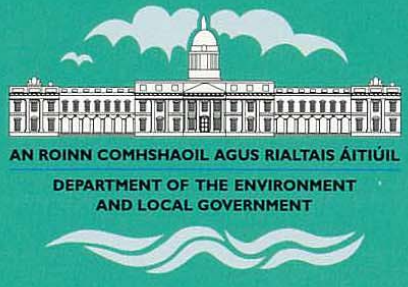
Guidelines on the Rehabilitation of Roads over Peat



AN ROINN COMHSHAOIL AGUS RIALTAIS ÁITIÚIL

DEPARTMENT OF THE ENVIRONMENT AND LOCAL GOVERNMENT

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Acknowledgements

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1. Introduction

In Ireland peat bogs or other soft organic deposits cover about 17 per cent of the total land area as shown in Figure 1.1, the Peatland Map of Ireland by R.F. Hammond (1). Peat formations in Ireland can be divided into three main groups:

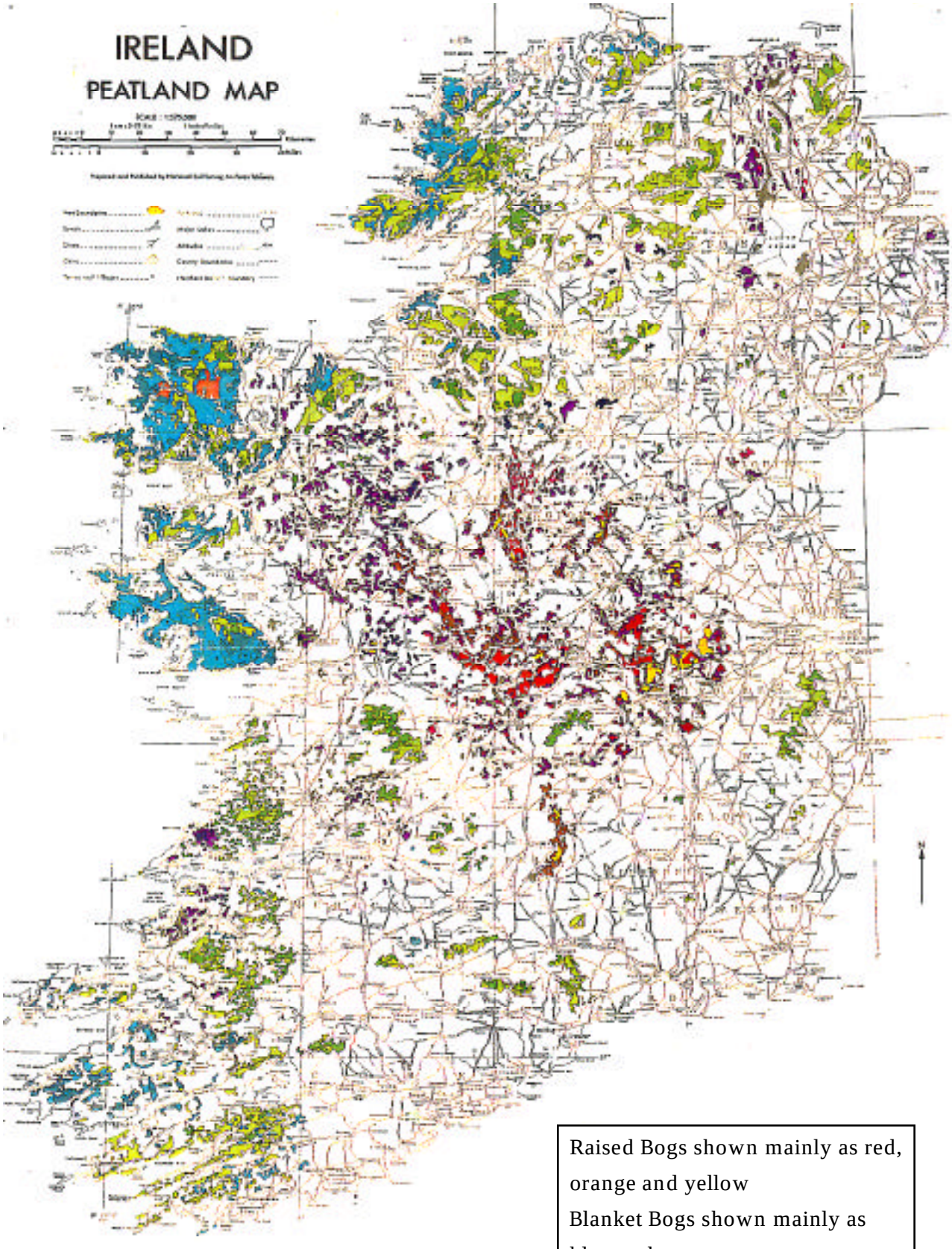
(1) The raised bogs of the Central Plain;
(2) Blanket bogs of the Western seaboard and upland regions, and
(3) Fen peats.

More detailed information on the occurrence of peats can be obtained from the county series of the National Soil Survey of Ireland, available from Teagasc.

The present road network in Ireland had its origins in the 18th and 19th century. A comparison of the road network shown in Ordnance Survey maps of the late 19th century and that of modern times shows that in the past 100 years there has been little change in road alignments in the case of the non-National roads.

Since the 1980's road improvement programmes aimed mainly at our major strategic routes, notably the National Primary Routes, have produced new long- life road pavements which will make minimal demands on maintenance. However, in the case of other routes and particularly the non-National roads element which constitutes about 94 per cent of the total road network very little realignment has taken place over the last 25 years. The strengthening and maintenance of these roads, in particular those sections with peat subgrades, poses a major challenge to Road Authorities in view of the ever increasing traffic volumes and axle loads which these roads must carry.

Fig 1.1



Raised Bogs shown mainly as red, orange and yellow
Blanket Bogs shown mainly as blue and green

2. Objective of Report

The aim of this report is to review the techniques and materials currently used in the rehabilitation of roads over peat in Ireland and to recommend the most suitable forms of rehabilitation, having regard to the importance of the roads, traffic levels, costs and the level of serviceability expected from the motoring public for the particular category of road.

This document should be read in conjunction with Guidelines on the Depth of Overlay to be used on Rural Non National Roads (2), which deals with the maintenance of roads with normal subgrades.

Many traditional maintenance techniques are no longer considered cost effective as they provide only temporary relief to the problems associated with bog roads. Hence the identification of the best techniques capable of delivering a pavement with longer intervals between maintenance treatments is considered to be a priority.

