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**PUBLISHED PROJECT REPORT PPR136**

**Survey of impregnated structures**

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**by A Calder, N Anderson and M McKenzie**

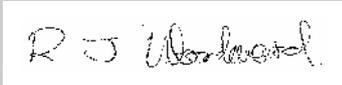
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## Executive summary

**PPR136**

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**Project Reference**

**3/359. Framework Arrangement - Provision of R&D Advice for the Design and Management of Highway Structures**

**Task Sponsor**

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### SCOPE AND OBJECTIVES

BD43/90 (1990) 'Criteria and material for the impregnation of concrete highway structures' was published by the Highways Agency (HA) in 1990. This document specified the requirements for new HA structures to be treated with hydrophobic pore-lining impregnants to provide protection against the ingress of de-icing salts. There was also a requirement to apply impregnants to all in-service structures provided that their condition was suitable.

Since 1990, it has been assumed that all new bridges have been treated and that the maintaining agents responsible have implemented the policy of treating in-service bridges. The HA commissioned TRL to carry out a survey of the 14 maintaining agents in England to assess the extent and effectiveness of treating bridges which have been constructed since 1990 and the older in-service bridges. The survey involved inviting the maintaining agents to complete questionnaires designed to yield information on the number of new and in-service bridges that had been treated.

### SUMMARY

Initially it was planned that each of the 14 maintaining agents in England would be invited to complete detailed questionnaires to provide the information needed for the survey. But, after consultation with two maintaining agents known to TRL and members of the Technical Appraisal Group of the HA, it was decided to split the data gathering into a two stage process:

1. Seek information and opinions from the maintaining agents in all 14 areas on general issues relating to the use of impregnants and establish the availability of more detailed data relating to the extent and effectiveness of application (preliminary questionnaire).
2. Select agents which had indicated that they have detailed information on impregnation which is reasonably accessible and invite them to give a price for completion of the main questionnaire. Two of the agents were then invited to complete the main questionnaire.

The maintaining agents in all 14 areas completed and returned the preliminary questionnaire. The following conclusions were drawn:

- Most of the agents considered that impregnation was an effective method of improving durability of concrete structures although there were some concerns regarding the health risks involved in application.

- The standards have been generally followed for new construction and in most cases repairs and remedial work, but it is unlikely that many in-service structures have been treated.
- Generally, the agents reported that they were able to implement the standard, but some had operational difficulties.
- Only nine of the agents had information as to which bridges in their area had been impregnated. Eight claimed that they had details of the treatment but collated information was only available for three areas. Eight agents were confident that they would be able to complete at least some of the main questionnaire.
- Half the agents had pre/post treatment monitoring data.

The maintaining agents for Area 7 and Area 9 completed the main questionnaire. Detailed information was supplied for Area 7 which showed that over 90% of the post-1990 structures had been treated compared with 30% for the pre-1990 structures. Information from Area 9 showed that some of their pre-1990 structures had been treated. No information was supplied for the post 1990 structures.

Additional information obtained from Area 7 demonstrated that some in-service structures had been treated in that area and the effectiveness of the treatment in controlling corrosion was being monitored. The report received only gave a summary of the data, although more details were available. A more detailed analysis of the data was outside the scope of the current project.

The results from the survey have highlighted the limitations in the current record keeping of impregnation and associated monitoring.

## **IMPLEMENTATION**

It is recommended that the Highways Agency should analyse the long term monitoring data held by some of the maintaining agents in order to demonstrate the effectiveness of impregnation in improving durability.

It is also recommended that the Highways Agency instruct maintaining agents and authorities responsible for new construction to keep detailed records of future impregnation of concrete highway structures. Provision should be made within the Highways Agency structures database (SMIS) for this information to be stored for use in planning future maintenance strategies.

# 1 Introduction

BD43/90 (1990) 'Criteria and material for the impregnation of concrete highway structures' was published by the Highways Agency (HA) in 1990. This document specified the requirements for new HA structures to be treated with hydrophobic pore-lining impregnants to provide protection against the ingress of de-icing salts. There was also a requirement to apply impregnants to all in-service structures provided that their condition was suitable.

Initially, monomeric alkyl (isobutyl) - trialkoxy silane, with a minimum active content of 92%, was specified. Since 1990, other products which are environmentally more friendly and easier to use have become available and European standard test methods to evaluate their performance have been developed. Other research projects to assess the effectiveness of silane impregnation, to develop techniques for checking that the impregnants had not been adulterated with solvents such as paraffin or white spirit and to investigate early age application have provided support for the updated guidance given in BD43/03 (2003) published in 2003.

