Report by the Comptroller and Auditor General

Quality Control of Road and Bridge Construction

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Comptroller and Auditor General

National Audit Office
16 November 1989

The Comptroller and Auditor General is the head of the National Audit Office employing some 900 staff. He, and the NAO, are totally independent of Government. He certifies the accounts of all Government departments and a wide range of other public sector bodies; and he has statutory authority to report to Parliament on the economy, efficiency and effectiveness with which departments and other bodies use their resources.

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Summary and conclusions

1. The Department of Transport, the Scottish Development Department and the Welsh Office (the transport departments) together spent well over £1,000 million in 1988–89 on the construction and maintenance of the national road system which covers some 9,500 miles of motorways and trunk roads and 14,500 bridges and other structures.

2. Until 1985, bituminous and concrete roads were designed for 20 and 40 years respectively. Since then the design life of bituminous roads has been increased to 40 years. Bridges are expected to last for 120 years. Within their design lives all roads and bridges require maintenance. In a number of cases, however, the transport departments have incurred substantial expenditure on maintenance and repair earlier than expected at the time of construction — included in this report under the general term "premature maintenance". The National Audit Office examined the procedures for identifying and analysing the causes of such expenditure and what the departments had done to learn lessons and prevent recurrences. The main findings and conclusions were:

Identification, Reporting and Analysis of Defects

(a) Defects are defined by the transport departments as problems arising from weaknesses in design, specification, workmanship or supervision. Maintenance has also been needed earlier than expected as a result of other causes not regarded by the departments as defects (paragraphs 1.5–1.6).

(b) In 1982 the Department of Transport reinforced their long standing arrangements for consultation and feedback on technical problems by introducing a more formal procedure for reporting and investigating defects. In April 1983 and May 1987, they issued more detailed guidance on the need to investigate promptly all cases where the Department might have spent highway funds unnecessarily or unwisely and where engineering lessons could be learned (paragraphs 2.1–2.4).

(c) The formal reporting of defects by the Department of Transport's regional offices has varied, partly because they have put different interpretations on the term "defect". There has also been some delay in reporting (paragraphs 2.5–2.6).

(d) The National Audit Office recommend that the Department should develop the defect reporting system to give a more comprehensive analysis of their performance on setting standards and specifications (paragraph 2.9).

(e) The National Audit Office estimate that, in the 210 cases they examined, premature maintenance is costing some £260 million

(mainly since 1980). Taking account of the delay to users while repairs are carried out the total economic cost could amount to £400 million (paragraphs 2.10–2.12).

(f) The departments consider that the scale of remedial expenditure should be looked at in the context of the cost of construction. The Department of Transport's assessment, based on roads and bridges referred to in this report and built in the 1970s, has shown that the cost of actual and prospective remedial work is equivalent to 3 per cent of the initial construction cost. (This calculation excludes delay costs.) The departments consider that raising the standards of design and construction to try to eliminate all risk of remedial expenditure would add far more than 3 per cent to the costs of initial construction; and in their view that would not represent better value for money than current practice (paragraphs 2.11 to 2.12).

Design and Specification

(g) The departments have issued design standards and specifications which are revised in the light of their consultation and feedback arrangements and the results of their commissioned research (paragraphs 3.1–3.2).

(h) The National Audit Office recommend that, in view of the high costs of geotechnical failures, the Department of Transport and the Welsh Office should consider whether spending more on initial site investigations would save money in the long run (paragraphs 3.4–3.7).

(i) There have been problems with concrete roads for many years which the Department of Transport attribute mainly to poor workmanship. The National Audit Office consider the persistence of such problems must also raise questions about the adequacy of supervision and the departmental specification (paragraphs 3.12–3.17).

(j) Some roads, built before the design standard was revised in 1978, and bridges have required premature maintenance because heavy lorry flows and loadings have been greater than predicted. The National Audit Office recommend that departmental reporting procedures should include such cases so as to provide a total picture (paragraphs 2.15 and 3.18–3.21).

(k) The most significant problems on bridges have arisen from the overall design, from chloride contamination, from unsatisfactory joints and from inadequate waterproofing (paragraph 3.24 and Table 2).

(l) Substantial expenditure has been required to maintain or strengthen major structures built by the Department of Transport in the 1960s and 1970s. The National Audit Office recommend that the Department should, therefore, review their practice for ensuring that bridge designs will allow them to achieve their design lives without undue risk of incurring extra maintenance costs (paragraphs 3.25–3.28).

(m) Consultants appointed in 1986 to investigate the condition of the Department of Transport's concrete bridges estimated (in 1988) that £800 million will be required over the next 15 years to ensure that these bridges continue to give satisfactory service. A substantial proportion of this expenditure is due to chloride contamination (paragraph 3.38).

(n) The National Audit Office recommend that, in view of the cost of remedying the damage caused by de-icing salts, the transport departments should urgently complete their research into alternative treatments and their examination of the costs and benefits of all the options available to combat the problem (paragraphs 3.35–3.43).

(o) The Department of Transport have learned from the technical problems identified in this report. In some cases, however, the National Audit Office consider that the Department could have reacted more quickly in amending standards and specifications and adopting new methods and done more research to address the main problems (Tables 3 to 10).

Management Issues: Workmanship and Supervision

(p) Poor workmanship and/or inadequate supervision were important factors contributing to premature maintenance (paragraph 4.2, Table 2).

(q) Consulting engineers have a range of responsibilities which the National Audit Office consider may give rise to difficulties in allocating responsibility for faults, particularly in cases where the engineer was also responsible for the design and supervision (paragraphs 4.3–4.4).

(r) During the last few years the departments have introduced competitive fee bidding for the appointment of consulting engineers, leading to a progressive lowering of fee rates (paragraph 4.6).

(s) The Department of Transport have been successful in obtaining some financial redress in about a quarter of the cases where they had received defect reports. But the amounts received have usually been only a small proportion of the remedial costs (paragraphs 4.11–4.13).

(t) The National Audit Office recommend that, in view of the difficulties in recovering the costs of remedial work, the departments should review their arrangements for control over supervision and workmanship (paragraph 4.14).

(u) The National Audit Office recommend that departments should develop better liaison and agree common guidance on sanctions to deal with poor workmanship or supervision (paragraphs 4.15–4.17).

Part 1: Introduction

1.1 Central government spent over £1 billion in 1988–89 on new construction, major improvements and capital maintenance of motorways, trunk roads and bridges in Great Britain. Table 1 shows the breakdown between the Department of Transport, the Scottish Development Department and the Welsh Office (collectively referred to in this report as the transport departments).

Table 1

1988–89 Expenditure on new construction and capital maintenance

	New construction and major improvements[1] £m	Capital maintenance[2] £m
Department of Transport	658	190
Scottish Development Department	87	22
Welsh Office	121	16
Total	**866**	**228**

Source: The departments
[1] excluding the cost of land and motorway communication
[2] excluding the purchase of vehicles and equipment

1.2 The Secretary of State for Transport is statutorily responsible for the construction, improvement and maintenance of motorways and trunk roads in England. Responsibility for other roads is vested in local highway authorities, although the Secretary of State maintains a broad oversight over local authority road programmes. There is a similar division of responsibilities in Scotland between the Secretary of State and the regional and island councils, and in Wales between the Secretary of State and Welsh local authorities.