3. Methodology used in preparation of Report

The information on which this report is based was obtained by reviewing the problems associated with maintaining roads over peat, gathering and assessing information from a questionnaire circulated to Road Authorities and arranging site visits to roadworks sites where new techniques or materials were used in the rehabilitation of roads with peat foundations.

3.1 Review of problems associated with maintaining roads over peat

The difficulties associated with maintaining roads over peat arise because peat provides a poor foundation for a road pavement as it is frequently weak and highly compressible compared with normal subgrades such as boulder clay. The low strength of peat traditionally necessitated thick unbound pavement layers which were needed to attenuate the traffic stresses to a level which did not exceed the strength of the peat. Increasing the depth of the pavement layers, while successful in reducing traffic stresses on the subgrade, causes long term problems as the road surface settles because of the compressibility of the peat. Any further regulation by overlaying the pavement increases settlement and if such rehabilitation is resorted to on a regular basis the interval between treatments may become shorter.

If the roads are constructed on peat embankments, commonly described as bog ramparts, which are raised above adjoining land, the problems of maintenance are magnified. Such peat embankments are subject to volumetric changes during prolonged dry periods which leads to distortion of the road surface. Regional drainage schemes, which lower water table levels in peatlands, also contribute to road maintenance problems.

The traditional solution of overlaying the existing road with a sufficiently thin layer of material to restore a smooth riding surface, has been often adopted as it causes the least disruption to traffic. Alternative solutions, such as reducing the level of the road surface, and thus removing some of the weight on the compressible peat, is very disruptive to traffic and may necessitate road closure while the work is being carried out. In some instances high local water levels during the winter months may preclude any reduction in pavement levels because of the fear of flooding.

It is clear because of the above constraints that maintaining a high level of serviceability on roads with peat foundations is very difficult. The prospect of achieving long life cycles of the order of 20 years between treatments is unlikely for most bog roads due to the costs

involved compared to benefits. However, it is suggested that with a better understanding of all the issues involved and the utilisation of the best of the existing techniques, better and more economic solutions which will give longer pavement life can be adopted.

3.2 Questionnaire

To determine current practice in Ireland relating to the maintenance of roads over peat, a questionnaire was circulated to road authorities seeking information on the scale of the problem in the various authorities, the techniques and materials used and the costs associated with such maintenance work.

Road authorities were asked to list the different treatment options which they utilised on roads with peat foundations for the different road categories of National, Regional and Local. They were also asked to list, in each category, the most widely used treatment as Option 1, the second most widely used treatment as Option 2, and the third most widely used treatment (if any) as Option 3.

The survey results should be interpreted carefully for the following reasons:

1. Unit rates can vary greatly depending on many factors, such as the distance from a site to the nearest quarry or macadam batching plant, local competition, the amount of regulating material used and on the method and specification for the overlay treatment in the case of macadams used in association with geogrids.

2. The lifespans given for treatments of roads with peat foundations cannot be definitive due to the changing environmental impacts on such roads (water table, drainage, frost, etc.). In some cases the lifespans are of necessity predicted by the local authority and are not actual time periods.

3. In most cases local authorities apply the least cost solution to the less problematic sections of road and reserve the more expensive treatments for difficult sites.

Accordingly, it would not be appropriate to compare directly the life-spans and costs for two sites which are at different ends of the spectrum in terms of site conditions.

3.3 Site Visits

In a number of counties new techniques and materials have been used, sometimes on an experimental basis, over the past ten years, in an attempt to find longer lasting maintenance techniques to extend the life of road pavements over peat foundations. In particular the use of reinforcement techniques to strengthen pavement layers was reviewed and visits were made to sites where new techniques and materials were used over the past decade. In addition, the Working Party visited road sites in Scotland where the use of geosynthetics was pioneered about ten years ago. Meetings were arranged with highway engineers from the Highland Regional Council who took part in the original road trials and who monitored the performance of such sections of road since the resurfacing experiments. These guidelines are mainly based on Irish experience and practice but the experience of the Scottish engineers, which was considered valuable by the Working Party, was also taken into account.

4. Summary of current Practice of Maintaining Roads Over Peat

4.1 General

This summary of present practice is based mainly on the responses to the questionnaire, which was circulated to the road authorities. Information was sought on the techniques used for the various road categories and the costs of such techniques.

Replies were received from 12 road authorities and the more important findings are summarised in Appendix A. The answers to the questionnaire show that the scale of the problem of maintaining roads over peat varies considerably from one road authority to another. The results of the questionnaire show that it is a significant problem in Counties Clare, Mayo, Donegal, Kerry, Longford, Offaly, Kildare, North and West Cork and in parts of County Galway. In all of the above mentioned road authorities a significant percentage of road maintenance funds are spent on the roads with peat foundations and it is recognised that a disproportionate amount of funding has to be allocated to roads with peat foundations compared with those roads which have normal subgrades.

4.2 National Roads

The current practices used to maintain National roads with peat foundations in ten counties are summarised in Appendix A1. In most counties the treatment is to overlay the existing pavement with hot-mix bituminous material or crushed stone. The option of reinforcing the pavement by using geogrids along with a bituminous overlay was a recently preferred option in some counties which offered the prospect of longer life but at higher cost. In a small number of counties the option of excavating the peat and using granular fill was reported, but such a choice was generally made when the roadworks were part of an improvement scheme and consequently cannot be considered as a normal rehabilitation measure.

Where peat excavation was practised it was reported that the depth of peat was very influential on the unit costs which varied from £30 / m^2 to about £100 / m^2.

Due to the reconstruction programme on National Primary routes, the mileage of roads with peat foundations on such routes is now very small. In the case of National Secondary roads the mileage is more significant and is concentrated in the midland counties of Offaly, Laois and Roscommon and in the western seaboard counties of Kerry, Clare, Galway, Mayo and Donegal.

4.3 Regional Roads

The current practices used to maintain Regional roads with peat foundations in eleven counties are summarised in Appendix A2. Overlaying the existing pavement with crushed stone or hot-mix bituminous material is the preferred option in most counties. A second or third choice in a number of counties is to reinforce the pavement with geogrids in combination with a crushed stone or bituminous overlay.

The results of the questionnaire indicated a certain amount of variation in practices between the different counties and also a great variation in the expected life span of the various treatments being used.

4.4 Local Roads

The current practices used to maintain local roads with peat foundations in twelve counties are summarised in Appendix A3. The results of the questionnaire show that there is great uniformity in maintaining local roads throughout the country. All of the counties, with the exception of Clare, indicated that the preferred method of maintaining local roads is to overlay the existing pavement with high quality crushed stone and apply a double surface dressing. The attraction for adopting this maintenance technique on local roads is because it is easy to carry out and it is of relatively low cost. In many counties no other technique was reported and in the case of Co. Clare overlaying with crushed stone was listed as a second option after retreading.