Since 1990, it has been assumed that all new bridges have been treated and that the maintaining agents responsible have implemented the policy of treating in-service bridges. HA commissioned TRL to carry out a survey of the 14 maintaining agents in England to assess the extent and effectiveness of treating bridges which have been constructed since 1990 and the older in-service bridges. The survey involved inviting the maintaining agents to complete questionnaires designed to yield information on the number of new and in-service bridges that had been treated. It was anticipated that the output for this project would provide information on the success of the policy of treating bridges with impregnants and could be used by the Highways Agency to encourage the maintaining agents to treat their in-service bridges that have not already been treated. It was also anticipated that the information would be in a form that could be uploaded into the Highways Agency structures database (SMIS).

This project report gives the outcome of consultations with the maintaining agents and results of the data obtained from the questionnaires.

## 2 Project objectives

The objectives of the project were:

- (i) To determine the proportion of new and in-service structures within the current stock that have been treated.
- (ii) To assess the effectiveness of the impregnation of new and in-service treated structures

## 3 Approach

### 3.1 Draft introductory letter and questionnaire

Originally, it was planned that a questionnaire would be designed and sent to each of the 14 maintaining agents in England. TRL would provide a list of bridges (obtained from SMIS) in each area. It was suggested at the project inception meeting that TRL would write to each agent giving advance warning, explaining the background and purpose of the survey, and giving details of the information required. The letter along with a short accompanying paper was drafted and is reproduced in Appendix A. The introductory letter and paper were aimed at managers of each maintaining agent and gave some background on the project. The managers were to be asked to pass the paper to the agents' SMIS administrator and members of the bridge group who would be responsible for completing the questionnaire.

The next stage was to design the questionnaire which was to be sent to each agent electronically in the form of an Excel workbook. The workbooks to be sent to each area included lists of bridges built since 1990 and before 1990 on separate sheets. All the information required for each structure was to be entered on a single row. The first five cells in each row were filled in by TRL giving the structure key, bridge name, road number, structure type and date commissioned. The remaining cells contained the details required from the maintaining agents. The workbook included two additional sheets giving instructions and space for general comments (see Appendix B). The number of structures in the area was given along with details of what to fill in. The questions asked for each structure were listed for structures built before and after 1990. The questions were split into sections including treatment, retreatment, treatment following repairs and monitoring of structures. The sections were colour coded to assist with data entry.

Before sending the introductory letter and paper to the maintaining agents, two maintaining agents known to TRL and members of the Technical Appraisal Group of HA were consulted. Comments were sought on the letter, paper and draft questionnaire. It was generally considered that the information being requested was too detailed, and would be difficult and time consuming to provide. In many cases, the maintaining agents have changed periodically and therefore the information may not be available in all areas.

It was therefore decided to split the data gathering into a two stage process:

1. Seek information and opinions from the maintaining agents in all 14 areas on general issues relating to the use of impregnants and establish the availability of more detailed data relating to the extent and effectiveness of application (preliminary questionnaire).
2. Select agents which had indicated that they have detailed information on impregnation which is reasonably accessible and invite them to give a price for completion of the main questionnaire. Two of the agents were then invited to complete the main questionnaire.

### **3.2 Preliminary questionnaire**

The preliminary questionnaire and covering letter are given in Appendix C. This included some background information about the project and a short questionnaire (Annex A) along with a list of questions which were to be included in the main questionnaire (Annex B). Each of the 14 maintaining agents were requested to complete Annex A. The questionnaire was divided into two parts; the first part dealt with general issues relating to the use of impregnants and the second part enquired about the availability of detailed information.

Initially 13 out of the 14 agents completed Annex A and returned it to TRL. Only five of the agents claimed to have at least a reasonable amount of data and would be prepared to attempt to complete the main questionnaire. However, some of the agents indicated that this would take a significant amount of time. The five agents were invited to estimate timescales for completing the main questionnaires. These are given in Table 1. The reply from Area 6 was not received in time for it to be included in this exercise although data was available and they would have been able to complete the main questionnaire.

A detailed analysis of the data obtained from the preliminary questionnaire is reported in Section 4.1 below.

