a break in the terrain.

(2) Avalanche Control Measures

The choice of a particular avalanche protection measure depends on the level of protection required, the terrain, type of avalanche prevalent in the area and cost. Avalanche control measures influence the start or course of avalanches and can be divided into two categories below:

- Modification of the terrain
- Modification and stabilization of the snowpack.

The implementation of control measures which would completely eliminate the avalanche hazard, and damage is impractical and uneconomical. Rather, it is common practice to accept those measures that reduce the hazard to some acceptable level.

(3) Modification of Terrain

In avalanche control and protection work, terrain modifications include those structures and earth works that are constructed either to prevent the release of avalanches or deflect the sliding snow away from the facilities to be protected.

(4) Supporting Structures

Supporting structures or retaining barriers are used in the starting zones of avalanches. The functions are:

1) To provide external support to the snowcover, thereby reducing the internal stresses within the snow,
2) To produce a discontinuity in the snowcover, thereby limiting the propagation of a fracture and the resultant size of the avalanche, and
3) To stop small avalanches before they gain sufficient momentum to cause major damage.

Supporting structures are earth terraces, posts and masonry walls. Today the structures are made out of wood, steel, aluminum, concrete, and various combinations of these materials. Supporting structures are expensive because of their large physical size. They must be at least as high as the deepest snow, usually between 3 and 5m, capable of resisting the forces produced by creeping snow and small avalanches, and of covering the full width and length of the starting zone. Because of their high cost, supporting structures can be justified only for the protection of inhabited areas or for installation at sites where the starting zone is small.

Temporary low cost structures of wood are often used on reforestation projects to protect young trees from snow creep and avalanches. These temporary structures weather and decay. However, they generally last sufficiently long for the trees to grow large enough to provide natural avalanche protection.

(5) Snow Fences and Wind Baffles

Collector fences and baffles control drifting snow that would contribute to avalanche formation. The structures have proven effective in reducing avalanches but do not eliminate them. They are generally used in combination with supporting structures for control of avalanches as well as cornices. Cornices can be a hazard when they break and roll on a road; occasionally they may start an avalanche. The function of collector fences, which are usually 4 to 6m high and located on the windward side of ridges is to decelerate the wind velocity and to retain blowing snow. Conversely, wind baffles are either vertical walls about 4m high and 2m wide or jet roofs (blower fences) made of inclined boards 4m long.

(6) Deflectors

Deflecting structures are used as protection devices in the track and runout zones of avalanches. Three major types are commonly used: dykes and walls, splitting wedges and galleries. Deflecting dams or walls intercept avalanches and direct the flow to an area where they can run out harmlessly as shown in Fig. 13.5.10.

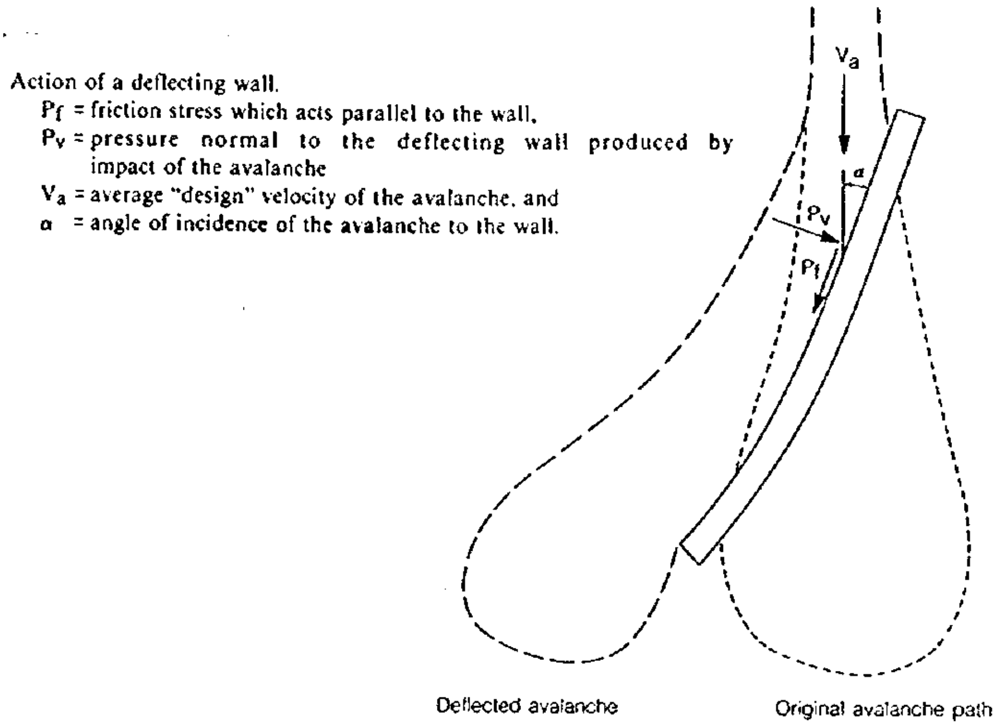


Fig. 13.5.10 Action of deflecting wall

Guiding dams or walls are constructed parallel to the direction of the avalanche and confine it in a narrow channel; they are often used in combination with galleries. Most are built as earth banks but may be concrete or steel walls, gabion walls and cribs.

Dykes and walls are effective against flowing avalanches, but do not control powder avalanches. Deflecting dykes for avalanche control can essentially only be used in areas having enough space for the deflected avalanche to run out harmlessly, but this often limits their application.

(7) Retarding works

Retarding works, also called breakers or arresters, are obstacles located in the paths of avalanches, whose function is to slow down or stop the avalanche. These works are effective in controlling wet flow avalanches but they are ineffective against powder avalanches. The most common type, which has proven both economical and efficient, is massive earth mounds, which are usually from 4 to 10m high arranged in two or more rows. Other types are wall and earth and snow dykes. Dykes stop very slow avalanches but are easily flooded by rapidly moving large avalanches.

The best location of a retarding structure is on flat terrain near the end of the runout zone. As a general rule, retarding structures should not be built on slopes steeper than 20 degrees.

(8) Protection by Forests

The cause of many early avalanche disasters can be traced to the extensive deforestation accompanying habitation. As the population in the mountain regions increased, forest were often removed to obtain more grazing land. Avalanches began to run on denuded mountains where there had been no history of occurrence. A forest with high trees in the starting zone inhibits the formation of avalanches because:

- The tree trunks support the snowcover and anchor a potential slab avalanche,
- There is little snow drifting,
- The crowns of the trees retain snow and release it gradually to form a stable cover on the ground,
- The forest canopy moderates variability in the net energy exchange with the snow surface which tends to produce a uniform snow temperature distribution and stable snow.

To be effective for avalanche control, the forest must be dense, i. e. the spacing between young trees should not exceed 3m. An open forest offers no protection against avalanches. A forest in the track and runout zone would probably stop small and slow avalanches but would not inhibit the progress of large avalanches. When avalanches break trees, they are carried in the flow, thereby increasing its mass destructive power.

In potential avalanche zones the forest must be protected from fire. Also logging project on steep terrain should be investigated as to their potential impact on the avalanche hazard. The most important consideration is the preservation of trees in potential avalanche starting zones and at tops of ridges.
A large avalanche denudes the slopes of trees. The areas can only be reforested with great difficulty. In the meantime, temporary supporting structures should be made large enough to provide natural control.