5. Assessment of different techniques and materials currently used in the maintenance of roads over peat.

5.1 Crushed Stone Overlays

The survey of present practice showed that traditional methods used in maintaining roads with normal subgrades, still prevail in many counties in the maintenance of roads over peat. Overlaying the existing pavement with crushed stone, hot-mixed bituminous material, or in recent years with cold-mixed bituminous materials is the most popular form of treatment in many road authorities. In a small number of counties there is a clear recognition that overlaying, and increasing weight on the compressible peat, only gave temporary improvement to the pavement, and retreading which involved no significant increase in weight is practised.

5.2 Bituminous Overlays

Where hot-mixed bituminous materials were used to overlay roads over peat, the results reported from the survey indicated that the unit costs were higher than for crushed stone overlays. In general the life span reported for such bituminous overlay treatments was longer than for the stone overlays, but in some counties there was no increase in life span over that reported for crushed stone, and in a small number of counties shorter life spans were reported indicating perhaps that bituminous overlays were being used on the more difficult sites where the likelihood of long periods – in excess of ten years – between treatments was less likely.

The use of cold-mixed bituminous material, such as stabilised wet-mix macadam or foamed bitumen macadam, was reported in four out of the twelve counties which participated in the survey, and the unit costs were similar to those for hot-mixed bituminous material. Stabilised wet-mix macadam is the most common description given to bitumen emulsion bound crushed stone with the same grading as wet-mix macadam, and foamed bitumen macadam is a similar material where the bitumen is foamed before being mixed with the cold aggregate. As these materials are relatively new to this country, and experience in their use is limited to date, any estimates of their life span must be speculative. However, they do have some advantages over hot-mixed bituminous material as they can be stockpiled before use and can therefore allow work to proceed more quickly particularly on remote sites, and the material is more likely to tolerate slight settlements than hot mixed materials with harder binders. The main advantage of both types of bituminous material over crushed stone is that the bituminous material is stronger and more efficient structurally and can be applied at about half the depth of the unbound

crushed stone for the same structural contribution to the pavement. It therefore applies less weight to the peat subgrade and should cause less settlement.

5.3 Use of Geosynthetics combined with Unbound or Bituminous Overlay Materials

Over the past decade geosynthetics, mainly in the form of geogrids or geonets, have been used by a number of road authorities to reinforce pavements over soft soils, particularly pavements in need of rehabilitation over peat. The results of the survey show that their use in rehabilitating Regional and Local roads is now mainly confined to Counties Galway, Mayo and Waterford. The initial experiments with geogrids in East Galway in October 1986, where polypropylene grids were used in combination with a 50mm depth of dense bitumen macadam, have showed that this technique can succeed in maintaining a lightly trafficked road over peat for more than ten years. On the same site, traditional maintenance methods were used at 3 to 4 year intervals to maintain the same section of road in a safe, serviceable condition. In all of the counties where geosynthetics are used, life spans up to, or exceeding 10 years, are expected.

Unit costs of £13.50/m^2 were reported for recently completed work in Co. Waterford where bitumen coated polyester grids were used in combination with dense bitumen macadam. In Co. Galway the practice of using more rigid polyethylene grids with thin crushed stone overlays, is now well established, and at the unit rate of £7-9/m^2 is of similar magnitude to the rate of £8.70/m^2 quoted for such work in Co. Mayo. On Regional roads in Co. Mayo unit rates of £9/m^2 were reported for overlays with cold mixed bituminous material combined with geogrid reinforcement. Overall the evidence indicates that the cost of using geogrid reinforcement along with unbound or bitumen bound overlays varies from about £9/m^2 to £14/m^2 depending on the type of material used and the amount of preparation work needed to regulate the original surface before installing the geogrid. Because of the higher costs involved in using this technique, it has been used sparingly in the three counties referred to above, but it has been deemed successful and cost effective because of the long life of this method of treatment compared with traditional methods and also due to the higher serviceability which resulted from its use.

The works carried out in 1986 on the East Galway site near Mountbellew are described in detail in an NRA report RC.375 (3), where the installation of the polypropylene grid is described. The pavement performance for the subsequent ten years is described and unit costs for the work are reported. **In the description of the works the importance of correct installation of the geogrid and securing a high standard of contact between the grid and**

the underlying road surface which had to be regulated, is emphasised. Close contact between the geogrid and the regulated surface was ensured by fixing the grid at close intervals to the underlying layer and surface dressing the grid before overlaying with dense bitumen macadam. The surface dressing of the geogrid on this site is shown in Figure 5.1. In some isolated depressions where close contact between the grid and road surface was not achieved, difficulties arose when the dense bitumen macadam surfacing was laid and compacted, and some repairs had to be carried out in these areas. Despite these initial problems the subsequent performance of the experimental section of road has been excellent compared with adjacent sections where reinforcement techniques were not used. In Figure 5.2 the distressed condition of the unreinforced pavement in the foreground, can be compared with the reinforced section of road, about eight years after construction of the experimental section.

Another significant experiment which involved the use of bitumen coated polyester geogrids was carried out on the R396 Regional road near Coole, Co. Westmeath in November 1992. This type of geogrid is more flexible than the more rigid polypropylene grid. In addition, the coating of binder to the polyester filaments which make up the grid ensures that the grid adheres to any tack coats or bituminous overlays. For this reason installation of such a geogrid is considered easier and more likely to produce a satisfactory result than the more rigid polypropylene geogrids. In the road experiments carried out in Scotland, which were referred to in paragraph 3.3, different types of geosynthetics were used and compared at the construction stage and later during service. It was concluded from these experiments that while all of the geogrids performed equally well once properly installed in the pavement, the bitumen coated polyester geogrids were found to be easier to install and were subsequently preferred for such work in Scotland.

The installation and overlaying of the polyester geogrid on the R396 Regional road in 1992 is shown in Figure 5.3.

Figure 5.1

Surface Dressing Polypropylene Geogrid on Local Road CR 459, Mountbellow, 1986

Figure 5.2

Condition of Geogrid Reinforced Pavement after 8 years compared with unreinforced pavement

Figure 5.3

Overlaying Polyester Geogrid

6. Recommendations

6.1 General

In making decisions on the most appropriate techniques and materials which should be used in the maintenance of roads over peat, cognisance should be taken of a number of factors which influence the choice of treatment including:

- Traffic levels and importance of the road.
- Physical constraints on site, including depth and strength of peat, water levels and possibility of flooding.
- Traffic constraints including width of road and the possibility of road closure for reconstruction work.
- Costs.
- Level of serviceability expected by motorists.
- Expected duration of maintenance treatment.