### **3.3 Issue of main questionnaire**

The main questionnaire was sent to AmScott and Amey Mouchel who are responsible for Areas 7 and 9 respectively. The instruction sheet listing the information required from each of the areas is given in Appendix D. This questionnaire was much simpler than the original draft questionnaire and only required information on details of the treatment for structures built before and after 1990 and if any subsequent retreatment had taken place.

**Table 1: Estimated costs and timescales for completing the follow up questionnaire**

Area Number	Maintaining agent	Area covered	Estimated timescale
2	InterRoute	Somerset, Avon, Wiltshire and Gloucestershire	6 months
7	AmScott	Leicestershire, Lincolnshire, Nottinghamshire and Derbyshire	2-3 months
8	Carrillion-URS	Buck, Herts, Beds, Essex, Cambs, Northants, Oxon, Leics and parts of Warwickshire (M45)	>8 weeks
9	Ameymouchel	West Midlands, Herefordshire, Worcestershire, Shropshire, part of Warwickshire	Within 2 months
10	Atkins	Cheshire, Greater Manchester, Merseyside and parts of Lancashire	Not stated

## 4 Analysis of data

### 4.1 Preliminary questionnaire

The analysis of the Annex A responses from all 14 maintaining agents is given below:

#### 4.1.1 General issues relating to the use of impregnants

The answers from the first part of Annex A are given in full in Appendix E and are discussed in turn:

*Do you believe that impregnation is an effective method for improving durability?*

Most agents thought that the use of impregnants is an effective method of improving durability although some thought that it is not a panacea and that good quality concrete and detailing are essential. One agent thought that application was highly dangerous to the operatives and the public and thought that it was debateable as to the coverage achieved and hence its effectiveness. This negative response may have come from experience of using alcohol based products and therefore may now be out of date.

Three of the agents did not feel that they had sufficient evidence for or against.

*To what extent are you implementing BD43/90 and BD43/03?*

Only three of the agents said that they treated new structures, but this may reflect the fact that many are not involved in construction works. Eight agents said specifically that they treat repairs, planned maintenance or remedial works. None of the agents claims to have treated in-service structures routinely although three have made proposals or are reviewing the possibility of doing so; however

priorities and financial restrictions prevented any action. One agent estimated that up to 80% of structures in his area had been treated but thought that a comprehensive list of treated structures would be difficult to obtain.

It seems that the standards are being implemented for new construction and in most cases repairs and remedial works. It is unlikely that many in-service structures have been treated.

*Have you experienced any difficulties in implementing BD43/90 and BD43/03?*

Four agents reported that they had not had any difficulties implementing the standards, but one agent reported problems with satisfying health and safety requirements and difficulties with the weather. Other problems were with difficulties carrying out the treatment at the correct intervals and obtaining a high enough score within the Continual Value Management Scheme to treat vulnerable structures. One agent preferred the use of more environmentally friendly products because of the health and safety issues involved in using volatile solvent based products.

*Comments on general issues:*

The following comments on general issues were received and are reproduced verbatim below:

*Area 2:*

Work is often done at night due to TM requirements. Often temperatures are close to the dew point. It is uncertain that the structures are dry enough to impregnate only 24 hours after rain in autumn/winter conditions.

*Area 3:*

During the last year our contractors have been proposing the use of an alternative surface impregnant which is not in full compliance with the current contract specifications. Departures from Standards have been approved to enable the product PAVIX, to be incorporated into the works.

*Area 5:*

Funding for preventative measures is required. The cost of treating concrete surfaces with silane (or similar) is far less than concrete remedial measures in the future.

*Area 8:*

We are currently using stainless steel reinforcement in areas subject to de-icing salts in order to avoid a return visit for silane treatment.

*Area 7:*

Impregnation should not be seen as a substitute for good quality impervious concrete with adequate cover, and good detailing to direct water borne chlorides away from the structure. In some cases of deterioration, protective coatings may be a more beneficial alternative.

*Area 10:*

As part of routine cyclic maintenance duties, parts of structures are power washed to clean them. It has been noted that when structures have been silaned, care is needed to prevent interaction between the Silane and the carriageway surfacing. I understand that the asphalt can degrade in these circumstances. Care must also be taken when working near drainage, watercourses or other areas of habitat.

*Area 11:*

Should this information be recorded on SMIS?