1.3 The transport departments are together responsible for some 9,500 miles of trunk roads and motorways. Although these roads represent only 4 per cent of the total road network in Great Britain, they carry over 30 per cent of all traffic and nearly 60 per cent of heavy goods traffic. The departments are also responsible for 14,500 bridges and other highway structures such as the Midland Links. (Throughout this report the term "bridges" is used to refer to all such structures.)

1.4 Until 1985, bituminous and concrete roads were designed to carry traffic loads over 20 and 40 years respectively. Since then the design life of bituminous roads has been increased to 40 years. Bridges are intended to provide a design life of 120 years. Within their design lives all roads and bridges require maintenance; for example, bituminous roads require strengthening after 20 years and steel bridges require repainting every 15 years. To contain expenditure on maintenance and repair it is essential to ensure adequate standards of design and construction. Civil engineering, however, cannot be risk free and avoiding all risks of defects could lead to over-design and over-provision which would be unnecessarily costly. A balance must be struck between the cost of avoiding all risk and the cost of premature failure.

1.5 For many years there has been consultation and feedback between and within the departments on technical problems. In 1982 the Department of Transport reinforced these arrangements by introducing a more formal procedure for their regional offices to report construction defects to headquarters. For this purpose they have defined a defect as a problem arising from poor design, specification, workmanship or supervision. The Scottish Development Department and the Welsh Office have a broadly similar definition, with a system for reporting defects during the contract period. In January 1989 the Scottish Development Department extended this to cover defects occurring up to five years after the scheme was opened.

1.6 In practice, some roads and bridges have required major repair or maintenance earlier than expected at the time of construction — throughout this report referred to under the general term "premature maintenance". The National Audit Office have sought to identify the causes and costs of all such premature maintenance, including that arising from unforeseen heavy lorry flows and loadings which is not regarded as a defect under departmental reporting procedures (see also paragraphs 2.7 and 3.20 below). The main issues examined were:

(a) whether the transport departments have effective procedures for reporting defects and analysing the main causes;

(b) whether they have taken all necessary steps to learn from technical problems and to amend design standards and specifications;

(c) whether there has been effective action to improve workmanship and supervision.

Part 2: Reporting and Analysing Problems

Reporting arrangements

2.1 The Department of Transport's nine regional offices are responsible for the day to day management of the new construction and maintenance of national roads and bridges in England. For many years the Department's quality control has been based on feedback from regional offices, who also seek advice on technical problems from specialist engineers in headquarters. The Department have also used liaison committees, involving representatives of their regional offices, the Transport and Road Research Laboratory and the construction industry to consider problems with roads and bridges and changes to standards and specifications. They told the National Audit Office that these technical feedback arrangements have enabled them to identify common problems and initiate investigations and research to prevent recurrences.

2.2 In 1980 the Department recognised the need for a more formal and regular system of feedback, but were unable to introduce it due to staffing constraints. In 1982, however, following serious problems on a number of major schemes which required extensive and costly repairs, the Department introduced more formal procedures for reporting and investigating defects (as defined in paragraph 1.5). The aim of the new procedures was to provide a basis for apportioning responsibility for the cost of remedial measures as well as to supply information on problems and remedies. In April 1983 the Department issued further guidance to enable the regions to distinguish between defects arising from:

(a) deficiencies in design standards or specifications, which would need to be addressed by the Department;

(b) faulty design, materials, workmanship or supervision, where claims for redress might be pursued.

2.3 Early experience of the new arrangements showed that regions were not reporting all defects. For example, from January to August 1984 only three cases were reported to headquarters, but they learned of a further five cases in other ways. The Department therefore expanded their guidance and required each region to appoint a liaison officer to co-ordinate defect reporting. In May 1987, after further extensive consultation with the regions, the Department issued revised guidance including examples of defects and more detailed reporting procedures.

2.4 Under the revised procedures regional offices were required to identify and investigate promptly all cases where there was any indication that the Department had spent highway funds unnecessarily or unwisely or had failed to obtain proper value for money. The guidance stressed that a failure fully to investigate such matters "may expose Ministers, the Department or individual officers to allegations of culpability, incompetence, negligence, participation in a cover-up or even corruption". The guidance underlined the importance of reporting cases where there were potential claims against contractors or consulting engineers which, if not pursued and resolved, could lead to adverse criticism. And it emphasised that there should be no delay in reporting to the Department's specialist engineers those cases where engineering lessons could be learned. The Department told the National Audit Office that, in addition, regular day to day contacts continued to disclose common problems well before they were formally reported.

Defects reported

2.5 Between 1982, when the reporting procedure was introduced, and March 1988 105 defects were reported. The analysis of defects by regions compared with the percentage of new construction expenditure is in Figure 1. This shows some wide variations; for example, Eastern region, with 32 per cent of expenditure, had 14 reported defects, but Northern region, with only 3 per cent of expenditure had 16 reported defects.

2.6 The National Audit Office examination showed that the wide variation in the number of defects being reported was partly due to regional officials interpreting the meaning of a defect differently. Most thought they were required only to report cases involving a potential claim against contractors or consulting engineers. As a result the number of reported defects tended to understate the incidence of premature maintenance. The National Audit Office noted also that some regional offices had not reported defects promptly to the Department's headquarters; the delays ranged from six months to over two years in a few cases.

2.7 In addition to examining defect reports the National Audit Office also examined the records at the nine regional offices. This disclosed another 34 instances of premature maintenance — of which seven arose as a result of excess traffic loading — not covered by the defect reporting system. Although the Department said that they were aware of the problem caused by excess traffic loading through their feedback arrangements, the National Audit Office found that details of all cases had not been collated centrally (see paragraph 3.20).

2.8 Widespread problems with concrete bridges had also not been identified through the defect reporting procedures. But the Department pointed out that they had learned of such structural problems through their bridge inspection procedures introduced in 1977. As a result they had appointed consultants between 1980 and 1985 to carry out some more detailed inspections and then commissioned, in 1986, the first comprehensive survey of concrete bridges. Defects were identified in 144 of a representative sample of 200 bridges examined (see paragraph 3.38).

2.9 The National Audit Office recommend that the Department should make better use of the defect reporting system to inform work on standards and specifications. The introduction of a formal defect reporting system and the conclusions of an Efficiency Scrutiny report (see paragraph 3.3) show that the previous arrangements had not systematically identified defects and the necessary work on standards and specifications.