The most effective maintenance treatment is that which is based on limiting change of surface shape, distortion and deterioration of the pavement, to tolerable levels at the lowest overall cost to the road user. Hence, for any site given the above factors, including financial and engineering constraints, there will be many different solutions to the problem of providing a pavement that will support traffic on an acceptably even surface.

While recommendations are made for the three main road categories, National, Regional and Local, it is recognised that some Regional roads are carrying heavy traffic and are probably of equal importance to some National Secondary routes, and similarly some Local roads are heavily trafficked and will deserve as much consideration as Regional roads. The recommendations should therefore be applied judiciously recognising that some sites may need special attention and will have to be considered on their merits.

While the recommended maintenance methods in this document refer specifically to the maintenance of roads over peat, all maintenance work should be carried out in accordance with best engineering practice, which should include the practices set out in Table 6.1:

Table 6.1

(i)	Roads should be restored to their original width, and edges strengthened where necessary. The provision of additional width should only be countenanced where traffic considerations warrant it.
(ii)	Particular attention should be paid to drainage and road crossfall (min. 3%) in the interests of maintaining the life of the pavement.
(iii)	Superelevation should be provided where necessary.
(iv)	Minor longitudinal irregularities should be eliminated by regulation with selected material prior to overlay.
(v)	A paving machine should be used where the lengths of road being treated are reasonably long and the machine can be accommodated within the available width.
(vi)	Surface dressing should be carried out in accordance with best practice and the guidelines entitled "SURFACE DRESSING" (4) issued by the Department of the Environment in 1981; the use of polymer-modified binders should be considered, where appropriate.
(vii)	Surface dressing should be applied to bituminous overlays as soon as it is practicable for skid resistance purposes. Where surface dressing of bituminous bound materials is deferred for 30 days or longer, the coarse aggregate retained on the 6.3mm B.S. sieve in the final bituminous layer shall have a polished stone value of not less than 60. The aggregate passing the 6.3 mm BS sieve shall have a polished stone value of not less than 45. The polished stone value shall be determined in accordance with BS.812: Part 114. The coarse aggregate retained on the 6.3 mm BS sieve shall have an aggregate abrasion value, determined in accordance with BS.812: Part 113, not greater than 12.
(viii)	Wearing course macadams should not be used in the rehabilitation of rural non-national roads.
(ix)	Road markings should be provided, replaced or renewed as soon as practicable. Reference should be made to the document entitled "Guidelines and Tender Documentation for Road Marking Materials" (5) published by the DoELG in 2000.
(x)	Road signs, particularly those with implications for safety such as warning signs and regulatory signs such as STOP or YIELD, should be renewed as necessary.

6.2 Recommended Maintenance Methods

A summary of recommended treatments is scheduled in Table 6.2 and is based on replies received from the respondents to the questionnaire, the combined experience of the members of the Working Party, and the experience of road engineers in Ireland and Scotland who were consulted during the preparation of this document.

The unit costs and estimated lifespan for each technique are given as guidance, but are considered to be representative of the more likely values which will result if normal conditions prevail on site and if the specified treatments are carried out in accordance with good practice. Information on the recommended treatments and associated specifications are set out in greater detail in Appendix B which is divided into seven parts.

Table 6.2 Schedule of Recommended Maintenance Methods

	Maintenance Method	Unit Cost (£/m²)	Lifespan (Years)	Remarks
1	Retread existing pavement and apply double surface	3.5-5.5	6-8	Not suitable where depth or quality of pavement is inadequate
2	Overlay with crushed stone and apply double surface dressing	4.0-7.0	3-8	Suitable where method has been successful in past and where depth of pavement is inadequate
3	Overlay with cold mixed bituminous material and apply double surface dressing	5.0-8.0	5-10	Suitable for heavily trafficked Local or Regional roads
4	Overlay with hot mix bituminous material and apply surface dressing	5.0-10	5-10	Suitable for heavily trafficked Regional roads and National Secondary roads
5	Reinforce pavement with geogrid, overlay with crushed stone and apply double surface dressing	8.0-10	10	Suitable where pavement is weak and where methods 1-4 proved unsuccessful
6	Reinforce pavement with geogrid, overlay with cold mix bituminous material and apply double surface dressing	9.0	10-12	Suitable where pavement is weak and where traffic levels are fairly high as on Regional and National roads
7	Reinforce pavement with geogrid, overlay with hot mix bituminous material and apply double surface dressing	14	10-12	Suitable where pavement is weak, where a long period between treatments is desirable and where traffic levels are high as on Regional and National roads

6.3 National Roads

The routine maintenance of National roads over peat is not a big problem nationally but is significant for a small number of counties which have a large mileage of National Secondary roads.

With increasing levels of funding for National roads in prospect, many highway engineers will in the first instance consider the option of permanently removing the problems associated with roads over peat by excavating the peat and back-filling with free-draining granular fill. Cost estimates for the excavation of peat, back-filling with granular fill and constructing a surface dressed granular pavement are given in Table 6.3. The table is based on estimates from two counties and includes such items as traffic control, compaction of fill, construction of unbound pavement and surface dressing. The costs exclude accommodation works and relaying of services.

Table 6.3 Estimates of Costs of Excavation of Peat and Back-Filling With Granular Fill.

Depth of Excavation (m)	Cost £/m2
1.0	25
1.5	33
2.0	42
2.5	52
7.0	105

It is clear from Table 6.3 that excavation, even at shallow depths up to 2m, is a very expensive option and should not be used in a routine manner to avoid the problems associated with normal maintenance. Where new construction is planned the option of excavation along with other measures, such as preloading, becomes more likely, especially if the section of road is short and is important in the context of the whole route, as is often the case in new road projects.

While the incidence of National Primary Roads with peat foundations is now very small, there still remains the problem of maintaining National Secondary roads with peat

subgrades and it is desirable to choose maintenance techniques which will give a high level of service for as long as possible, and preferably up to, or exceeding ten years. Some very cost effective options have been identified, such as reducing the load on the supporting peat, even by small amounts, and retreading of the existing pavement. If the depths of granular material in the existing pavement are in excess of 1m, the option of off-loading should be considered, either on its own or in combination with reinforcement techniques, such as the use of geosynthetics. The skilful use of geosynthetics will increase pavement strength without adding weight to the peat subgrade. Overlays of crushed stone, cold mixed or hot-mixed bituminous material should be used in conjunction with the geosynthetics to protect the geosynthetic and to ensure that it acts in unison with the underlying pavement material. The crushed stone is the cheapest of the three overlay materials and the hot-mixed bituminous material the most expensive in terms of cost per unit weight. However, as the hot-mixed material is generally used in shallower depths, the final difference in cost per unit area of treated pavement may not be great. For important sections of National Primary or National Secondary Roads the use of high performance bituminous materials made with modified bituminous binders should be considered.