*Area 12:*

As noted above, little new concrete has been built in recent years. We are also considering the use of alternative products to silane

#### 4.1.2 Availability of detailed information

Table 2 summaries the availability of detailed information and shows that there are wide differences in the amount of information available from different areas. Some of the agents indicated that collation of the information would take a significant amount of time and would require some funding and approval from HA. The agents in areas 1 and 5 responded negatively to all the questions and were not confident that they could attempt the follow up questionnaire. Similarly, for areas 4, 12, 13 and 14, the agents also said that they were not confident about the questionnaire but that they did have some information. Of the other 7 agents that were prepared to fill in the follow up questionnaire, areas 3 and 11 have limited information. The remaining areas, 2, 7, 8, 9 and 10, have more information and consideration was given to sending the follow up questionnaire to the agents in some or all of these areas.

**Table 2: Data available from each area**

Area	Do you have accessible information as to which bridges/structures have been treated?	Do you have collated information on treated structures?	Do you have any information regarding the details of the treatment?	Do you have any pre/post treatment test data (eg half cell potential surveys or chloride ion contents) or any other assessments of effectiveness?	Are you confident that you would be able to complete at least some of the follow- up questionnaire?
1	No	No	No	No	No
2	Yes <sup>1</sup>	No	Yes <sup>1</sup>	Yes	Yes
3	Yes	No	No	No	Yes
4	No	No	No	Yes	No
5	No	No	No	No	No
6	Yes	No	Yes	Yes	Yes
7	Yes	Yes	Partial	Yes	Yes
8	Yes	No	Yes	No	Yes
9	Yes	Yes	Yes	Yes	Yes
10	Yes	Yes	Yes	Yes <sup>2</sup>	Yes
11	No	No	Yes	No	Yes
12	Yes	No	No	No	No
13	Yes	No	Yes	Yes <sup>3</sup>	No
14	No	No	Yes	No	No
Summary					
Yes	9	3	8	7	8
No	5	11	5	7	6

1 probably not comprehensive

2 would need to clarify

3 Limited testing works are carried out as part of the Principal Inspection, these results may give some indication of effectiveness

## Comments on availability of detailed information

### *Area 3:*

The records of structures treated relate only to bridges within Hampshire and prior to September 1997. Some half-cell testing was carried out at the first PI (principal inspection) following the issue of BD43/90 for those structures greater than 6 years old in the “old Area 3”, parts of which are now in Areas 2, 4 and 5. No specific funding has been available for silane treatment since April 1997.

### *Area 4:*

I have marked ‘No’ in most boxes because of the following:

We have access to ‘as built’ drawing information for a large number of our structures but by no means all. We maintain approx 850 structures and the information for the former Kent County Council bridges is good, East Sussex County Council bridges reasonable, Surrey County Council bridges patchy and for West Sussex County Council bridges poor.

We have very little ‘Health and Safety File’ or ‘Maintenance Manual’ type information. The ‘as built’ drawings would possibly state the extent of the silane treatment to the structure but I imagine would only be in the form of a note with very little specification type information. To search for this information on each ‘as built’ drawing for each structure would be a time consuming and laborious task. What would the budget in terms of both time and money be for this task if we were asked to carry it out?

As far as I am aware there is no ‘collated’ information concerning silane treatment.

When we carry out Principal Inspections (once every six years per bridge) concrete testing is carried out in accordance with BA 33/90 i.e. similar to the diagrams included in BD 43/03 so this information is available. Each individual structure would need to be interrogated either on SMIS for the PI’s for the last couple of years or from our records of the PI’s done by Atkins or the County Councils – again, a time consuming task.

New structures or maintenance works built since InterRoute took over Area 4 will have been treated with silane as appropriate and future schemes will be treated with PAVIX if possible as we have recently obtained approval to use this on an reinforced concrete column strengthening scheme

### *Area 5:*

This data (silane impregnation) is not entered into SMIS due to the functionality to record this data not being available. Therefore a search of the SMIS database under silane would be unfruitful. However SMIS would be the ideal vehicle for storing this data, and it can be expected that where concrete remedial works have been carried out this would have included silane treatment. We would be pleased to carry out a programmed detailed desk study subject to HA agreement.

### *Area 7:*

A schedule of structures which have not been impregnated has been prepared for Area 7.

*Area 8:*

Limited records likely to be available (probably less than 10% of the bridge stock). Likely to be limited to:

- Routes where newer structures (< 15 years old) were constructed
- Strengthening/maintenance schemes where new construction/components replaced

*Area 10*

The collation of the information required would take some time. Approval from Team Project sponsors would be required and funding available to complete this task. Would estimates be required?