(9) Use of Explosives

The prevention and control of avalanches by snowcover modification is a more versatile and usually a much cheaper procedure than terrain modification. However, it is only a temporary measure that must be undertaken every winter.

The artificial release of avalanches by explosives is the most widespread protective method. Explosives are most effective in inducing avalanches if they are placed in the starting zone at the time when the stress-strain relationship of the snow is critical, yet before the unstable snow is deep enough to produce large avalanches.

(10) Safety Measures

Several safety measures are employed in an attempt to reduce the possibility of disaster from avalanches, such as closures, avalanche detection, warning systems and warning signs. The simplest means of preventing disaster is to impose restrictions on the use of roads during high hazard periods.

The effectiveness of these measures depends on reliable evaluations of the daily hazard by a person capable of recognizing when a dangerous condition may begin and end. Preventive closures of roads with low traffic volume may be frequent but for major traffic routes are only acceptable when they are short and infrequent

A major problem in effecting closures as a safety measure is enforcement. Traffic can usually be controlled by warning notices posted on low volume private roads, such as forest and mine roads, but only by strong, physical barriers and police patrols on public highways.

13.5.5 General Procedure for the Selection of Optimum Snow/Ice Measures

General procedure to select the optimum measures against snow/ice hazards is shown in Fig 13.5.11.

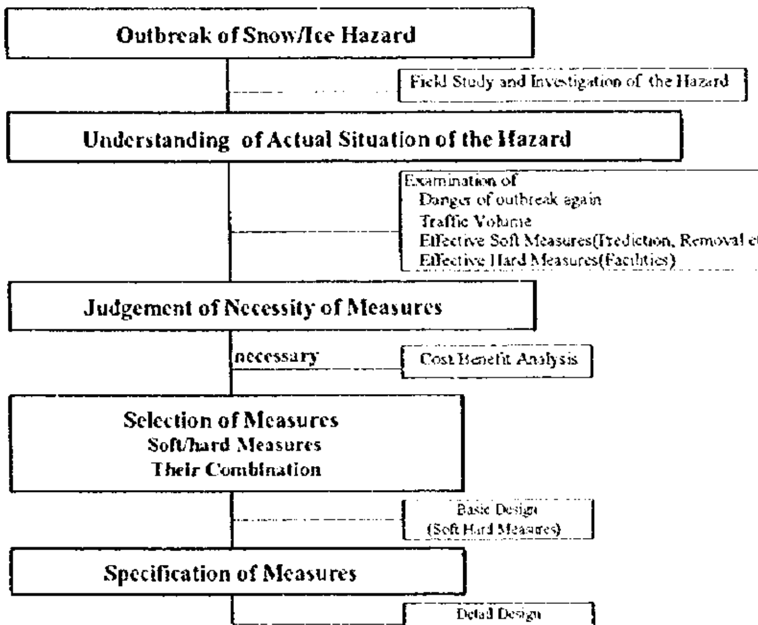


Fig.13.5.11. General Procedure to Select the Optimum Measures Against Snow and Ice Hazards

CHAPTER 14

FORMULATION OF SOCIOECONOMIC FRAMEWORK

CHAPTER 14 FORMULATION OF SOCIO-ECONOMIC FRAMEWORK

14.1 Introduction

The main features of the socio-economic situation in Turkey have been introduced in Section Two, 'General Appreciation of Turkey'- namely, population, population density, economic growth, national development plans and foreign trade. Also, an overview of the transport sector has been given in Section 2.3, and similarly for Highways in Section 2.4.

This section elaborates the socio-economic situation as introduced in Section Two, and provides background for the modeling of traffic demand which is reported upon in the next section. The key years for forecasting transport demand are 2005 and 2015.

Socio-economic inputs for the traffic models are:-

- population
- economic growth
- vehicle ownership

These inputs have applied to provinces.

Critical to road development in Turkey is the rate of growth in the economy of Turkey. This section elaborates on what the potential might be.

14.2 Population Growth

Population growth is an important variable in Turkey creating a dynamic situation that impacts upon many aspects of the economy and the transportation system, because:-

- population growth has been relatively high (2.2% per annum), much faster than Europe, and only a little lower than many developing countries. It is now reducing.

- there is considerable internal migration of population from rural areas to urban areas, making for a rapid growth in key cities such as Istanbul, Ankara etc., and also a rapid growth in non-agricultural activities

- the population shift means that different provinces are growing at quite considerably different rates across a very large geographical area, with some provinces declining in population, for example, Tunceli at -2.4% per annum, whilst others grow rapidly, for example, Antalya at 4.8% per annum.

The population situation affects transportation in that:

- internal migration is creating large urban population centres such as Istanbul, Ankara, Bursa etc., which then represent substantial centres of demand for a whole range of products, including agricultural products

• the internal migration (generally from east to west) creates a considerable personal demand for people to visit their ancestral home areas from their newly found homes, and indeed vice versa

The overall population growth by Census Years has been shown in Table 2.2.1 The growth in the urban population is illustrated in Fig. 14.2.1 below.

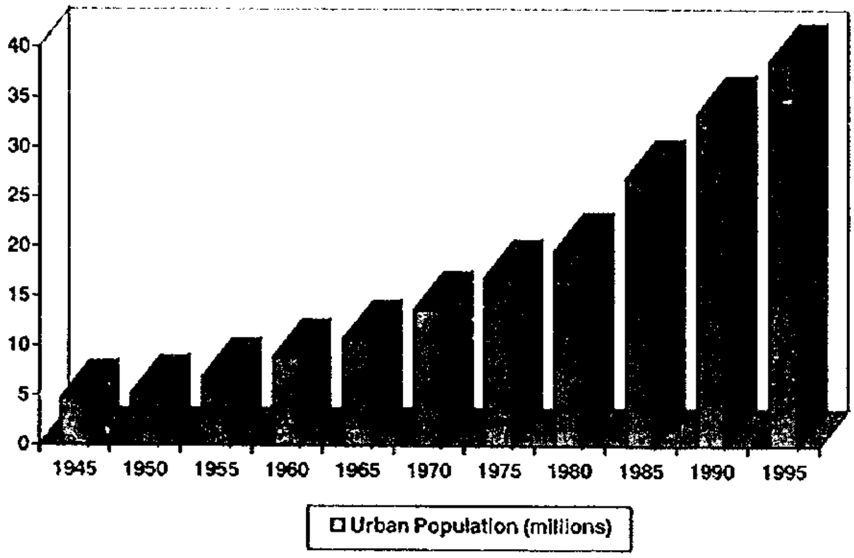


Fig. 14.2.1 Growth in Urban Population

The exceptionally rapid growth in the urban population of Turkey (4.4% per annum between 1985 and 1990 but ameliorating in future) will profoundly impact upon the general demand for transport putting a considerable focus upon:-

- provision of urban roads and grade separations
- road traffic management in urban areas
- car parking issues
- public transport and mass transit systems in urban areas
- interurban roads and their capacity

Whilst average urban growth is at 4-5%, some of the major cities are growing at a faster rate. For example, Istanbul is estimated to be growing at some 6-7% per annum.
Not surprisingly, this puts a considerable strain upon urban infrastructure and the provision of urban services. The balance between urban and rural population continues to undergo a profound shift turning Turkey into a highly urbanised country within the next few decades. The shift to an urban population is illustrated in Fig. 14.2.2.