6.4 Regional Roads

Because many Regional roads carry significant volumes of traffic and because of the relatively high mileage of such roads, the effective maintenance of such roads over peat is a considerable challenge to road engineers.

The options available to road engineers in the maintenance of such roads are listed in Table 6.2.

Before choosing any particular option for a site the length of road should be surveyed and investigated to determine the type and extent of the defects and to determine the construction thickness. The latter is important as it will provide information on the depth of pavement construction and the quality of the pavement materials. If the depth of pavement material is in excess of 1m, the option of reducing the level of the road by 100-150mm should be considered. In such circumstances the road should be regulated and new design levels achieved by adding new high quality crushed stone before double surface dressing. If the survey indicates that the pavement strength is doubtful, either cold-mixed bituminous material or hot mixed bituminous material up to 100mm in depth should be used to bring the reduced pavement to its final finished level.

If the section of Regional road is of strategic importance and carries heavy traffic the option of reducing the level of the road as described above and reinforcing the altered pavement with an appropriate geosynthetic combined with an overlay should be considered. The technical solution which has been found by many engineers to be most effective is to use a bitumen coated polyester geogrid sandwiched between two layers of dense bitumen macadam, the bottom layer being used to regulate the existing road and to provide an even surface to install the geogrid.

Similar solutions with slightly lower costs can be effected by replacing the dense bitumen macadam with cold mixed bituminous material or high quality crushed stone such as wet-mix macadam.

The options of overlaying the existing pavements with crushed stone, hot-mix or cold mix bituminous materials which are most common should be reconsidered in favour of other options, such as, those which involve load reduction or reinforcement of the pavement, if experience on the particular stretch of road has shown that overlay treatments in the past has given a relatively short life of the order of 2 to 4 years. The survey results indicate that crushed stone overlays, with greater depths than the bituminous overlays, are more likely to have shorter lives. Where overlays of unbound crushed stone and bituminous materials have been found to be cost effective and capable of maintaining the road in a serviceable condition for more than 5 or 6 years their use should be continued.

6.5 Local Roads

Because of the lower traffic levels on Local roads there is less justification for adopting some of the more expensive techniques recommended for Regional roads. While the practice of overlaying the existing pavement with crushed stone predominates in most counties and was reported as giving a reasonable life span up to ten years in many counties, there were a number of counties where this technique is short-lived and expected to last for about five years or less.

It is recommended that where the existing technique of using crushed stone overlays has proved successful, this practice should continue because of ease of application, minimal disturbance to traffic, and moderate cost. Experience in many counties has shown that the addition of small depths of new material for regulation purposes is preferable to causing disturbance to the existing pavement. Where, however, crushed stone overlays have been

noted to perform poorly and have given a short life of less than five years, other techniques should be considered. The first alternative which should be considered to overlaying with crushed stone, is to retread the existing road by scarifying and recycling the existing pavement to a depth of about 100mm-150mm, reshape the road surface and if necessary add sufficient new crushed stone to produce a dense smooth profile. The new surface should be double surface dressed. This technique should only be applied where there is a minimum depth of 200mm of high quality crushed stone in the road base.

The second alternative to overlaying with crushed stone, is to use a lesser depth of hot-mixed or cold-mixed bituminous material to overlay the existing pavement. This option will be more attractive in counties where the cost of bituminous materials is competitive, and where experience has shown that this technique gives a longer life than that given by unbound stone overlays.

Where some sections of local road have given rise to particular problems which are unlikely to be solved by any of the above techniques, the option of reinforcing the pavement with geosynthetics should be considered. On sites where there is a combination of shallow pavement, weak subgrade, high water table and occasional heavy commercial traffic, there may be need to reinforce the pavement with geogrids and an overlay of crushed stone or bituminous material. On such sites it is recommended that the existing pavement be regulated to provide a smooth surface for the reinforcing grid, and when the grid is fixed in place according to the manufacturer's instructions, a crushed stone overlay 150mm in depth be applied, levelled and compacted to provide a smooth even surface. The crushed stone base should then be double surface dressed. Where bituminous materials are available at competitive prices a bituminous overlay to the reinforcing grid can be used and the depth of overlay reduced to 100mm.

6.6 Widening of Roads with Peat Foundations

The widening of roads with peat foundations as part of rehabilitation or minor improvement works is an issue which is worthy of special attention. On many sites it is desirable to widen the existing road by about 1m, but such widening often presents extra technical problems and costs, over and above those associated with such work on roads which have normal subgrade conditions.

In general the widened section of pavement will apply extra load to the underlying peat subgrade and induce settlement relative to the existing pavement. The rate of settlement

will reduce with time, but will finally result in the widening being slightly lower than the edge of the existing pavement and this drop in level will have to be made up, notably in the first year after widening, to ensure a safe serviceable pavement.

When roads constructed on peat embankments or ramparts have to be widened, the scale of the problem in terms of technical difficulty and cost can be greatly increased. The widening of such roads is often very desirable from a safety viewpoint, especially if successive overlays raises the level of the road and increases the probability of having a soft verge adjacent to a steep side slope. In some instances where safety may be compromised it may be necessary to widen one side of the embankment to improve side support to the road, and reduce the side slope to a more acceptable level. Such earthworks can be very costly as they will probably necessitate the acquisition of extra land, the use of free-draining rock fill and the relocation or piping of drains. If such earthworks have to be carried out as part of a widening and pavement improvement scheme, it is very important that the works associated with the widening be carried out in advance of the pavement rehabilitation. It is essential to have such earthworks carried out in the year previous to the pavement improvement to ensure that most of the settlement due to widening has taken place prior to the pavement improvement. On important routes advance earthworks should include some surcharge during the pre-loading period to reduce post-construction settlements to a minimum.

6.7 Provision of Passing Bays

It is sometimes appropriate to provide passing bays on what are effectively single lane roads. This allows narrow rural roads with low traffic volumes to be improved at reasonable cost. It can assist in regulating traffic and in improving traffic safety. The following points should be noted in respect of passing bays:

- They should be provided at regular intervals with approximately 5 to 6 bays per kilometre.
- The siting should be arranged so that from any point on the road at least one bay is visible and adjacent bays are inter-visible.
- On sharp bends a two lane carriageway is desirable.
- Information traffic signs should be provided on approaches to passing bays.
- It is useful to provide a special standard marker post at each passing bay to improve inter-visibility of bays.