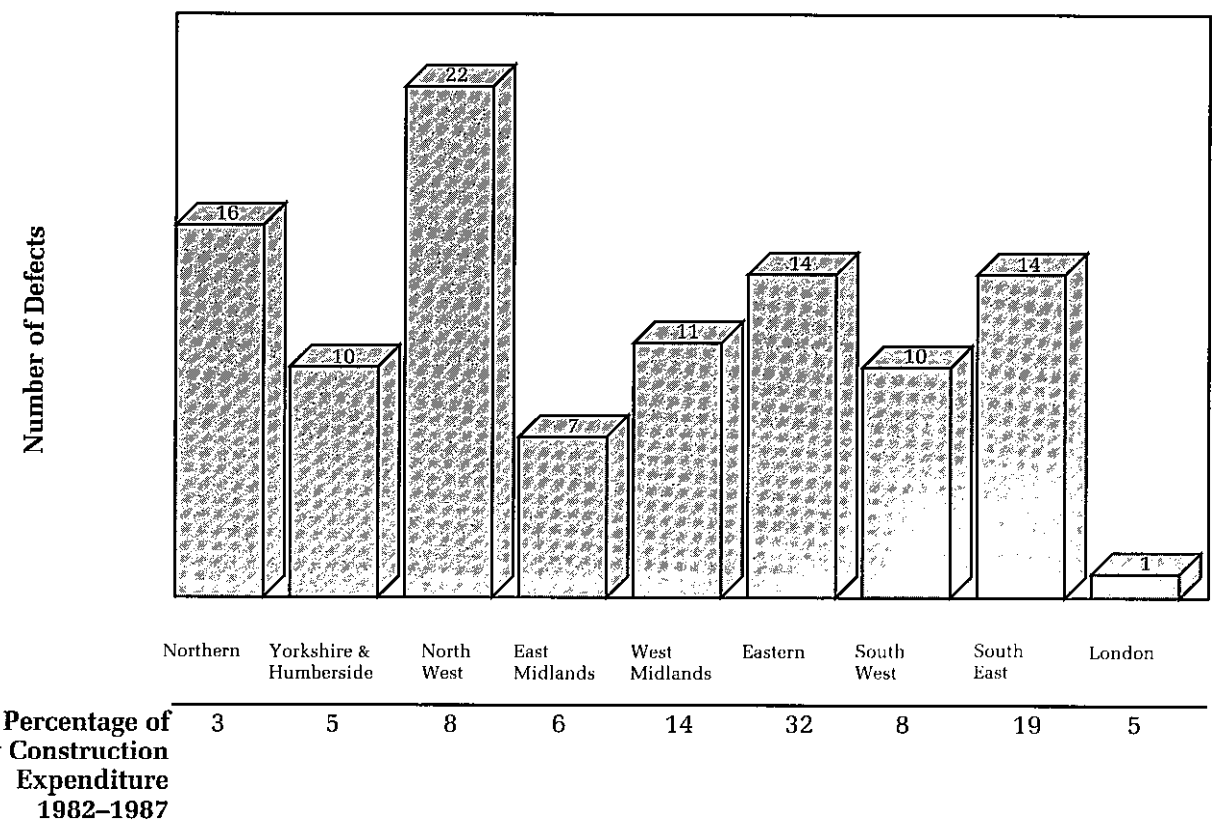
Analysing common problems

2.10 The transport departments have relied upon the technical feedback arrangements to identify common problems, but have not systematically analysed defect reports. The National Audit Office therefore sought to identify the main causes and broad costs of premature maintenance. They interviewed staff and examined departmental records about problems relating to over 200 roads and bridges, concentrating on cases where remedial costs were more than £100,000 during the last 10 to 15 years. In the cases examined remedial work (mainly since 1980) has cost £212 million, with a further £50 million remaining to be spent.

2.11 The departments told the National Audit Office that most of the problems could not have been foreseen and in some cases the costs would have

Figure 1

Defects reported by regions 1982–1988



been incurred anyway at a later date. They also considered that the costs of remedial work should be put into context by comparing them with total expenditure on new construction. In the Department of Transport cases examined by the National Audit Office and those included in the consultants' survey (paragraph 2.8) the remedial costs incurred or identified as required over the next 15 years for roads and bridges built in the 1970s represented 7 per cent of the costs of all new construction during that period (after allowing for inflation). These remedial costs, some of which will be incurred up to 35 years after construction, need to be discounted in judging how much would have been worth spending at the time of construction if by doing so all the remedial costs identified could have been avoided. On this basis the discounted costs of the remedial work are equivalent to 3 per cent of the construction costs; and this would represent some £26 million in relation to the departments' 1988–89 new construction programme of £866 million. The departments consider that raising the standards of design and construction to try to eliminate all risk of remedial expenditure would add far more than 3 per cent to the costs of initial construction; and in their view that would not represent better value for money than current practice.

2.12 The calculation in paragraph 2.11 is based on the cases examined in this report and takes no account of the costs of delays to road users whilst repairs are carried out. Such costs can be significant, but insufficient information is available within the departments to put a firm figure to them, given the many variations in circumstances. In one case (A405 Hunton Bridge to Maple Cross), however, the Department assessed delay costs at £1.2 million, equivalent to 50 per cent of the physical repair costs. This proportion is broadly consistent with the Department's assessment of delay costs on some major maintenance contracts in recent years. If these are taken as representative of the delay costs arising from remedial work in general, it would increase the economic cost of premature maintenance for the period under review from £262 million (paragraph 2.10) to a total of some £400 million.

2.13 The National Audit Office categorised cases of premature maintenance according to:

(a) the physical characteristics of the roads and bridges concerned (eg concrete, bituminous construction) and the nature of the problems encountered (eg geotechnical conditions, chloride contamination, etc);

(b) the four stages in the construction process where problems arise:

- design:
  (responsible for £139 million of remedial costs);
- specification:
  (responsible for £53 million);
- supervision:
  (responsible for £24 million);
- workmanship:
  (responsible for £46 million).

As illustrated in Table 2.

2.14 Premature maintenance frequently arises from a combination of factors. For example, with a concrete road a problem can arise from faults in the departmental specification, from poor workmanship by the contractors, and from inadequate supervision. With a concrete bridge a bad design can be followed by poor quality concrete and inadequate water-proofing resulting in damage by chloride contaminated water. For the purposes of the analysis in Table 2 the National Audit Office apportioned repair costs in such cases equally among the relevant activities. The departments considered that substantial investigation would be required to apportion these costs accurately. But the National Audit Office believe that the analysis carried out is sufficient to indicate the broad costs and categorisations involved.

2.15 Since problems caused by unexpectedly high flows or loadings of heavy lorries are linked with the design stage of a project they are included under that heading in Table 2. The National Audit Office consider that departmental reporting procedures should include such problems to provide a total picture of premature maintenance.

2.16 Table 2 shows that problems on roads and bridges demonstrate weaknesses in each of the four stages of the construction process. The results are analysed further in Parts 3 and 4 of this report.