*Area 12:*

I have not specifically looked for details but, from my knowledge of our records, I doubt we would have much to provide. It also depends on the content of the questionnaire.

*Area 13:*

Silane records should have been handed over from the previous agents. These records will have been archived but have never been transferred to electronic filing therefore collating information will require a significant amount of work

*Area 14:*

Very limited information on use of impregnation protection is available, especially in SMIS; limited historical information on maintenance projects and limited Health & Safety Files; significant research required to identify structures and materials used on recent maintenance projects.

## **4.2 Main questionnaire**

### **4.2.1 General**

Information was obtained from two agents representing Areas 7 and 9. The information from Area 7 was comprehensive but that from Area 9 was less detailed. The results from each area were analysed separately.

### **4.2.2 Area 7**

The agents for Area 7 supplied information on a total of 364 structures constructed pre-1990 and 42 post-1990. Over 90% of the post 1990 structures had been treated (Figure 1) and treatment had been carried out mainly in the year of construction or within the following two years (Figure 2). For in-service structures (those constructed pre-1990) only 30% had been treated (Figure 1). Whether in-service structures were treated would depend on their condition. It might be expected that older structures would be more likely to be in poorer condition so less likely to be treated. In fact the age at treatment varied from less than 10 years to over 40 years with 31 to 40 years being the most common age at treatment (Figure 2). However the Area 7 structure stock dated mainly from the 1960s and 1970s so there was a preponderance of older structures (Figure 3). Larger numbers of structures were treated during the 1990s than subsequently; there were two treatments recorded for 1984 (Figure 4).