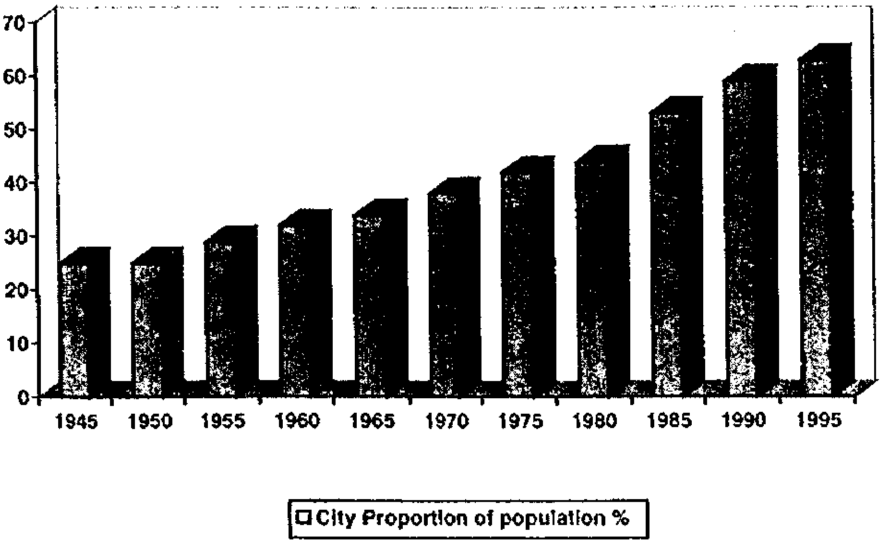


Fig. 14.2.2 The Urban Proportion of The Population

Population projections vary but an accepted Fig. within the Seventh National Plan is that future population growth will average 1.6% per annum through the next few years. It is expected it will come down further after that, so we have assumed a growth of 1.0% from 2005 to 2015. Even so, this will mean that Turkey has a population of nearly 80 million by the end of the study period (nearly the current size of unified Germany). Very early results from the 1997 Census suggest that the population growth has decreased at an even faster rate than expected (1.4% per annum) and that total population is around 62.5 million.but these Fig. need to be confirmed..

The urban population will continue to grow. Already, it is more than 60% of the population, and it looks likely to be around 80% by the end of the study period. These shifts towards urbanisation, and indeed industrialisation, will profoundly affect the way in which Turkey is perceived.

Table 14.2.1 Population Projections

	1990 Census	**1997 Estimate**	**2005 Projection**	**2015 Projection**
Total Population (1.6% per annum growth to 2005, followed by 1.0% to 2015)	56.5 million	63.7 million	72.3 million	79.9 million
Urban Population (3.0% per annum growth to 2005, followed by 2.0% to 2015)	33.3 million	41.0 million	51.9 million	63.3 million
Urban Proportion	59%	64%	72%	79%

14.3 Economic Growth

14.3.1 The Economic Background

Turkey with a land area of approximately 780000 square kilometres, a population of 64 million, located in a highly strategic economic location at the junction of Europe, Middle East and Central Asia, is expected to continue to enjoy a rapid rate of economic growth in the longer term. With the collapse of the Soviet Union, Turkey gained a new potential as the southern gateway to the countries around the Black Sea and the Turkic Republics of Central Asia.

Until the 1980s, industrialisation and development policies in Turkey were focused upon import substitution, protective barriers for imports, negative real interest rates and an overvalued Turkish Lira. International competitiveness was lacking. Despite these restrictions economic performance was reasonably good in the early 1970s. But the oil shocks of the 1970s exacerbated the problems for the economy and economic performance was poor by the end of the decade.

To turnaround the situation, radical economic policies (radical for Turkey) were introduced in the 1980s, many associated with the then Prime Minister, Turgut Ozal. These market-oriented policies were successful in improving the international competitiveness of the economy, and as a result the volume of international trade increased substantially.

In general in the 1980s, Turkey's development concept underwent a profound shift towards a liberalisation of the economy and an encouragement of private sector entrepreneurship. As a result the performance through the 1990s has been relatively dynamic as can be seen in the main economic indicators reproduced in Tables 14.3.1 & 14.3.2 However, the performance has been characterised by a high degree of volatility in many of the macroeconomic measures, such as:-

- gross fixed capital investment growth
- consumer prices
- interest rates
- foreign exchange rates

Consistency has been achieved in those measures where it has not been wanted, notably public sector financing deficits.

Notwithstanding these problems, the internal dynamics of the Turkish economy, along with its prominent location as an anchor between east and west, allow Turkey to occupy an unique place among the countries with high growth potential in the global economic environment. Not that the geographical location is always advantageous. For example, the Turkish economy has been badly hurt by the Gulf War and by the ongoing economic sanctions on Iraq. Estimates vary as to the losses but all agree it is in the billions of US$. A normalisation of economic relationships would be greatly to the benefit of the Turkish economy.

Table 14.3.1 Main Economic Indicators-1

	Unit	1991	1992	1993	1994	1995	1996
Population (mid-year)	1000 people	57,305	58,401	59,491	60,576	61,644	62,697
Growth							
GNP Growth (at 1987 prices)	%	8.5	6.4	8.1	-6.1	8.1	7.4
Agriculture		-1.2	4.3	-1.3	-0.7	2.6	5.2
Industry		2.7	5.9	8.2	-5.7	12.1	7.1
Services		-0.1	6.5	9.5	-4.0	6.4	8.8
GNP Per Capita	USD	2,655	2,708	3,056	2,184	2,795	2,950
Expenditure	%						
Gross Fixed Capital Investment Growth (at 1987 prices) [1]	%	1.2	4.3	24.9	-15.9	8.3	17.6
Public		1.8	4.3	3.4	-34.8	-16.9	17.3
Private		0.9	4.3	35.0	-9.1	14.9	17.7
Final Consumption Growth (at 1987 prices) [1]							
Public		4.5	3.8	5.4	-3.5	6.7	4.8
Private		1.9	3.3	8.4	-5.4	7.6	11.1
Unemployment Rate [2]	%						
General		8.4	8.0	8.0	7.9	6.6	5.8
Public Sector Balance / GNP	%						
Public Sector Deficit		10.2	10.6	12.2	8.1	6.5	8.9
Consolidated Budget	TL 000bn.						
Revenue		97	174	351	753	1,404	2.738
Expenditure		130	222	485	899	1,721	3,955
Deficit		34	47	134	146	317	1,217
Outstanding Domestic Debt	TL 000bn.						
Government Bonds		33	86	190	239	512	1,250
Treasury Bills		18	42	65	304	631	1,528
Government Debt Securities		52	129	254	544	1,143	2,778
CB Advances		16	31	70	122	192	371
Parity Difference		32	35	32	133	26	40
Total		99	195	357	799	1,361	3,149