Table 2: Analysis of problem roads and bridges and consequent expenditure

Categories	Total	Activities[3][4] Design[2]	Specifications	Supervision	Workmanship
Number of cases[1]					
Roads					
Geotechnical Conditions	8	6	1	1	—
Concrete Roads	17	4	8	5	8
Bituminous Pavements	14	6	5	2	6
Road Base & Sub Base	20	10	13	6	6
Other	4	3	1	—	—
Total roads	**63**	**29**	**28**	**14**	**20**
Bridges					
Alkali-Silica Reaction	4	—	4	—	—
Chloride Contamination	19	10	4	11	10
Concrete Cover	20	1	—	1	20
Bridge Joints	28	27	—	1	2
Waterproofing	28	17	9	1	5
Overstressing, Welding	4	3	—	1	2
Geotechnical Conditions	6	6	—	—	—
Severn Bridge	1	1	1	1	1
Midland Links	1	1	—	1	1
Tees Viaduct	1	1	—	1	1
Other	30	12	—	15	20
Total bridges	**142**	**79**	**18**	**33**	**62**
Total	**205**	**108**	**46**	**47**	**82**
Costs[5]	£m	£m	£m	£m	£m
Roads					
Geotechnical Conditions	13.8	9.3	0.6	3.9	—
Concrete Roads	42.9	9.4	17.4	2.4	13.7
Bituminous Pavements	45.5	26.6	8.9	0.1	9.9
Road Base & Sub Base	39.1	10.8	23.1	2.6	2.6
Other	0.2	0.2	—	—	—
Total roads	**141.5**	**56.3**	**50.0**	**9.0**	**26.2**
Bridges					
Alkali-Silica Reaction	0.8	—	0.8	—	—
Chloride Contamination	4.9	3.7	0.5	0.5	0.2
Concrete Cover	2.2	0.1	—	—	2.1
Bridge Joints	2.3	2.1	—	0.1	0.1
Waterproofing	5.7	2.2	1.7	0.1	1.7
Overstressing, Welding	0.2	0.1	—	—	0.1
Geotechnical Conditions	4.0	4.0	—	—	—
Severn Bridge	52.5	52.2	0.1	0.1	0.1
Midland Links	33.0	11.0	—	11.0	11.0
Tees Viaduct	10.8	3.6	—	3.6	3.6
Other	4.4	3.5	—	0.1	0.8
Total bridges	**120.8**	**82.5**	**3.1**	**15.5**	**19.7**
Total	**262.3**	**138.8**	**53.1**	**24.5**	**45.9**

Notes:

[1] The table excludes cases where no repair costs were borne by the departments.

[2] Design includes traffic forecasting.

[3] Where roads or bridges demonstrated problems in more than one category or activity they are included under each. Therefore the totals in the analysis columns exceed the grand total.

[4] For the purpose of this analysis, where problems arose from a combination of factors, repair costs have been divided equally among the relevant activities (paragraph 2.14), except for the Scottish cases, for which the Scottish Development Department provided apportionments.

[5] Remedial costs include actual (mainly since 1980) and estimated expenditure.

Part 3: Design and Specification

3.1 The departments set design standards and specifications, where possible adopting those of the British Standards Institute. They publish jointly the Specification for Highway Works, containing detailed specifications for materials, construction practices and quality control tests. The first edition, issued in 1948, has been periodically revised and the sixth edition was published in 1986. These standards establish the quality of construction that is expected from engineers and contractors.

3.2 Between major revisions, the Department of Transport have also issued amendments to the specification mainly on the basis of technical feedback arrangements from their regional offices, the Scottish Development Department and the Welsh Office. In addition they take into account the results of research which they have commissioned and their routine procedures for assessing maintenance needs, for example the bridge inspection system (see paragraph 2.8 above).

3.3 In 1987 an Efficiency Scrutiny on the role of the Department of Transport's specialist engineers noted, inter alia, that:

— the vital role of standards in relation to value for money was not always as prominent as it should be;

— new standards were rarely monitored to determine whether the planned benefits had been achieved;

— there was no focal point in the organisation so it was difficult to direct work in a coherent way;

— there was a "gap" between the engineering specialists and the rest of headquarters;

— staff had too many jobs to cope with efficiently which meant progress was often slow, or work on standards was not done well.

In implementing the scrutiny's recommendations the Department produced a formal business plan of the engineers' work, restructured the liaison committees, and improved the management and implementation of research.

Ground conditions

3.4 Knowledge of the ground conditions of the area through which a road is to be built is essential if engineers are to produce the optimum scheme design. Inadequate surveys can lead, for example, to the use of unsuitable material or poor drainage causing embankment failures and delays in construction while designs are altered. As a safeguard the Department of Transport and the Welsh Office liaise with the design consultants on the interpretation of the results of the ground investigations. The Scottish Development Department go further by appointing a separate consultant to check the interpretation of the survey.

3.5 The National Audit Office examination noted eight roads where geotechnical problems resulted in extra work costing in total some £14 million; the most expensive case — the A6 Chapel-en-le-Frith — is noted in Table 3. The Department of Transport's guidance on the conduct of surveys, published in 1970 has been revised three times up to 1987; they consider this has progressively improved the effectiveness of ground investigations.

3.6 The transport departments told the National Audit Office that geological surveys based on samples taken from limited areas cannot be comprehensive and results may be misleading. On the other hand, wider or more comprehensive surveys are expensive. Expenditure on geotechnical analysis therefore has to be balanced against the risks of problems arising during or after construction. As an additional safeguard the Department of Transport require surveys using special testing apparatus but only for certain soil types. The Scottish Development Department have a similar requirement and have also made geotechnical analysis a priority for research.

3.7 In view of the high remedial costs resulting from geotechnical problems, the National Audit Office recommend that the Department of Transport and the Welsh Office should carry out further cost benefit analyses to review whether spending more on site investigations would save money in the long run.

Road materials: wet mix

3.8 The National Audit Office identified several schemes where the use of a wet mix road base had proved unsatisfactory. The four cases noted in

Table 3

Ground conditions

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
A6 Chapel-en-le-Frith (August 1987) Ground movements caused the collapse of an embankment and the need for additional works on a cutting slope. There were also difficulties with the construction of a retaining wall.	In March 1989 the scheme had cost £36m compared with a tender price of £17m. Additional and remedial costs caused by the difficult ground conditions were responsible for about £12m of the total increased cost.	1970 — published recommendations for ground investigations 1976) 1981) issued revised guidance 1987)

Table 4

Road materials: Wet mix

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
A38 Exeter to Plymouth (1972–75) Various schemes opened between 1972–75 suffered extensive rutting.	£11m 1976–83	
A64 Malton Bypass (1978) Despite reservations by the regional office the Department of Transport required the use of wet mix in accordance with the approved specification. The pavement needed premature maintenance.	£3.1m 1985–88	1969 — banned wet mix from use on motorways 1973 — Working Party formed to investigate problems 1976 — wet mix banned from use on dual carriageways 1978 — wet-mix restricted to the construction of lowest trafficked single carriageway roads 1987 — use of wet mix completely banned on trunk roads
A49 Callow Hill (February 1980) Asphalt slippage and cracking in the year the road was opened.	£0.7m including major reconstruction 1980–85	
A17 Heckington Bypass (December 1982) Asphalt slippage and cracking within two months of opening.	£1.2m	

Table 4 have required remedial work costing some £16 million. The Department of Transport recognised construction difficulties with wet mix and banned its use from motorways in 1969. Further problems, however, occurred on the A38 and, following investigations by a working party in 1973 to 1975, the Department restricted its use between 1978 and 1987 to the construction of trunk roads carrying the lowest levels of traffic. In 1983 one English region banned the material but the Department did not finally remove it from the design standard until 1987.