The provision of passing bays (where feasible) instead of providing extra width along the full length of a road has particular advantages where a road is constructed on a peat foundation for the following reasons:

- It reduces the initial cost of widening by minimising road area.
- It minimises future maintenance.

References

1. Hammond, R.F. (1981). The Peatlands of Ireland, Soil Survey Bulletin No. 35, An ForasTaluntais, Dublin, 4.

2. Guidelines on the Depth of Overlay to be Used on Rural Non National Roads (1999), Department of the Environment and Local Government.

3. Davitt, S., Killeen, R.C. (1996). Maintenance Techniques for Bog Roads. National Roads Authority, Report RC.375, Dublin 4.

4. Surface Dressing. Department of the Environment. Government Publications Sales Office, Dublin 1.

5. Guidelines and Tender Documentation for Road Marking Materials (2000) DoELG.

6. N.R.A. Specification for Road Works (2000). National Roads Authority, Dublin

7. N.R.A. Specification for Stabilised Wet-Mix Macadam. National Roads Authority, Dublin 4.

Appendix A

Summary of Results of Survey on

Rehabilitation Treatments used on Irish Roads

Appendix A1

Summary of Treatments used on National Roads

COUNTY	DESCRIPTION OF TREATMENT	UNIT COST £/m²	ESTIMATED LIFE/YEARS
Clare	Retread exist. Pavement	4	6
	Overlay with crushed stone	7	4
	Hot-mix bituminous+geogrids	12	Unknown
Cork - North	Overlay with crushed stone (Used On National Secondary Roads Only)	8	4
Cork - South	Overlay with crushed stone	5	5-10
	Overlay with hot-mix bituminous	20+	10+
	Overlay with cold-mix bituminous	7.5	3-5
Cork - West	Excavate peat + quarry rock fill	-	20
	Overlay with wet-mix macadam	14	5
Donegal	Overlay with hot-mix bitminous	5	6 Max
	Overlay with crushed stone	4	3 Max.
	Overlay with cold-mix bituminous	5	4 Max.
Galway	Overlay with crushed stone	4.5	3-4
	Overlay with hot-mix bituminous	7.5-10.5	7-9
	Stone overlay + geogrids	7-9	7-10
Kerry	Overlay with crushed stone	7	7
	Retread +minimal stone overlay	5.25	6
	Excavate peat + granular fill	33	15
Leitrim	Excavate peat + rock fill	30-90	25+
	Overlay with hot-mix bituminous	10	3-5
	Hot-mix bituminous+geogrids	15	5
Longford	Overlay with hot-mix	10	5
	Partial excavation + light-weight fill	-	15
Mayo	Cold-mix bituminous + grids	9	10
	Stone overlay + geogrids	7.9	5
	Hot-mix bituminous + geogrids	9.5	10
Offaly	Overlay with crushed stone	8	3-12
	Overlay with hot-mix bituminous	14	5-15
	Retread + regulating existing	8	3-14
Waterford	Hot-mix bituminous + geogrids	13.5	10-15 Estim.
	Excavation peat + granular fill	20	6
	Overlay+hot-mix bituminous	6	3-10

Appendix A2

Summary of Treatments used on Regional Roads			
COUNTY	DESCRIPTION OF TREATMENT	UNIT COST £ / m²	ESTIMATED LIFE / YEARS
Clare	Overlay with crushed stone	5	8
	Retread existing Pavement	3.5	5
	Insitu cement stabilisation	N / a	N / a
Cork - North	Overlay with crushed stone	7	3-10
	Excavate peat + granular fill	14	20
Cork - South	Overlay with crushed stone	5	5-10
	Overlay with hot-mix bituminous	10	7-10
	Overlay with cold-mix bituminous	7.5	10
Cork - West	Overlay with wet-mix	7	7
	Heavy patching + surface dressing	5	7
Donegal	Overlay with crushed stone	4	7 max
	Overlay with hot-mix bitminous	5	10 max.
	Overlay with cold-mix bituminous	5	8 max.
Galway	Overlay with crushed stone	4.5	3-4
	Stone overlay + geogrids	7-9	10
Kerry	Overlay with crushed stone	6.5	5-10
	Retread + stone overlay	5.15	6
	Recycle existing pavement	6	8
Kildare	Crushed stone overlay + retread	5.5	6
	Overlay with hot-mix bituminous	5	4
	Hot-mix bituminous + geogrids	20	10+
Leitrim	Overlay of stone + hot-mix bitumen	10-15	7-10
	Overlay with crushed stone	5-10	5-8
	Overlay with hot-mix bituminous	5-10	5-8
Longford	Overlay with hot-mix	10	5
	Overlay with crushed stone	7	15
	Overlay with cold-mix bituminous	8.5	10
Mayo	Overlay with crushed stone	2.9	9
	Overlay with cold-mix bituminous	4	12
	Cold-mix bituminous + grids	9	12
Offaly	Overlay with crushed stone	7	3-10
	Retread + regulating existing	7	3-12
	Overlay with hot-mix bituminous	12	5-14
Waterford	Hot-mix bituminous + geogrids	13.5	10
	Overlay with crushed stone	7	2

Appendix A3

Summary of Treatments used on Local Roads

COUNTY	DESCRIPTION OF TREATMENT	UNIT COST £/m²	ESTIMATED LIFE/YEARS
Clare	Retread existing pavement	2.5	8
	Overlay with crushed stone	4.5	5
Cork - North	Overlay with crushed stone	7	4-10
	Overlay with cold-mix bituminous	3	2-3
Cork - South	Overlay with crushed stone	5	10
	Overlay with cold-mix bituminous	10	10
	Overlay with hot-mix bituminous	10	10
Cork - West	Overlay with wet-mix	8	10
	Regulating deformed areas with cold-mix bituminous	5	7
Donegal	Overlay with crushed stone	4	7
	Overlay with hot-mix bituminous	5	10
	Overlay with cold-mix bituminous	5	8
Galway	Overlay with crushed stone	4.5	3-4
	Stone overlay + geogrids	7-9	10+
	Cold-mix overlay + geogrids	13	15+
Kerry	Overlay with crushed stone	6.75	6-10
	Retread existing pavement	5.25	6
Kildare	Overlay with crushed stone	4.2	5
	Overlay with hot-mix bituminous	5	5
	Retread existing pavement	4	First used 1997
Leitrim	Overlay with crushed stone	5-10	5-8
Longford	Overlay with crushed stone	7	5
Mayo	Overlay with crushed stone	3.7	5
	Stone overlay + geogrids	8.7	6-10
Offaly	Overlay with crushed stone	6	3-10
	Retread existing pavement	6	3-12
	Overlay with hot-mix bituminous	10	5-10
Tipperary South Riding	Overlay with crushed stone	6.5	10
	Hot-mix bituminous + geogrids	7.5	12
	Remove 150mm depth of stone + double surface dress	4	10
Waterford	Overlay with crushed stone	7	6