Source :
SPO,CB,SIS,UT
(1).As of the first half of 1996
(2).October 1996

Table 14.3.2 Main Economic Indicators-II

	Unit	1991	1992	1993	1994	1995	1996
Inflation	%						
Consumer Prices(year-on-year)		71.1	66.0	71.1	125.5	78.9	79.8
Interest Rates (simple annual)	%						
G-Bonds		72.1	75.4	86.3	117.0	106.2	126.7
Treasury Bills (3 month)		68.4	74.4	69.8	101.3	95.0	109.2
Foreign Exchange Rates (% change of average exchange rate)	%						
USD		59.9	64.7	59.7	170.6	54.0	77.8
Foreign Trade	USD Billion						
Export		14	15	15	18	22	23
Import		21	23	29	23	36	42
Trade Deficit		7	8	14	5	14	19
Balance of Payments	USD Billion						
Foreign Trade Balance		-7.3	-8.2	-14.2	-4.2	-13.2	-18.5
Invisible Balance		7.6	7.3	7.8	6.8	10.9	14.1
Current Account Balance		0.3	-0.9	-6.4	2.6	-2.3	-4.4
International Reserves	USD Billion						
Total		12	15	18	17	24	25.1
Outstanding External Debt	USD Billion						
Total		50	56	67	66	73	59

Source :
SPO,CB,SIS,UT

14.3.2 Gross National Product (GNP)

In the 1980s, the Turkish economy really started to take off. GNP growth began to approach the sort of levels achieved by some of the East Asian 'Tiger' economies, certainly faster than the main European economies. The only noticeable setback was in 1994. The rate of growth of GNP is illustrated in Fig. 2.2.3 & 2.2.4.

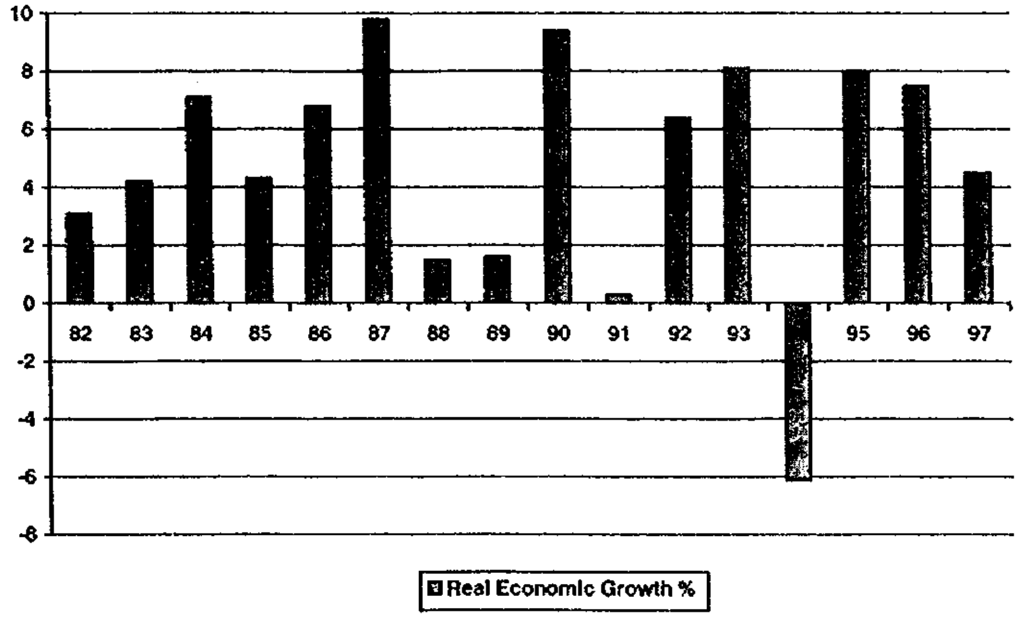


Fig. 14.3.1 Real Growth in GNP

Above in Fig. 14.3, the year on year economic growth is illustrated - a dynamic picture but with exceptional volatility.

The 1988 and 1989 slowdown in growth was brought about by contractionary economic policies (fast upward adjustments in public sector prices and raised interest rates) following the expansionary policies of 1987.

The 1991 recession resulted from the Gulf Crisis which decreased the exports to the region and raised uncertainties as to the economic prospects. As already mentioned, the aftermath of the Gulf War still haunts the Turkish economy preventing it realising its full potential and leaving it hampered in dealing with its own internal problems in the South East.

The 1994 financial crisis arose from a mismanagement of the domestic debt market. Following years of fiscal laxity and high inflation, the April 1994 stabilisation programme nearly halved the public sector borrowing requirement (PSBR) to 8% of GDP, greatly reduced domestic demand and brought the current external account into surplus. However GNP declined by some 6.1%.

The Turkish GNP for 1996 is shown in Table 14.3.3

Table 14.3.3 Gross National Product - 1996

SECTOR	REAL GROWTH RATE (%)	1996 VALUE (BILLION TL)
AGRICULTURE	5.2	2,545,288
INDUSTRY Mining Manufacturing Energy	7.1 2.3 7.1 9.7	3,716,528 183,080 3,123,034 410,414
CONSTRUCTION	4.8	850,060
COMMERCE	8.7	3,025,416
TRANSPORTATION/COMMUNICATION	8.4	1,928,852
FINANCIAL INSTITUTIONS	2.4	668,544
OWNERSHIP OF DWELLING	2.4	442,903
BUSINESS AND PERSONAL SERVICES	6.8	553,611
(-) IMPLICIT BANK SERVICE CHARGES	1.1	600,837
GOVERNMENT SERVICES	-0.3	1,238,527
PRIVATE NON-PROFIT INSTITUTIONS	0.9	26,922
IMPORT DUTIES	22.9	458,588
---------------------------- GROSS DOMESTIC PRODUCT (In Purchaser's Prices)	7.2	14,854,405
NET FACTOR INCOMES FROM ABROAD		270,687
---------------------------- GROSS NATIONAL PRODUCT	7.9	15,125,092

(1) Current Prices
SOURCE : State Institute of Statistics (SIS)

The origin of GNP is shown in Table14.3.4 Again there is some volatility in the contribution from the different sectors, because each sector is forced to react to the, sometimes quite strong, economic measures that are adopted from time to time to try to bring the economy into balance.

Table 14.3.4 GNP by Origin (in 1987 Prices, %)

	1994 SHARE	1995 SHARE	1996 SHARE
AGRICULTURE	15.7	14.9	14.4
INDUSTRY	27.0	28.0	27.8
Mining	1.8	1.5	1.5
Manufacturing	22.3	23.5	23.4
Energy	2.9	2.9	3.0
SERVICES	50.2	49.3	48.9
Construction	6.7	5.9	5.7
Trade	20.1	20.8	20.9
Trans.&Comm.	12.9	12.6	12.7
Financial Institutions	2.6	2.4	2.3
Imp.Inc.on Residences	5.6	5.3	5.0
Business &Pers.Serv.	2.3	2.3	2.2
Gross Domestic Product	99.6	98.9	98.2
Gross National Product	100.0	100.0	100.0
Source :State Institute of Statistics			

14.3.3 Agricultural, Industrial and Commercial Growth

Agricultural Output

Agricultural output continues to grow quickly (7/8%) but its economic contribution to GDP continues to reduce in significance (14%) as other sectors gain in size. Products produced in large tonnages (Fig. in millions of tonnes for 1996) include:-

- Wheat (18.5 m), Barley (8 m) and Maize (2 m)
- Sugar Beet (14.5 m)
- Milk (10.6 m - 1995)
- Potatoes (4.8 m) and Onions (1.9 m)
- Grapes (3.6 m) and Apples (2.1 m)
- Timber (2.9 m - 1994) and Firewood (3.4 m - 1994)
- Raw Cotton (2.2 m - 1995)
- Olives (1.5 m)

Agriculture operates under a system of support prices. It is also excluded from the Customs Union with the EU. The large agricultural project in the South East, known as the GAP project, should help to realise the substantial agricultural potential in the Sanliurfa & Diyabalir area through the irrigation from the dams. Of course, surplus agricultural produce will create a considerable demand for transport in the South East.