Road materials: bitumen

3.9 For many years most roads in Great Britain have been constructed from bituminous materials. But bitumen is sensitive to temperature changes during manufacturing and laying. The sensitivity of bitumen also presents difficulties in specifying materials which resist heavier traffic loading but do not become brittle in winter. As a result the transport departments have generally been unable to hold contractors responsible for subsequent defects.

Table 5

Road materials: Bitumen

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
M67 Hyde Bypass (1978)		
Deterioration of the surface leading to widespread breaking up and potholing. This was due partly to a decision to use a stiffer than normal bitumen mix and possibly to poor workmanship.	£414,000	1979 — revised specification and advice issued on design requirements for hot rolled asphalt to reduce surface deformation; 1980 — revised specification and advice issued on requirements for hot rolled asphalt relating to cold weather working; — specification issued for hot rolled asphalt with crushed rock fine aggregate.

3.10 Since 1976 the Department of Transport have defined the temperatures suitable for laying bitumen. More recently they have issued advice on wind chill factors but the specification will not be amended until they have the results of further research. From the sample of cases the National Audit Office examined they noted four bituminous roads which had required maintenance earlier than expected because of problems with laying the surface, resulting in remedial work costing £1 million; see the example in Table 5.

3.11 The Department of Transport established in 1985 a new testing facility, at a cost of £1.5 million, to speed up the evaluation of new pavement materials. It cannot model long-term environmental conditions so full-scale site trials are still necessary. But the use of the new equipment and the processing of the data produced has been hampered by lack of staff. Consequently, information concerning the suitability of new materials has not been available as quickly as the Department had hoped.

Road materials: concrete

3.12 Since most roads are bituminous, engineers in Great Britain have less experience in designing and constructing concrete roads. The National Audit Office examination noted 17 roads where defects in concrete strength and in joints required remedial work costing £43 million. The Department of Transport attribute problems with concrete roads mainly to poor workmanship but the National Audit Office consider the persistence of these problems must also raise questions about the adequacy of supervision and the departmental specification.

3.13 Joints between concrete slabs allow for expansion and contraction in response to temperature changes. The joints are sealed to stop water and grit entering and the seals have to expand and contract with the concrete. The joints on concrete roads built in the 1970s and early 1980s were too narrow, leading to problems when used with certain types of sealant, causing breaks in the seals. Some types of sealant material also proved unsatisfactory. Examples of difficulties are included in Table 6.

3.14 Although problems arising from narrow joints were identified on the A405 in 1982, the specification was not amended until 1984. The departments acted more promptly, however, by excluding from the specification polyurethane-based sealants which complied with the British Standard but proved unsatisfactory in practice. The National Audit Office note that these materials displayed problems within one year of installation, which raises the question whether they had been adequately researched before being brought into use. Remedial work cost the Department of Transport £0.5 million.

3.15 The Department of Transport stopped research into joint sealants 15 years ago. No further work was carried out until a new programme costing £25,000 a year was launched in 1985.

3.16 Concrete roads without joints ("continuous reinforced concrete pavements") were introduced in the United States in the early 1930s and have since

Table 6

Road materials: Concrete

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
A405 Hunton Bridge to Maple Cross (1976)	£2.4m 1983	
M25 A111 to A1(M) (1975)	£1.9m 1985	
M25 (between J24 and J25) (1981)	£3.7m	
Joint widths specified were too narrow to allow the sealant to expand and contract without coming away from the joints.		1983 — specification for sealants changed 1984 — specification changed to increase width of joint 1985 — new research programme started at £25,000 a year 1986 — specification amended to improve workmanship 1987 — new design standard for concrete roads issued
A449 Usk to Coldra (1982)		
Failure of dowel bar debonding agent.	£6.6m	
M25 (M11 to A12) (April 1983) **M1 Breakspears to Berrygrove (November 1982)**	Resealing of joints. Estimated cost £0.5m	
Failure of cold pour polyurethane-based sealant..		

been used there extensively. Since 1968 they have also been used in Belgium notwithstanding some early problems. Between 1975 and 1986 the Department of Transport built nine road schemes in Great Britain taking account of the problems in this form of construction encountered overseas. In August 1987 they cautiously introduced a design standard for continuous concrete roads. Whole life costing for such construction suggests that higher initial costs will be more than offset by reduced expenditure on maintenance, especially for roads carrying heavy traffic.

3.17 The specification for concrete was changed in 1984 to increase durability. This followed reports by the Department of Transport's Concrete Advisory Panel on the results of their inspection of unreinforced concrete pavements built over the preceding 10 years. The Concrete Advisory Panel, which was funded by the Department and the concrete industry, ceased to function in 1982. Advice on concrete roads is now handled by the Department's own specialists and the concrete industry.

Lorry flows and loadings

3.18 The Department of Transport first published in 1960 the recommended thicknesses of the constituent layers of a road considered necessary to achieve the design life for different traffic loadings and ground conditions. Following continuous monitoring of lorry axle loading they amended this standard in 1970 and 1978 to take account of the increases in commercial vehicles and their loadings. In 1983 the Transport Committee, Session 1982–3 (HC 28-I) criticised the Department for having reacted too slowly to the increase in the number of heavy vehicles and their weights. The Committee considered these to be the main causes of premature failure of motorways.

3.19 The Department assured the National Audit Office that following the changes in 1978 to the design standard, premature maintenance due to a drastic reduction in design life caused by heavy lorries should not recur. They also said that recent research showed their previous calculations of the damaging effect of lorries to be overestimated.

Table 7

Lorry Flows and Loadings

Scheme (date of opening) and problem	Costs of Remedial Work	Departmental action and comments
M621 (1973)	Reconstruction and overlay £2.3m, 1981–84	
A19 Teesside Diversion (stage 1–1975)		
Strengthening required within seven years of opening because of higher than expected heavy lorry flows and loadings.	£2m up to 1984	1978 — pavement design standard revised to increase allowance for damaging effect of lorries 1985 — interim design standard to cover high traffic loadings 1987 — pavement design standard updated to allow at least 2 per cent growth in lorry flows
A45 Spikes Lane to Creeting St Mary and A140 to Claydon Interchange (1975)		
Strengthening required nine years after opening because pavement was not thick enough.	Reconstruction and overlay estimated at £2.5m in 1987–88	
M4/A48(M) Tredegar Park to St Mellons (1977)		
Risk of structural failure appeared in 1985. Traffic loadings had already exceeded the design life.	Estimated costs £6.7 million	
M25 Thorpe to Egham (1976) and M25 Chertsey to Thorpe (1980)		
Reconstruction required in 1987, seven and eleven years after opening, because of higher than expected traffic loadings. Overlay which is normally about one third of the cost of reconstruction, was not cost effective because there was insufficient headroom for the overbridges and the underbridges could not accept the weight of an additional overlay.	Estimated costs of £9m in 1988–89.	Remedial measures advanced to incorporate them in M25 widening work

3.20 Because premature maintenance arising from unexpectedly high traffic loadings or heavy lorry flows is not classified by the departments as a defect and not reported, the full extent of this problem has not been assessed. The National Audit Office examination noted nine such cases, all built before the relevant standard was changed in 1978. Five of them involving remedial costs of £22.5 million are described in Table 7. Two of these cases required premature maintenance within seven years of opening. Some of the estimated remedial costs for these cases could have been saved if thicker pavements had been provided when the road was built. In the case of the A19 Teesside Diversion the traffic loading had reached the level forecast for the 15th year by the fourth year after opening.