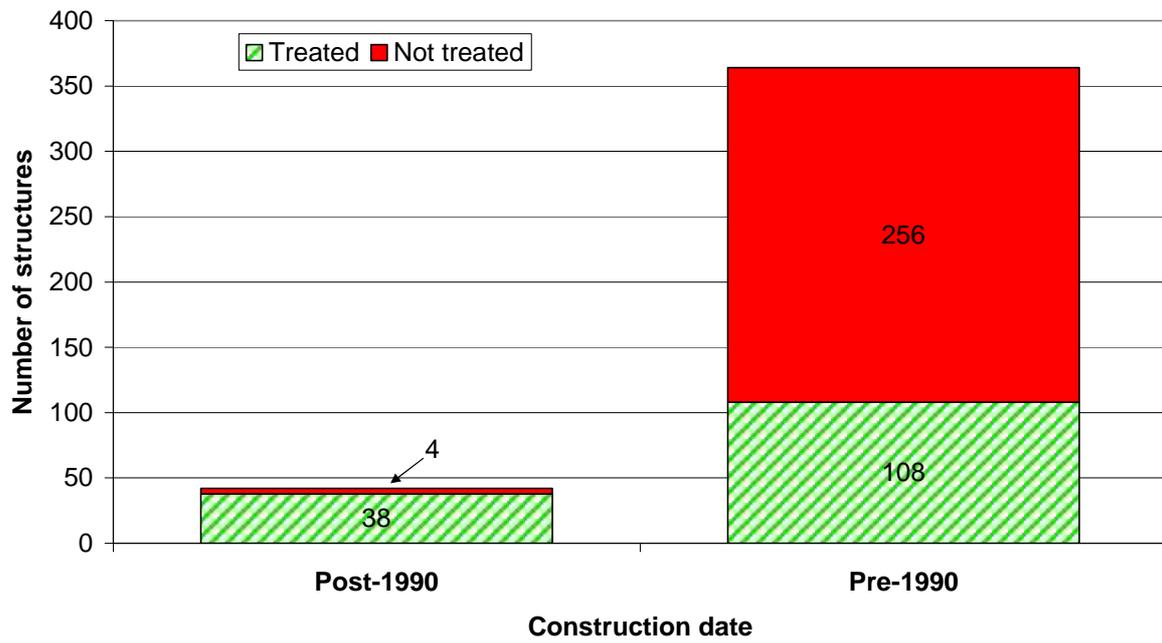


Figure 1: Number of treated and untreated structures: Area 7

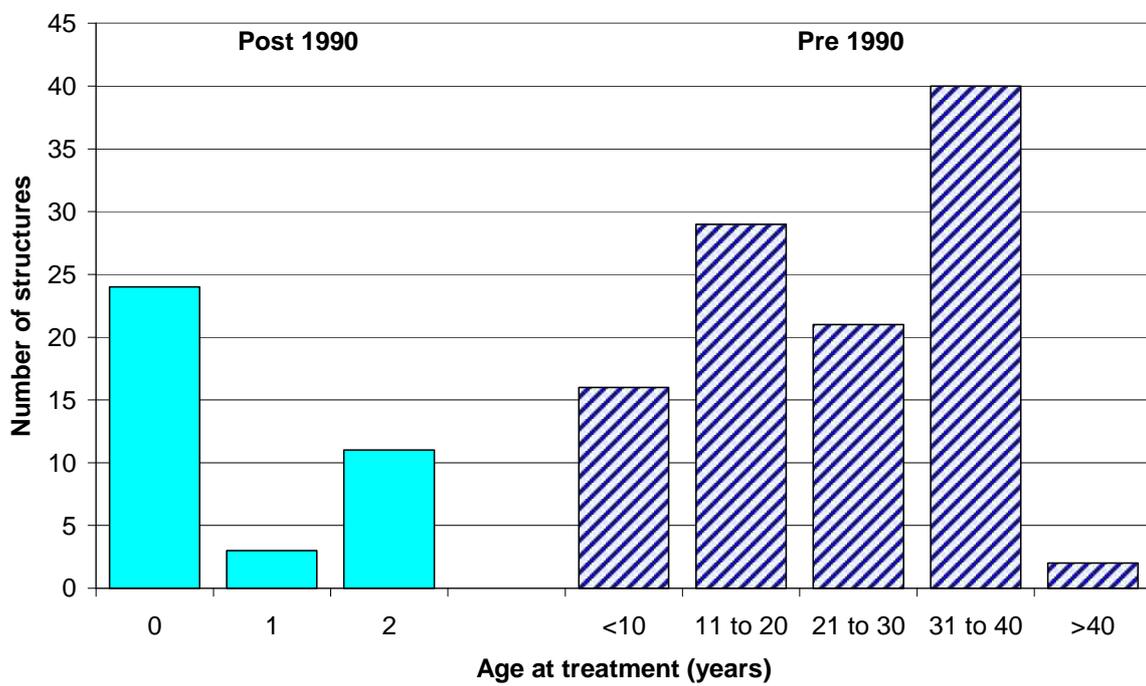
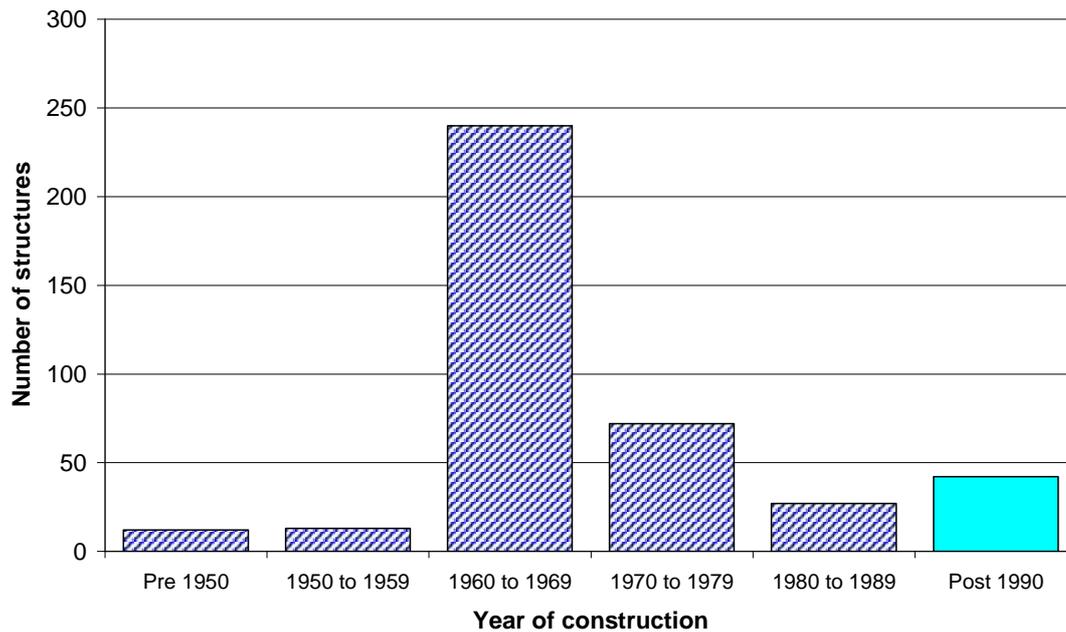
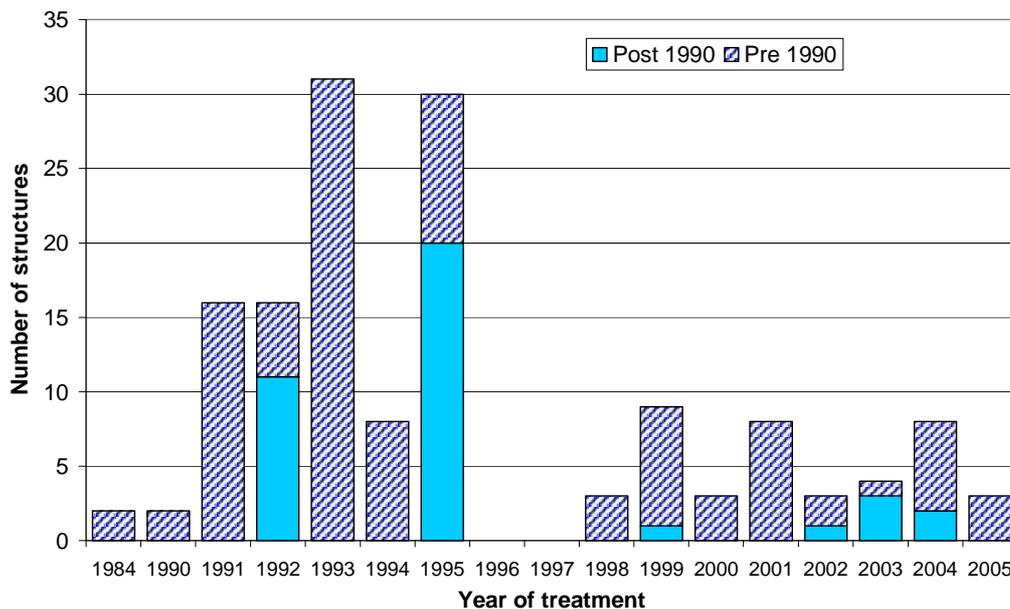