Agricultural output for different products and commodities is shown in Table 14.3.5

Land Use is along the following lines:-

Area sown	18.5 million ha (i.e 185000 sq km out of 780000 - increasing)
Area Fallow	5.1 million ha (falling)
Vegetable Gardens	0.8 million ha (increasing)
Vineyards	0.6 million ha (falling)
Orchards	1.3 million ha (static)
Olive Groves	0.6 million ha (static)
Forests	20.2 million ha (static)

Industrial output

Industrial output now contributes 28% of GNP, making Turkey an important industrial economy, contrary to a widespread perception which still sees Turkey as a predominantly agricultural economy. The fastest growing major subsectors have been textiles, iron and steel, glass, food, chemicals, durable consumer goods and automobile production.

Large industrial tonnages (Fig. in million tonnes for 1996) emanate from:-

Lignite (52.5 m) and Hard Coal (2.4 m)
Cement (35.2 m)
Steel Ingots (13.4 m) and Crude Iron (5.3 m)
Fuel Oil (7.4 m), Gas Oil (7.5 m), Gasoline (3.4 m) and Naphtha (1.6 m)
Crude Oil (3.5 m)

Industrial output of selected products is shown in Table 14.3.6 Industrial products create a considerable demand for road transport. Some products in some instances have their own modes of transport, for example oil pipelines, whilst others are more suitable to rail transport where this exists, notably products of high volume or weight but low value e.g. coal.

Commercial Output

Services now contribute nearly half of GNP. The fastest growing service subsectors have been construction, commerce, tourism, transportation, communications and finance.

Tourism has grown into a very major industry in Turkey, generating a significant transport demand.

Table 14.3.5 – Output of Agricultural Commodities (000m.tons)

	1992	1993	1994	1995	1996(2)
CEREALS					
Wheat	19300	21000	17500	18000	18500
Barley	6900	7500	7000	7500	8000
Rye	230	235	195	240	236
Oats	240	245	230	250	275
Maize	2225	2500	1850	1900	2000
Rice	129	135	120	150	174
Other	47	44	39	44	36
PULSES					
For Food	1644	1746	1498	1675	1642
For Fodder	178	200	81	174	165
FRUIT AND NUTS					
Grapes	3450	3700	3450	3550	3550
Fig. (fresh)	250	270	279	300	235
Apples	2100	2080	2095	2100	2100
Peaches	370	370	375	340	340
Oranges	820	840	920	842	920
Other	2441	2390	2656	2461	2446
Hazelnuts	520	305	490	455	450
Pistachio nuts	29	50	40	36	50
Other unshelled nuts	252	243	243	224	223
MISCELLANEOUS PROD.					
Sugar Beets	15126	15621	12944	11171	14455
Potatoes	4600	4650	4350	4750	4750
Onions	1700	1650	1800	2850	1900
OIL SEEDS					
Sunflower	950	815	740	900	790
Sesame	34	30	34	30	28
Peanut	67	70	70	70	80
Soybean	95	63	70	75	50
Olive	750	550	1400	515	1500
TOBACCO,TEA, etc.					
Tobacco	334	339	187	204	230
Tea (Leaves)	724	579	654	523	604
Poppy pods (tons)	6	3	12	25	5
TEXTILE RAW MAT.					
Mohair, fleece, hair	64	61	58	55	(3)
Cotton (Raw)	1536	1561	1620	2224	(3)
Silk cocoons	1	1	0.4	0.2	(3)
HIDES(thousands)					
Cattle	2327	2346	2527	2037	(3)
Sheep and goat	9300	8547	9331	6903	(3)
LIVESTOCK(000)					
Sheep	39416	37541	35646	33791	(3)
Goats	9440	9192	8767	8397	(3)
Angora goats	1014	941	797	714	(3)
Cattle	11951	11910	11901	11789	(3)
Water Buffalo	352	316	305	255	(3)
Poultry	158770	184460	190033	135251	(3)
Silk worms(egg box)	27732	25884	17953	9702	(3)
ANIMAL FOOD PRODUCTS					
Meat	449	432	466	415	(3)
Milk	10279	10406	10561	10602	(3)
Eggs(millions)	8215	10006	9845	10269	(3)
Honey	60	59	55	69	(3)
Marine Products	454	556	601	649	(3)
FORESTRY PROD. (th.m3)					
Timber	3064	3177	2939(1)	(3)	(3)
Fire Wood	4600	4305	3351(1)	(3)	(3)

Source :State Institute of Statistics (1)Provisional (2)Estimate (3)Not Available

Table 14.3.6 Production of Major Industrial Commodities

	Unit	1993	1994	1995	1996(2)
MINING					
Hard Coal	(1000 tons)	2,722	2,839	2,248	2,424
Lignite	(1000 tons)	45,957	48,838	51,945	52,503
Crude Oil	(1000 tons)	3,892	3,686	3,514	3,499
MANUFACTURING					
Cotton yarn	(tons)	43,744	35,066	32,305	26,019
Wool yarn	(tons)	5,425	4,784	3,360	3,671
Filtered cigarette	(tons)	69,803	77,938	75,382	70,736
Raki & Beer	(mill lts.)	620	666	740	763
Newsprint	(1000 tons)	94	110	138	74
Craft paper	(1000 tons)	72	78	74	57
Sulfuric acid	(1000 tons)	757	730	630	623
Polyethlene	(tons)	270,772	282,964	301,087	299,457
PVC	(tons)	159,294	156,942	181,036	202,562
LPG	(1000 tons)	707	733	792	826
Naphtha	(1000 tons)	1,249	1,266	1,473	1,609
Gasoline	(1000 tons)	3,215	3,339	3,554	3,373
Gas oil	(1000 tons)	7,252	7,399	7,983	7,485
Fuel oil	(1000 tons)	8,701	7,588	7,786	7,408
Bottles & Glass artic	(1000 tons)	437	440	506	603
Crude iron	(1000 tons)	4,355	4,604	4,363	5,263
Steel ingot	(1000 tons)	11,519	12,179	12,798	13,382
Blistered copper	(tons)	33,453	30,437	24,416	30,341
Alumina	(tons)	141,550	155,299	171,978	159,298
Cement	(1000 tons)	31,311	29,493	33,153	35,214
Tractor	(No.)	33,294	24,249	38,295	45,656
Automobile	(No.)	343,481	208,531	222,145	196,176
Truck	(No.)	29,739	11,235	19,172	29,516
Bus and Minibus	(No.)	21,585	8,791	12,424	18,612
PRODUCTION					
Refrigator	(No.)	1,253,791	1,258,353	1,662,835	1,655,956
Washing machine	(No.)	979,717	780,015	865,927	1,051,499
Cooker (LPG)	(No.)	629,778	448,613	511,229	595,898
Vacuum cleaner,electric	(No.)	715,351	436,750	878,928	1,055,344
Sewing machine	(No.)	170,349	119,145	150,980	143,973
Television set (color)	(No.)	1,921,704	1,528,255	1,859,333	2,509,712
Video	(No.)	17,141	8,148	2,769	3,985
Hi-Fi Music system	(No.)	87,416	90,450	95,996	94,095
ENERGY					
Electric power	(Mil.Kwh)	73,734	78,261	86,291	95,373
Source :State Institute of Statistics					

14.3.4 Foreign Trade

Exports increased from less than US$ 3 billion in 1980 to US$ 23 billion in 1996. Industrial products represented 87% of the total, with leading items being textiles, iron and steel, food, ceramics/glass, machinery and chemical industry products.