3.21 The additional cost of providing extra pavement thicknesses at the time of construction is relatively low. In evidence to the Transport

Committee in 1982 (HC 28-II) the Department of Transport stated that the loading capacity of a road expressed in terms of million standard axles could be increased five fold for an increase of five per cent in construction costs. The Department are satisfied, however, that the 1978 standard is more than adequate for current and foreseeable lorry loadings. The National Audit Office nevertheless recommend that, given the uncertainties of heavy lorry forecasts, the Department should undertake sensitivity analyses of the effect of different forecasts on the design of pavements.

Specification tolerances

3.22 It is impracticable to construct a road with each pavement layer exactly the same thickness along its entire length, and the departmental specification sets out acceptable tolerances for this work. Two schemes, the M62 East of Ferrybridge and the M18 from junctions 6 to 7, built in 1975, developed problems in 1978 and 1984 respectively because the pavement layers had generally been constructed to the minimum thicknesses and, although within the specified tolerances, proved to be insufficient for the traffic using the road. Remedial costs have amounted in total to £16.8 million. Feedback arrangements from the regional offices identified this problem but there was considerable doubt about whether the specification or workmanship was at fault. Nevertheless changes were made to the specification in 1978 to prevent any recurrence.

Bridge design

3.23 The departments examine preliminary bridge design proposals to ensure that the subsequent detailed design will comply with departmental standards. Once these preliminary proposals have been approved any variations must be authorised by the departments.

3.24 The National Audit Office noted 79 bridges where problems with the design led to early remedial work costing in total £82.5 million (including the Severn Bridge where the estimated cost of repairs is £52.2 million). The most significant problems arose from acceptance of alternative designs, poor design or installation of joints and inadequate waterproofing.

3.25 The Department of Transport accepted alternative designs for four major structures which subsequently required substantial remedial work; see Table 8. In two of the cases the Department accepted alternative designs proposed by the contractor which offered cost savings and met the design requirements. In a third the Department asked the consultant to provide an alternative design because the original was too expensive.

3.26 The Severn Bridge, which was opened in 1966, was built to a radical new design. Within eight years there were signs of corrosion and fatigue, and by 1982 fatigue cracks had developed, which consultants appointed by the Department attributed in 1983 to traffic flows and loadings being greater than forecast. In 1984 the Department carried out a thorough appraisal of the options available on costs and timings for maintenance on the Severn Bridge, taking into account the proposals for a second crossing. They concluded that, even if a second crossing were provided, substantial expenditure, estimated at £28 million, would be needed to strengthen and maintain the bridge adequately in order to keep it operational.

3.27 In 1982 the Department examined the reasons why the bridge required major strengthening in less than 20 years. They found that just before construction of the foundations, in 1961, the design engineers had offered a revised design. The Department had not followed their procedures in operation at that time and had not approved the revised design calculations, methods or standards. The review concluded that:

(a) the Department must have rested on the assurance from the engineers that the structure would be satisfactory for its purpose with low cost maintenance and long life;

(b) the Forth Bridge, built just before the Severn Bridge with a design similar to that originally proposed for the Severn, had carried comparable loadings without requiring major strengthening;

(c) although heavy lorry traffic flows and loadings had increased since the design of the Severn Bridge the Armitage Report had recorded in 1980 that the numbers of heavy lorries had risen steadily from the late 1940s until 1967 and for the previous 30 years there had been an uninterrupted trend towards the use of heavier lorries.

The programme of strengthening work, including increased protection for the bridge against wind damage and ship collision, was started in 1985 and in 1988 was estimated to cost £70 million, including about £17 million for resurfacing and routine maintenance.

Table 8

Bridge design

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
M25 Gade Viaduct (1987)		
After the contract was awarded the contractor offered, and the Department of Transport approved, a cheaper alternative design using a different source of steel. The steel was not properly fabricated, early inspections failed to detect this, and alignment between sections of steel box girder and welding were faulty.	Remedying construction defects and correction of alignment required. The contractor has accepted liability and is carrying out work at his own expense.	
A19 Tees Viaduct (1975)		
An alternative design was offered by the contractors and accepted on the advice of the consulting engineer. There were problems with the bearings. Subsequent work by an independent consultant revealed chloride contamination and other deterioration.	Refurbishment programme costing £10m in Spring 1987 which includes fitting of bridge enclosures for protection and access.	The Department of Transport attribute only a proportion of £10m to design. Remedial action is to current standards, not those appertaining when the structure was opened.
M5/M6 Midland Links (1970–71)		
To reduce costs the Department of Transport required the designers to provide a cheaper design than the one originally submitted. Problems have occurred with bearings and expansion joints largely due to poor workmanship. There have also been problems with chloride contamination in certain elements.	Between 1975 and 1987 £33m has been spent on major works. Maintenance expenditure of £5m a year is expected for the foreseeable future. £1.5m was recovered from the contractors.	The Department of Transport attribute only a small proportion of £33m to design defects.
M4 Severn Bridge (1966)		
The Severn Bridge was a new design and cost £8m to construct. Problems were found with hangers in 1972 and the rocker bearings and weldings in the late 1970s. Fatigue cracks were found in the early 1980s.	Estimated cost of replacing bearings and weldings £1.4m. Major strengthening programme started in 1987 and estimated to cost £70m in 1988.	

3.28 More rigorous procedures for the technical approval of structures were introduced by the Department in the early 1970s. These include certification of the design and the design check. Nevertheless substantial expenditure has been required to maintain or strengthen the major structures built in the 1960s and 1970s. In view of this and the building of the Dartford River Crossing and the proposed second Severn Crossing, the National Audit Office recommend that the departments should review their practices for ensuring that accepted designs will allow them to achieve their design lives without undue risk of incurring extra maintenance costs.

Access for maintenance

3.29 In the 1960s and 1970s some bridges were designed and built without proper access for maintenance. It has proved very expensive to provide for such access later. In two cases, the Tees Viaduct opened in 1975 and the Severn Bridge opened in 1966, permanent access is now having to be provided at a cost of £2.75 million and £3.8 million respectively.

3.30 Since 1973 the Department of Transport have required designers to consider access when designing bridges and from 1979 proposals for access arrangements had to be approved by the Department. In 1983 they issued advice on the variety of possible access arrangements. The other departments have followed these requirements. In terms of detailed design of the structure the Scottish Development Department introduced in September 1987 a new design detail for access chambers to expansion joints and bearings on all new bridges of significant size. They also included a requirement generally to minimise the use of joints through surfacings where feasible. The problems with expansion of joints and the importance of providing adequate access at the design stage were also stressed in the consultants' report referred to in paragraph 2.8. The Department of Transport and the Welsh Office intend to issue advice later in 1989 similar to that of the Scottish Development Department.

Alkali-silica reaction

3.31 Alkali-silica reaction, commonly known as concrete cancer, is an irreversible reaction between alkalis in cement, moisture and certain types of rock, which may lead to cracking and structural weaknesses. The problem is aggravated by water penetration, the primary causes of which are poorly designed joints or inadequate waterproofing.