Appendix B

Recommended Treatments and Outline Specifications

Appendix B1

Method 1: Retread Existing Pavement and apply Double Surface Dressing

Unit Cost: £3.50 / m^2 to £5.50 / m^2
Lifespan: 6 to 8 years

This treatment adds the minimum extra weight to the existing road foundation.

It minimises disruption as importation of crushed stone is minimal and work can be carried out quickly.

It may be necessary to import some crushed stone for regulation purposes.

Treatment is not suitable where the depth of the granular pavement layers is less than 200mm. The depth and quality of the existing pavement layers should be checked by sampling to a depth of about 250mm and assessing the quality of the pavement materials by visual inspection or by carrying out laboratory tests.

Treatment is not suitable in peatlands where rock may outcrop close to the road surface.

Outline Specification

The existing road pavement shall be scarified, broken down and mixed until the resultant product is uniform in distribution of coarse and fine particles. If the resulting mixed material is deficient in terms of grading or the resulting surface is likely to be too low, crushed rock complying with either Clause 804 or Clause 806 of the NRA Specification for Road Works (6) shall be added in sufficient quantity to ensure that any deficiencies in grading or finished road level are made good. The mixed or blended material shall be spread to form a layer which is uniform in thickness and surface contour and spread to the full pavement width.

Immediately upon completion of each portion of the spreading operation the mixed or blended material shall be thoroughly compacted by suitable compaction plant. Compaction shall commence at the outer edge and successive passes of the compaction

plant shall be so spaced that not more than half of its width shall be on uncompacted material at any time.

Following the initial compaction the surface of the base shall be bladed with a grader or similar planing machine to secure a surface true to grade, line and level. Great care shall be taken during this operation to disturb no more material than is necessary to secure a true section. After completion of the blading operations compaction shall proceed without interruption across the area to be compacted until the required degree of compaction is attained uniformly throughout the mixed or blended material. Compaction following the blading operation shall be accomplished in such a manner as to avoid the formation of irregularities and every effort shall be made to secure a thoroughly compacted surface, true to grade, line and level.

On completion of compaction the surface of the material shall be double surface dressed using a cationic bitumen emulsion (70 per cent bitumen). The rate of spread of binder and surface dressing chippings shall be in accordance with the Guidelines on Surface Dressing published by the Department of the Environment (5).

Appendix B2

Method 2: Overlay with Crushed Stone and apply Double Surface Dressing.

Unit Cost: £4.00 / m^2 to £7.00 / m^2

Lifespan: 3 to 8 years

This treatment involves minimum disruption to traffic but leads to a significant increase in weight on the peat foundation. It should be considered in the following situations.

- On roads where the treatment has previously given satisfactory results
- On roads where there is inadequate pavement depth.

Outline Specification

The existing road pavement shall be overlaid with the minimum depth of crushed rock which is necessary to produce an even finished surface true to grade, line and level. The

crushed rock shall comply with Clause 804 or Clause 806 of the NRA Specification for Road Works.

On completion of compaction the surface of the material shall be double surface dressed using a cationic bitumen emulsion (70 per cent bitumen). The rate of spread of binder and surface dressing chippings shall be in accordance with the Guidelines on Surface Dressing published by the Department of the Environment.

Appendix B3

Method 3. Overlay with Cold Mix Bituminous Material and apply Double Surface Dressing.

Unit Cost: £5.00 / m^2 to £8 / m^2
Life Span: 5 to 10 years.

Outline Specification:

The existing road pavement shall be overlaid with the minimum depth of cold mix bituminous material which is necessary to produce an even finished surface which is true to grade line and level. The material shall comply with the requirements of the latest edition of the NRA Specification for Stabilised Wet-Mix Macadam (7).

Unless hand placing is permitted cold mix bituminous materials shall be spread, levelled and tamped by an approved self-propelled paving machine. As soon as possible after arrival at site the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously.

The material shall be protected from weather during transit to the site, whilst awaiting tipping and during laying.

The travel rate of the paver, and its method of operation, shall be adjusted to ensure an even and uniform flow of material across the screed free from dragging, tearing and segregation of the material.

Cold-mix bituminous materials shall be laid and compacted in layer thicknesses which enable surface level and regularity requirements to be met and adequate compaction to be achieved.

Compaction should be carried out using a combination of a vibrating roller and a pneumatic tyred roller. The mass per metre width of roll of the vibrating roller should not be less than 2000 kg. The vibrating roller should operate at a speed of about 2 km / hr. The mass per wheel of the pneumatic tyred roller should not be less than 300 kg and the inflation pressure of the tyres should not be less than 7 bars. The pneumatic roller should be operated at a speed of about 6 km / hr.

Compaction shall continue until the specified density for the approved material is achieved.

On completion of compaction the surface of the material shall be protected with a single or double surface dressing as specified.

Surface dressing shall be carried out in accordance with the recommendations of the Department of the Environment Publication "Surface Dressing".

Appendix B4

Method 4. Overlay with Hot Mix Bituminous Material and apply Surface Dressing.

Unit Cost: £5.00 / m^2 to £10 / m^2.
Life Span: 5 to 10 years.

The existing road pavement shall be overlaid with the minimum depth of bituminous material which is necessary to produce an even finished surface which is true to grade, line and level. All bituminous materials used shall comply with the Series 900 requirements of the NRA Specification for Road Works.

The most suitable bituminous material for overlaying roads over peat is 28mm size dense bitumen macadam roadbase material complying with Clause 903 of the NRA Specification for Road Works. In general this material shall be used for rehabilitation work but other bituminous materials which have performed satisfactorily in the past such as 28mm or 20mm size dense bitumen macadam basecourse complying with Clause 906

of the NRA Specification for Road Works, may also be used. The nominal layer thickness shall be specified and shall be within the range 60 to 100mm for the 28mm size material, and within the range 50 to 80mm for the 20mm size material.