Imports increased from nearly US$ 8 billion in 1980 to US$ 42 billion in 1996. More than 50% of imports came from the EU, notably Germany. Raw materials are particularly important imports, notably oil.

The trade deficit is largely made good by invisible earnings notably from tourism (nearly US$ 6 billion in 1996), which has been one of the extraordinary success stories of Turkey, and contractor services. This growth in the tourism sector has generated a significant transportation and construction demand.

Capital flows were liberalised in the late 1980s. This has resulted in a substantial inflow of capital and portfolio investment. Turkey has a substantial external debt (US$ 80 billion) but its hitherto reliable foreign exchange earnings indicate that forex shortage is not likely to be a constraint in the near future.

14.3.5 The European Union Framework

There is some scepticism about the prospects for Turkey's entry into the European Union. Also, as in most aspects of economic management in Turkey, there is some controversy about the value to Turkey of the customs union with the European Union even though it does show Turkey's commitment to realising full integration with the EU.

It has been a blow to Turkey's hopes of full integration that the EU's blueprint for the enlargement of the Union (Agenda 2000 - a recommendation) envisaged the first wave of new members in 2000-2002 as including Poland, Hungary, the Czech Republic, Slovenia and Estonia, as well as Cyprus but not Turkey. A second wave could follow a few years after and this might include Bulgaria, Rumania, Slovakia, Latvia and Lithuania but there is no mention of Turkey. The desire of Turkey to join the Union is still impeded by the EU's views on Turkey's macroeconomic problems (high inflation, public finance deficiencies) and its stance on human rights. EU membership for Turkey looks unlikely to occur until well into our study period, say 2005-2015, and indeed may occur beyond this period.

Customs Union

In the meantime a strengthened Customs Union will continue. This Customs Union, which commenced in January 1996 reduced the duties for bringing in European industrial goods to Turkey and removed export incentives for Turkish manufacturers. In effect protection in the Turkish market was reduced.

Turkey agreed to take action to:

- eliminate all customs duties and quantitative restrictions on trade in industrial commodities with the EU on 1/1/96

- introduce the common EU customs tariff rates against third countries and adopt all preferential agreements the EU has concluded with third countries by the year 2001

- ensure adequate and effective protection and enforcement of intellectual, industrial and commercial property rights

- adopt the EU competition rules, including measures regarding public aid, within two years (although aid given for structural adjustment purposes will be permitted for another five years)

EU customs union will also require harmonisation of Turkish laws and procedures in related areas including quantitative restrictions, anti-dumping rules, rules of origin, patents and licences. The agreement notably excludes trade in agriculture as well as trade in services. government procurement and the movement of capital and labour.

In 1994 nominal protection rates (NPR) (import weighted) with the EU were 10.2% and are expected to fall to 1.3% once the customs union is fully in place. The economy wide effective protection rate is estimated to drop from some 18.4% in 1994 to 1% in 2001.

Customs Union with the EU is seen as potentially the biggest positive supply side shock to hit the economy since the early 1980s. The effects of trade liberalisation are likely to come from:

- more efficient use of resources along the lines of comparative advantage
- economies of scale, as international specialisation is further extended
- real income gains for consumers as trade barriers are reduced

The OECD estimates those subsectors which will have to adjust as their EPRs come down in the new regime of the Customs Union will include:-

- textiles and clothing
- petroleum refining
- footwear
- motor vehicles
- non-metallic mineral products
- glass and glass products
- paper and paper products
- leather and fur products

Turkish Businessmen take the view that the Customs Union will help with international competitiveness as shown in a recent survey

14.3.6 Immediate Economic Prospects

The immediate economic prospects are coloured by the uncertainties that inevitably surround a coalition Government (three parties with differing views) and the probability of a new election in 1998. The 55th Government, compared with the 54th, has seen a shift in emphasis in macroeconomic management with a greater reliance on increases in petrol prices, on domestic borrowing which may push up interest rates, and on possible tax increases. Inflation continues as a major worry for most of the population.

However, in the short term the new fiscal and monetary policies of the 55th Government are seen as expansionary (for example, upward revision in public investment). The new Government revised the GNP growth target to 5.5-6.0% for 1997, and this looks likely to be achieved.

14.3.7 Economic Growth Potential

The above survey vividly illustrated the problems of uncertainty and inflation in the short term. In the longer term the worries concern inflation, unemployment, public expenditure ,income distribution and education & health.

The principal difficulties faced by the Turkish economy are persistent large fiscal deficits and persistently high inflation. Both these difficulties are considered to have their root cause in the slow pace of public sector reform. So, structural reform is at the heart of maintaining rapid rates of economic growth and thus economic prosperity within the country. The Customs Union with the EU is one factor that will help accelerate structural reform by strengthening competitive forces in the economy and by modernising Turkey's legal framework. A second factor is the Seventh Five Year Plan. The plan aims for GDP growth at 5.0-6.6% per annum, and GDP per capita growth between 3.5-5.0 percent per year. PSBR would be reduced to 3.0% by the Year 2000. Tighter monetary policy and structural reform would bring inflation down to single digits by the Year 2000.

Public Finance

Improving the fiscal picture on the revenue side involves widening the tax base and improving tax collection notably in the presently unregistered economy. The latest tax reforms, namely, reducing income tax for the lowest paid (25% to 15%), reducing corporate tax and reducing VAT over the next three years, allied with administrative improvements to bring about tax collection plus new taxes on stocks, bonds etc. should start to improve tax revenues.

The previous Government had targeted a significant level of Government revenue from privatisations and from sale of public real estate, but this has been pared down by the new Government.

On the other hand, public expenditure has to be brought under control, firstly, by tackling the problems of the State Economic Enterprises (SEEs) including agricultural support, secondly, by making reforms to some of the social provisions and, thirdly, by trying to reduce the heavy debt-service burden (10% of GDP).

Inevitably, tackling the vested interests that exist in many of the SEEs is difficult under coalition Governments without strong majorities and mandates. However, privatising such enterprises, or restructuring them, to eliminate both losses and cross-subsidies continues to be essential.

Reform of some of the social provisions has centred upon the retirement system, and the general issue of trying to bring contributions and benefits into line.