3.32 The problem appeared in other countries many years ago — for example in Denmark in the 1950s. But the first cases were not found in the UK until 1980. In 1982 and 1983 the Department of Transport issued interim advice to limit the possibility of alkali-silica reaction and this was consolidated in the 1986 edition of the specification. The Department consider that adherence to this specification should ensure that the incidence of the reaction in new construction will be very low or non-existent. In addition, the Department started in 1983 a 10 year research programme costing £1.5 million.

3.33 By July 1988 the Department of Transport's routine inspections of bridges had found 165 confirmed and 300 potential cases of alkali-silica reaction. Between 1982 and 1988 they spent £6 million on remedial work and expect to spend a further £3.9 million over the period 1988–1992. No estimates are available of further expenditure that will be involved in later years.

3.34 Bridges suffering from alkali-silica reaction include several on the A38 in Devon, amongst them the Marsh Mills Viaduct which was built in 1970 and is particularly badly affected. Interim repair work has cost £0.5 million and in 1983 consultants concluded the viaduct would need to be replaced within 10 years at an estimated cost of £5 million (at 1983 prices).

Chloride contamination

3.35 Chloride contamination:

— arises when de-icing salts seep into the concrete covering, corrode the steel components and weaken the structure;

— progresses more rapidly where there is inadequate waterproofing or concrete cover;

— can drastically reduce the life of a bridge from the notional life of 120 years to less than 20 years; for example the deck of the A465 Taf Fawr Bridge, opened in 1964, was replaced in 1982 at a cost of almost £3.0 million.

3.36 In 1965 the Department of Transport issued instructions that all new bridges must be waterproofed. By the late 1970s they recognised that the increasing use of road salts since the 1960s had caused more frequent and severe chloride contamination; and by 1987 their bridge inspections had identified chloride contamination in 151 bridges built after 1965. The National Audit Office examination showed that chloride contamination had been responsible for remedial work costing £4.9 million on 19 bridges; examples are in Table 9.

Table 9

Chloride contamination

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
A406 Angel Road Railway Bridge (1962) The bridge was built before the Department of Transport required waterproofing membrane and has suffered extensive chloride contamination. Although the Department were aware of these problems in the late 1960s they did not install waterproofing until 1983.	£1.2m	The Department of Transport delayed waterproofing because a new scheme was likely to require demolition of the structure. Remedial works commenced when the new scheme was further delayed.
A46 Widmerpool Interchange Bridge (1965)	£0.2m 1986 and 1988	1965 — the department required all new bridges to be waterproofed
A1 Balderton Hospital Link Bridge (1971) Seepage of de-icing salts through poorly designed expansion joints. Problems identified in 1984; remedial work undertaken 1987.	£0.16m 1987	1969 to 1986 — progressively increased concrete cover to reinforcement 1978 — bridge inspection procedures introduced 1980 to 1985 — consultants carried out more detailed inspections on 120 bridges
A80 Dullatur and Old Inns Bridges (1964) The bridges were built without waterproofing membranes and have suffered extensive chloride contamination.	Estimated cost £0.16m	1986 — the Department appointed consultants to investigate condition of concrete bridges 1988 — the Department received consultants' report 1989 — report published

3.37 The scale of the problems caused by chloride contamination was underlined by the results of an investigation by consultants appointed by the Department of Transport in 1986 to investigate the condition of their concrete bridges. The consultants were due to report in 1987 but the problems were greater than expected and they did not submit their report until July 1988. The Department published it in April 1989 and are still considering the recommendations.

3.38 The report identified widespread chloride contamination affecting 144 of the 200 bridges surveyed on a random and representative basis. Most of these cases had not been picked up by the Department's defect reporting system. Extrapolating these figures suggested that some 4,250 of the Department's 5,900 concrete bridges might be affected. The consultants estimated in 1988 that £800 million would be required for repairs over the next 15 years to ensure that these bridges continue to give satisfactory service. A substantial proportion of this cost is due to chloride contamination.

3.39 There are a number of ways of combating chloride attack. One method which has been successfully used in several other countries for a number of years is to protect the concrete surfaces by spraying them with a product called Silane. The departments are now considering its use for bridges in Great Britain, as recommended in the consultants' report referred to above. The Department of Transport however, have expressed reservations about the long term effectiveness of Silane, in particular the effect of carbonisation which might present itself in 50 to 60 years time.

3.40 The consultants also recommended other specification changes to reduce the rate of chloride penetration. They concluded that the depth of concrete cover required by the existing design standard was insufficient and recommended increasing it. Further, they suggested that, if practicable, the specification for concrete should be amended to reduce the proportion of chloride. The Department are considering these recommendations.

3.41 Chloride contamination can also be avoided at source by using alternatives to salt as a de-icing agent. However, the available alternatives are several times more expensive. Urea has been used on the Midland Links but the Department of Transport are concerned about its environmental side effects and are researching this further. Glycol has been used on some bridges in Scotland even though it costs seven times as much as salt. In 1987 the Department of Transport initiated research into the alternatives available in order to assess the economic benefits.

3.42 In 1985–86 the Department of Transport spent some £10 million on de-icing trunk roads and motorways. As a substantial proportion of the £800 million required over the next 15 years (see paragraph 3.38) will be needed to remedy chloride contamination, and one of the main causes of the damage is the use of de-icing salts, there is in the National Audit Office's view a clear case for a thorough examination of the costs and benefits of the various de-icing options available.

3.43 The remainder of the Department of Transport's research programme on chloride contamination has concentrated on improving detection, advising on methods and materials for extending the life of affected bridges and developing improved design standards to reduce the vulnerability of new bridges. The consultants' report (see paragraph 3.37) recommended extending research into a number of other areas including additional work on methods of testing for and repair of bridges affected by chloride contamination.

Bridge materials

3.44 The specification for the proprietary products which may be used in highway construction applies also to bridges. Before new products are approved and added to the specification they are subject to trials by the Department of Transport, who also monitor their use and performance. Any unsatisfactory characteristics are dealt with by modification or withdrawal of the product. The National Audit Office nevertheless noted three cases where waterproofing products have failed, with remedial work costing some £1.4 million; two examples are given in Table 10.

Table 10

Bridge materials

Scheme (date of opening) and problem	Costs of remedial work	Departmental action and comments
M180 Trent Bridge (1979)	Remedial work estimated £0.29m	
A19 Billingham Diversion (November 1982)	Re-waterproofing at £0.1m	
Failure of bondings on waterproofing led to break-up of surface on M180 Trent Bridge. In the same year the same product was used on the A19 Billingham Diversion.		The Department of Transport attributed the failure partly to the novel use of lightweight concrete in the A19 bridge deck.

Part 4: Workmanship and Supervision

4.1 The construction of roads and bridges involves three parties:

the transport departments

— set design standards and specifications to be followed by consulting engineers and contractors;

— appoint consulting engineers and select contractors;

— are responsible, through their project managers, for maintaining progress and ensuring the overall achievement of the project's objectives;

the consulting engineer

— designs the scheme;

— prepares detailed contract documents;

— administers, supervises and ensures the successful performance of the contractor.

the contractor

— trains, instructs and supervises the workforce;

— provides the materials and equipment in accordance with approved design standards and specification;

— carries out the work on site.