On completion of the overlaying operation the bituminous material shall be double surface dressed. Surface dressing shall be carried out in accordance with the recommendations of the Department of the Environment Publication "Surface Dressing".

Appendix B5

Method 5. Reinforce Pavement with Geogrid, overlay with Crushed Stone and apply Double Surface Dressing.

Unit Cost: £8 / m^2 to £10 / m^2.
Life Span: 10 years.

This technique should be used where reinforcement of the existing pavement is considered necessary and where financial constraints preclude the use of cold mix or hot mix bituminous overlays along with geogrid reinforcement. Where this technique is chosen, the more rigid polypropylene grid which has been used successfully on a number of sites in Ireland should be considered along with other types of geogrid. A possible disadvantage of the technique is that the rigid geogrid may impede recycling or re-use after the life-span of this particular rehabilitation method.

Outline Specification

The surface of the existing road shall be regulated with crushed stone complying with Clause 804 of the NRA Specification for Road Works, or similar approved granular material. The regulation work shall be carried out in a manner which will remove all irregularities in the original profile and every effort shall be made to secure a dense compacted surface true to grade, line and level to receive the tensioned geogrid.

The geogrid shall be installed in such a manner as to ensure close contact between the underlying regulated profile and the tensioned geogrid. The geogrid shall be anchored at one end and tensioned in accordance with the manufacturer's instructions. The geogrid shall be aligned in such a manner to ensure that the geogrid has sufficient anchor width

at the edge of the road and that longitudinal overlaps in the geogrid are located at least 500 mm from the wheeltrack. The amount of overlap between geogrids and the method of tying overlapping geogrids shall be in accordance with the manufacturer's instructions. After tensioning, a high standard of contact between geogrid and underlying surface shall be achieved by pulling the reinforcement into any local depressions which may occur in the underlying surface and nailing or fixing the geogrid to the underlying layer. Geogrids shall be cut neatly to suit the width of the carriageway and to ensure adequate overlap between adjacent rolls of geogrid.

After installation, the geogrid shall be surface dressed using a cationic bitumen emulsion (70 per cent bitumen) sprayed at a rate of between 1.1 and 1.4 litre / m^2, and lightly rolled.

The crushed stone layer, which should not exceed 150 mm in depth, should then be overlaid and surface dressed as described for Method No. 2.

Appendix B6

Method 6. Reinforce Pavement with Geogrid, overlay with Cold Mix Bituminous Material and apply Double Surface Dressing

Unit Cost £9.00 / m^2
Life Span: 10-12 years.

This technique should be used where reinforcement of the existing pavement is considered necessary and where there will be technical or financial advantage in using cold mix bituminous material over conventional hot mix bituminous products.

Outline Specification

The surface of the existing road shall be regulated with the minimum depth of cold mix bituminous material that is necessary to produce an even surface which is true to grade, line and level. The material shall comply with the requirements of the latest edition of the NRA Specification for Stabilised Wet-Mix Macadam.

The regulation work shall be carried out in a manner which will remove all irregularities in the original profile and every effort shall be made to secure a dense compacted surface to receive the geogrid.

The geogrid shall be a bitumen coated polyester geosynthetic, or similar approved.

The geogrid shall be installed in accordance with the manufacturer's instructions and in such a manner as to ensure close contact between the underlying regulated profile and the tensioned geogrid. The geogrid shall be anchored at one end and rolled out in accordance with the manufacturer's instructions. The geogrid shall be aligned in such a manner to ensure that the geogrid has sufficient anchor width at the edge of the road and that longitudinal overlaps in the geogrid are located at least 500 mm from the wheeltrack. The amount of overlap between geogrids and the method of tying overlapping geogrids shall be in accordance with the manufacturer's instructions. After installation, a high standard of contact between geogrid and underlying surface shall be achieved by pulling the reinforcement into any local depressions which may occur in the underlying surface and nailing or fixing the geogrid to the underlying layer where necessary. Geogrids shall be cut neatly to suit the width of the carriageway and to ensure adequate overlap between adjacent rolls of geogrid.

After installation contact between the geogrid and underlying surface shall be enhanced by surface dressing or adopting an alternative technique in accordance with the manufacturer's instructions. The surface dressing shall be carried out by spraying cationic bitumen emulsion at a rate between 1.1 and 1.4 litre / m^2, covered with 6mm chippings at a rate of spread of 6 to 8 kg / m^2, and lightly rolled. All excess chippings shall be removed before overlaying with the cold mix bituminous layer. The depth of cold mix bituminous overlay shall be between 80 mm and 100 mm. The protection, laying, compaction and surface dressing of the material shall be as described as for Method 3.

Appendix B7

Method 7. Reinforce Pavement with Geogrid, overlay with Hot Mix Bituminous Material and apply Double Surface Dressing.

Unit Cost: £14.00 / m^2
Life Span: 10-12 years.

This technique should be used on more heavily trafficked routes where a long period between treatments is desirable and where sufficient funding is available to achieve this objective.

Outline Specification

The surface of the existing road shall be regulated with the minimum depth of bituminous material that is necessary to produce an even surface which is true to grade, line and level. The regulating material shall be 20 mm size dense bitumen macadam basecourse complying with Clause 906 of the NRA Specification for Road Works or 10 mm size close graded bitumen macadam wearing course complying with Clause 7.4 of BS 4987: Part 1: 1993.

The geogrid shall be a bitumen coated polyester geosynthetic, or similar approved. The geogrid shall be installed as specified in Method 6.

Before installation a bituminous tack coat shall be applied to the underlying surface to enhance bond between the geogrid and the underlying surface.

The bituminous overlay shall be 28 mm or 20 mm size dense bitumen macadam basecourse complying with Clause 906 of the NRA Specification for Road Works. The nominal layer thickness shall be specified and shall be within the range 60 to 100 mm for the 28 mm size material, and within the range 50 to 80 mm for the 20 mm size material.

On completion of the overlaying operation the bituminous material shall be surface dressed in accordance with the recommendations of the Department of the Environment publication "Surface Dressing".

If it is planned to defer the surface dressing of the bituminous overlay as specified above, the use of hard durable skid resistant aggregates for the final bituminous layer is required. The coarse aggregate retained on the 6.3 mm B.S. sieve shall have a polished stone value of not less than 60. The aggregate passing the 6.3 mm BS sieve shall have a polished stone value of not less than 45. The polished stone value shall be determined in accordance with BS.812: Part 114. The coarse aggregate retained on the 6.3 mm BS sieve shall have an aggregate abrasion value, determined in accordance with BS.812: Part 113, not greater than 12.