In the past the Government's domestic debt-service burden has been greatly reduced by rampant inflation. But the Turkish public now demand high yields plus a risk premium for holding Government securities. Also the Government has been forced to finance its PSBR with very short-term paper (e.g. 3 months) and high interest rates. Clearly, there needs to be a restoration of credibility as well as longer term financing. The Government has had to introduce 'inflation-indexed' Government Bonds (March 1997). It is hoped that this will reduce the 'uncertainty premium' which high and variable inflation was forcing potential 'bond purchasers' to demand.

14.4 Socio-economic Conditions and Roads

14.4.1 General

In the study period through to 2015, it is likely that the perception of Turkey as a primarily agricultural and rural country will change, as it is realised that Turkey, far from being rural, will by then be a highly urbanised and industrialised country, albeit a geographically large country akin to France and Spain but with a population akin to unified Germany.

Despite future rapid economic growth, Turkey will still not have a socio-economic framework akin to Europe, but nonetheless there will be a substantial proportion of the population enjoying a European standard of living. The urbanised and industrial nature of the country will mean that the main road network will be highly trafficked. Road capacity (in terms of number of lanes/motorways) is likely to have to increase substantially even though the basic route network will remain substantially unchanged.
Also it will mean that the urban road network will have to be substantially uprated.

14.4.2 Per Capita GDP

Without doubt economic prosperity is the key to future road development. Turkey is an extraordinary economy. Despite the political turbulence, inflation at more than 90%, and many other problems such as internal migration from rural to urban areas, the economy still goes forward at a rapid rate. Whilst the nominal GDP per capita is less than US$ 3000, when one translates these GDP per capita figures into Purchasing Power Parity (PPP) then Turkey's performance looks much better. Turkey's GDP per capita in PPP is around US$ 5000. (See Fig 14.4.1).

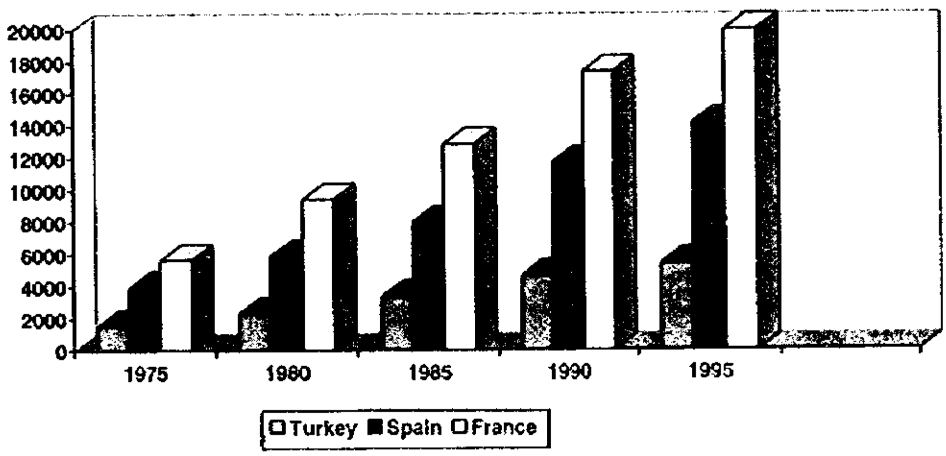


Fig. 14.4.1 Per Capita GDP US$

By Year 2015 it is perfectly possible for Turkey to exceed a GDP per capita (in PPP) of US$ 10000 i.e. a growth rate of around 3.5% per annum. Indeed Turkey could easily do better but it is perhaps better to be cautious because the problems facing the economy are still large. This would mean that Turkey is not as prosperous as Portugal is now, and there is still a wide gap with most of Europe, including Spain and France. Nonetheless it provides a sound basis for a substantial growth in vehicle numbers and in the demand for road capacity.

Table 14.4.1 Per Capita GDP Projection (PPP) - Turkey

	1990 Actual	1995 Actual	2005 Projection	2015 Projection
Turkey GDP per capita US$ PPP	4660	5411	7601	10678

14.4.3 Vehicle Growth

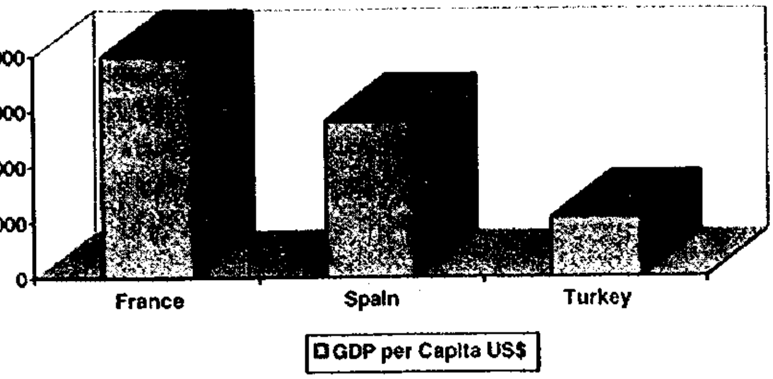
Even under these modest forecasts for GDP per capita in Turkey, it is likely that the vehicle park will increase substantially. Mostly this increase will occur with private cars. Private cars impact most substantially upon the urban areas rather than the main road network. A better guide to the requirement for main road capacity is the growth in trucks.

We have assumed an income elasticity factor of about 2.0 for growth in vehicles, in effect a growth rate of 3.5% in GDP per capita translates into a growth rate 7.0% per annum in total vehicles. This is lower than the growth rate over the last 15 years which has been about 9.0% per annum.

Table 14.4.2 Projections of The Vehicle Park in Turkey

	1990 Actual	1995 Actual	2005 Projection	2015 Projection
Cars (average growth at 8.2% per annum)	1650000	3059000	6711000	14723000
Minibus (average growth at 5.3% per annum)	125000	173000	290000	487000
Bus (average growth at 5.9% per annum)	64000	90000	160000	283000
Small Truck(average growth at 5.1% per annum)	263000	398000	656000	1080000
Truck(average growth at 3.5% per annum)	257000	321000	451000	634000
Total(average growth at 7.1% per annum)	2359000	4041000	8267000	17206000

Forecasts of the vehicle park illustrate the challenges which are going to have be faced by the Turkish authorities in providing infrastructure and in managing the traffic. Of course, these challenges have already had to be faced by other countries such as Spain and France as shown in Fig 14.4.2



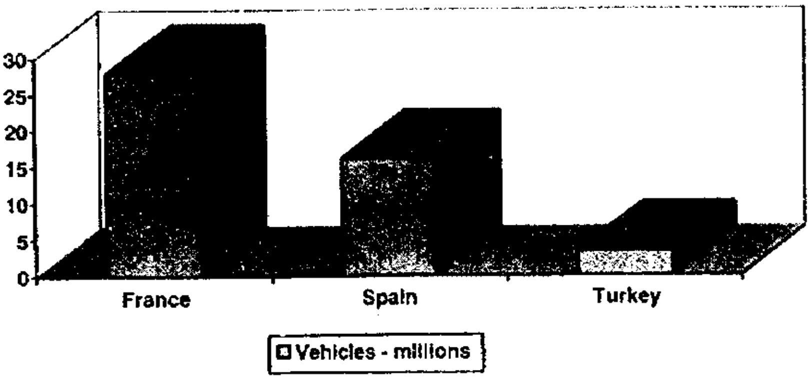


Fig. 14.4.2 GDP Per Capita and Vehicle Park in France, Spain & Turkey

14.4.4 Road Capacity

For Turkey the best guides, as far as road development is concerned, are Spain and France. They are good guides for Turkey because they are similarly large countries, populations are similar and both have a large agricultural and rural economic base. Comparisons with Britain and Germany are difficult because these two countries are very highly urbanised and industrialised. Another country with similarities with Turkey is Ukraine.