Figure 2: Age of structures when treatment was carried out: Area 7



**Figure 3: Construction year of structures in Area 7**



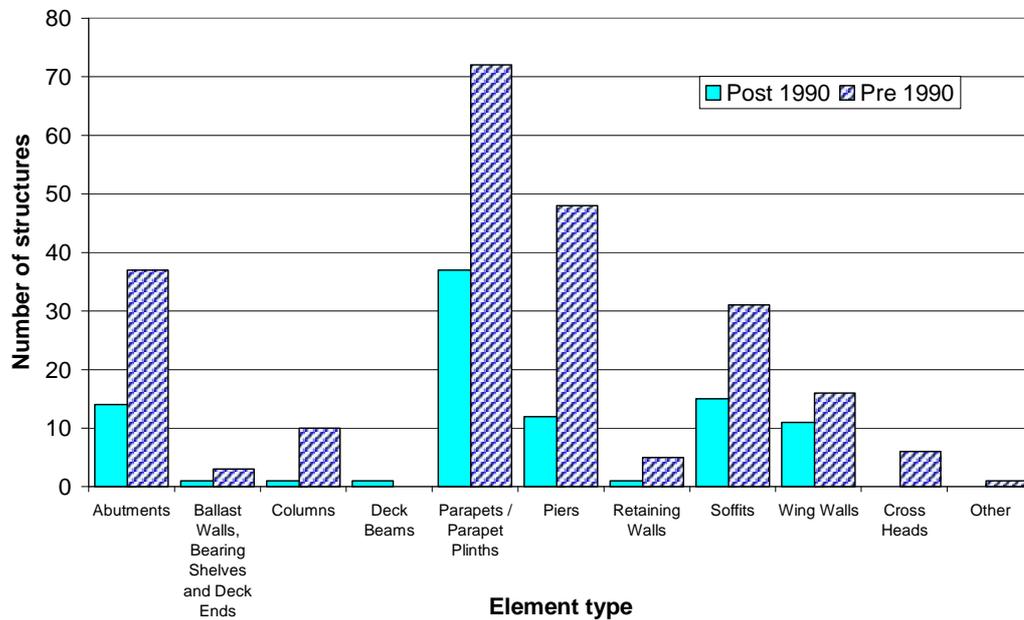
**Figure 4: Cumulative number of post-1990 and pre-1990 structures treated in each year: Area 7**