4.2 The analysis by the National Audit Office noted that poor workmanship was a factor leading to remedial work on 20 roads and 62 bridges examined. Inadequate supervision contributed to problems on 14 roads and 33 bridges. The total cost to the departments of such cases was some £70 million (see Table 2). In addition, the consultants' survey referred to in paragraph 3.37 found that poor workmanship was to blame for 77 of the 144 bridges suffering from chloride attack. The extent to which the departments may seek to recover costs involved from other parties is discussed in paragraphs 4.11–4.14 below.

Role of consulting engineers

4.3 Engineers who design and supervise the construction of the departments' roads and bridges may come from local authorities but are more usually consulting engineers appointed from the private sector. During construction they have a dual capacity. For certain purposes they act as agents of, and must consider the wishes and interests of, the departments. But they are also responsible for resolving disputes and deciding — independently — the rights and obligations of the parties under the contract. They effectively determine such matters as the contractor's entitlement to a certificate of payment or granting an extension of time. For example, the Leatherhead to Reigate section of the M25 was due to open in December 1984 but this was delayed by 10 months largely due to extensions of time granted by the engineer under the contract. The contractor closed the site during the 1984–85 winter period after the receipt of one of these extensions of time.

4.4 The transport departments have no formal right to intervene in the contractual decisions of the appointed consulting engineers. Since 1985 the Department of Transport have been reviewing the role of their project managers and their relationship with consulting engineers on construction projects. In order to exercise greater control over these projects the Department intend to let three contracts in 1989 under new conditions which will redefine the role of the consulting engineer.

4.5 Some 7,800 cracks on the Leatherhead to Reigate section of the M25 were identified both during construction and after contract completion and substantial remedial work was required. The consulting engineer decided that some of the defects were due to poor workmanship and were therefore the responsibility of the contractor; but others were caused by a combination of materials and construction details permitted by the specification and so were the liability of the Department of Transport. On 2 June 1988 the Department commissioned another consulting engineer to investigate the technical issues underlying the engineer's view of the causes of the defects and his allocation of technical liability. The investigation was to be independent and was also to cover other concrete roads built to the same specification. The report has been submitted and is under consideration. Matters arising from the M25 contract were referred to arbitration in December 1988.

Selection of consulting engineers

4.6 For selecting consulting engineers the transport departments have in recent years introduced

procedures similar to those for construction contractors. Since January 1985 the Department of Transport have chosen consulting engineers by competitive fee bidding. This has led to a progressive lowering of fee rates, which in 1987–88 were 27 per cent lower than those under the previous arrangement. The Welsh Office have used fee competition since October 1985 and the Scottish Development Department introduced competitive tendering for consultants' fees in April 1986.

Monitoring consulting engineers' performance

4.7 The departments recognised that reduced fees could adversely affect the quality of service provided by the consulting engineers. The Department of Transport have, therefore, reviewed their performance reporting arrangements and introduced a computerised system to monitor movements in fees and to identify trends and differences in cost between firms. The Department's regional offices produce annual and final scheme reports on the performance of all consulting engineers and these are used in selective tendering for new work.

4.8 The Scottish Development Department are also introducing computerised monitoring and have increased the frequency of their meetings with consulting engineers at the design stage of a scheme. In September 1988 the Welsh Office completed a review of their performance reporting system and decided to computerise their records, including reports on contractors (see 4.10 below).

Monitoring contractors' performance

4.9 Consulting engineers appointed by the Department of Transport make interim, annual, and final reports on the performance of contractors on every contract. All reports are submitted to the Department's headquarters and used for drawing up lists of contractors approved for selective tendering.

4.10 Engineers appointed by the Scottish Development Department submit performance assessments on contractors at interim and final stages of schemes. The Welsh Office have progressively improved their arrangements for obtaining engineers' reports on contractors. These are now required to be submitted at six-monthly intervals, and on completion of the contract.

Claims against contractors and consulting engineers

4.11 The National Audit Office examined 72 cases where at the end of June 1988 the Department of Transport considered that there was a potential claim against the contractor or consulting engineer. The situation was as follows:

- in 20 cases the Department obtained either compensation or remedial work at no cost to themselves, although eight of the cases were not finally resolved in April 1989;
- in 16 cases neither the contractor nor the engineer was found responsible;
- 10 claims were not pursued or failed for various reasons, including insufficient evidence, cases being statute barred;
- in the remaining 26 cases the question of liability had not been resolved;
- 11 cases in all had been under consideration for more than four years.

4.12 In determining recoverable costs only direct costs are eligible; the departments cannot claim for delays to road users during remedial work. As noted in paragraph 2.12 such economic costs are substantial, and may be equivalent to 50 per cent of the costs of remedial work.

4.13 The recoveries which are made are often much less than the costs incurred on remedial work, and below the amounts claimed as recoverable. In nine cases examined by the National Audit Office, remedial costs amounted to some £7 million, the Department of Transport considered £0.4 million to be legally recoverable, and they received some £0.2 million. In another case (the Midland Links), where defects appeared before the reporting system was set up, the Department incurred remedial costs up to 1988 totalling £33 million, they regarded £3.2 million as legally recoverable and they recovered only £1.5 million.

4.14 The Department's Yorkshire and Humberside region had tackled the problem in three cases by persuading contractors to carry out remedial work at their own expense — a practice which could be extended. The Department consider that it is more likely to be successful in smaller cases where the liability is clear cut. In view of the difficulties the departments have experienced in recovering any significant proportion of the costs of remedial work, the National Audit Office recommend the arrangements for control over supervision and workmanship should be reviewed (see also paragraph 3.12).

Sanctions

4.15 The following sanctions are available against contractors or consulting engineers whose performance is unsatisfactory:

— suspend them from approved tender lists permanently or for a period of time or for a specified number of contracts;

— invite them to tender only for lower value contracts;

— issue a formal warning.

4.16 The transport departments have not issued guidance on the action to be taken against contractors or consulting engineers who perform badly. The National Audit Office found little evidence that the sanctions available in principle were in practice regularly applied. In 1987 the Department of Transport had decided to give no new commissions to one consulting engineer for one year, and his performance on existing work was then to be reviewed. In the last two years they had given three other firms a formal warning. The Department's regional offices and the Welsh Office told the National Audit Office that on occasions they had excluded certain contractors from tendering. In 1985 the Scottish Development Department had suspended one contractor for two years and their dissatisfaction with the performance of another had been reflected by limiting the opportunities to tender for subsequent commissions.

4.17 There is informal liaison and exchange of information between the departments to co-ordinate action against contractors and consulting engineers with a poor record. Nevertheless the three departments together spent £866 million in 1988–89 on new construction, including £100 million on consulting engineers' fees, and the National Audit Office recommend that further consideration should be given to agreeing common guidance on sanctions to deal with poor workmanship or supervision. Better liaison on such matters, could help to influence the performance of contractors and consulting engineers who operate nationally. Consistency in departmental and regional approach would therefore be valuable.