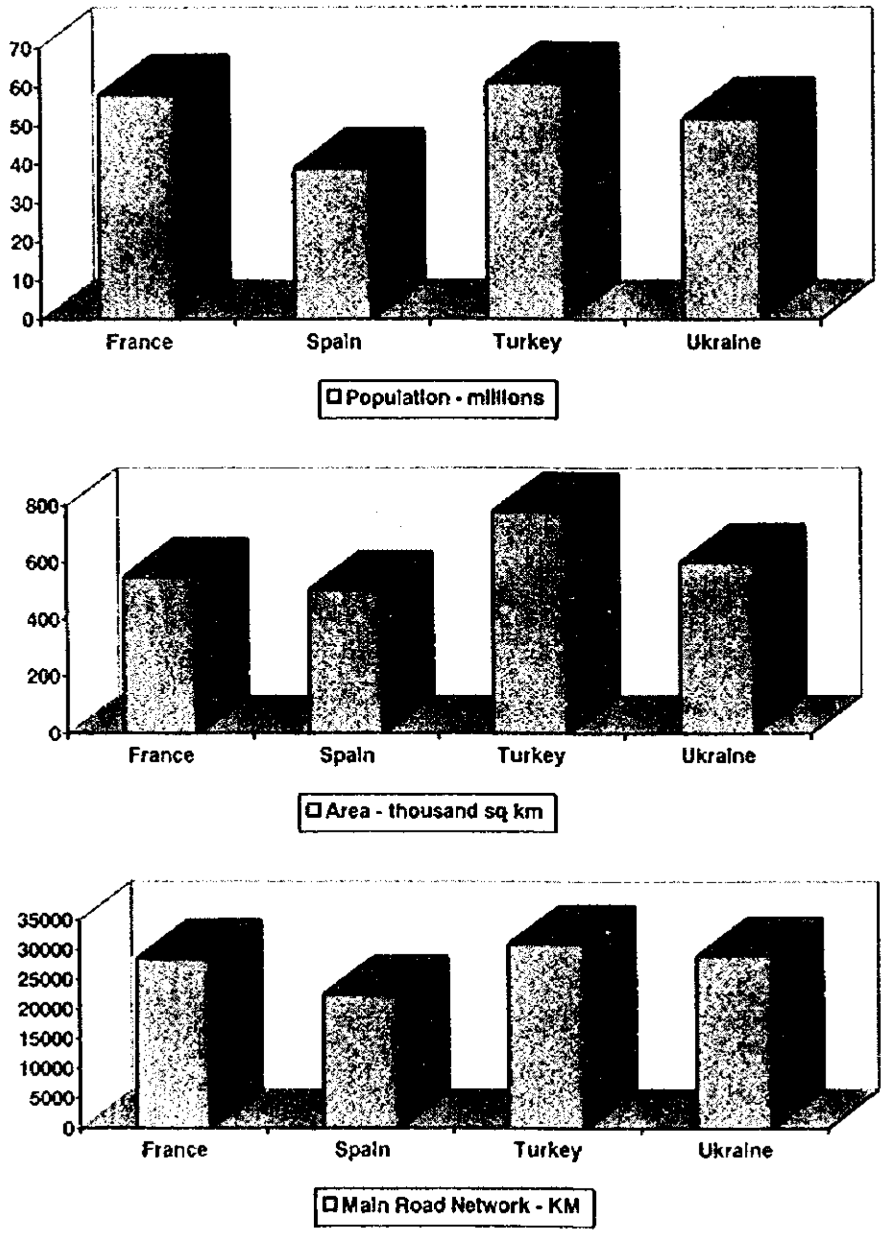


Fig. 14.4.3 Main Road Networks in France, Spain, Turkey & Ukraine

Fig. 14.4.3 illustrates the similarities between France, Spain, Turkey and Ukraine.

In looking forward to the Years 2005 and 2015, The impact on the road network in terms of new route kilometres is likely to be modest. Indeed new alignments will nearly all come from the development of motorways. However there is likely to be a strong increase in demand for road capacity. This will have to be met by a combination of motorways and dual carriageways. As a rule of thumb, dual carriageways provide triple the capacity of a single carriageway and motorways provide five times the capacity of a single carriageway road. The composition of the road network will change substantially as motorways and dual carriageways become more important. And of course this will impact very greatly upon the approach to maintenance of the road network.

An illustration of the differences in the motorway network are shown in Fig. 14.4.4

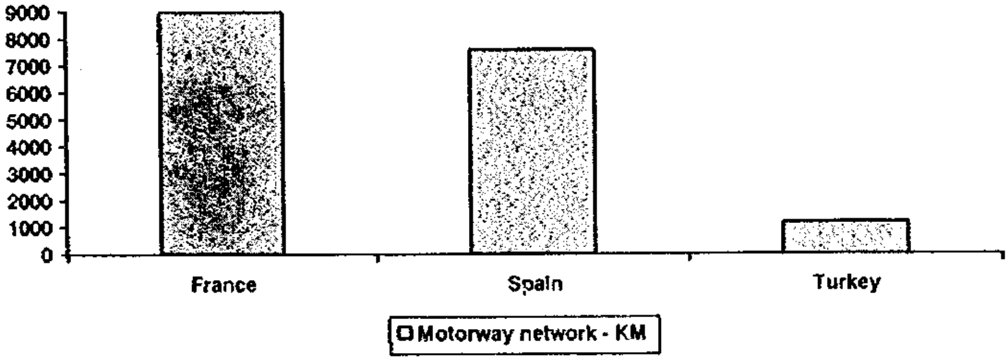


Fig. 14.4.4 Motorways in France, Spain & Turkey

Bearing in mind the economic development in the country and the expansion of the vehicle park (notably the trucks), the main road network in Turkey is likely to develop in the following manner during the JICA study period through to 2015.

Table 14.4.3 Projection of The Main Road Capacity - Turkey

Type - Kilometres	**1996**	**2015 HIGH Projection**	**2015 HIGH Projection**
Single Carriageway	28500	19500	14000
Dual Carriageway	2500	11500	17000
Motorway	1200	6000	8000
	32200	37000	39000

New construction will continue as a significant feature in Turkey because dualling will need to take place at an average between 400 & 700 new kilometres per year, and motorways will need to be constructed at the rate between 150 & 350 new kilometres per year through to 2015.

14.4.5 Road Maintenance

All this new construction will dramatically impact upon road maintenance. Firstly there will be a need for more motorway maintenance. Secondly, more dualling will usually be associated with improvement of existing carriageways and a shift away from surface treatment towards asphalt concrete. Thus, in the longer term there will be a greater emphasis upon plans for the periodic maintenance of paved surfaces -which will necessitate a Pavement Management System (PMS).