Impregnant had been applied to a range of elements on the structures but the most common area treated for both post-1990 and pre-1990 structures was parapet/parapet plinths (Figure 5)

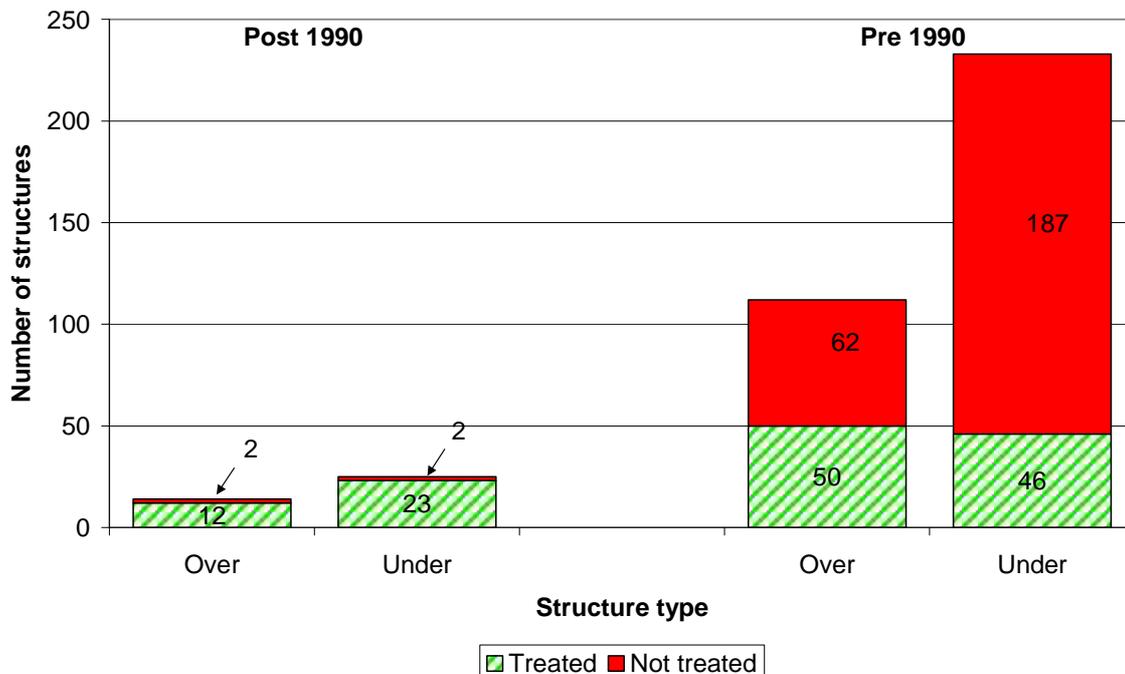
The types of structures treated were mainly bridges but also included some culverts, underpasses and pedestrian subways. Structures can be classed as either overbridges or underbridges depending on whether they cross or carry the road to which they relate. Figure 6 shows the structures classified in this manner for the pre-1990 and post-1990 structures. There were larger numbers of underbridges in

both time periods but the proportion of pre-1990 overbridges treated was relatively higher than for underbridges although the actual number of structures treated was similar.

There was some evidence of re-treatment after periods ranging from 4 to 10 years but this applied to only 5 structures all dating from pre-1990.



**Figure 5: Number of structures where particular elements were treated: Area 7**  
 (Note that this refers to number of structures not number of individual elements)



**Figure 6: Number of overbridges and underbridges treated: Area 7**

Table 3 shows the products that have been used to treat structures in Area 7. The associated manufacturer/supplier is also given; in some cases products with the same chemical type had been obtained from different manufacturers/suppliers. Unfortunately there were many cases where information was not known. Some products have been used over a long time period (eg Funcosil Silane 100) whereas others were relatively new to the market and claim environmental advantages over traditional materials (eg Pavix). Whilst most of the products were trimethoxy or triethoxy silanes some were alternative materials aimed at achieving the same effect (eg Pavix is a 'breathable' pore blocker and MCI 2020 is a pore blocker/corrosion inhibitor).

Two structures within Area 7 were treated in 1984 which was before the publication of BD43/90 with Dynasytan BH which is believed to be isobutyl triethoxy silane. One of the structures was retreated in 1994, although details of the product used are not known. It was also not clear whether this represented re-treatment of previously treated areas or treatment of additional elements.

**Table 3: Impregnant products used and date of application (Area 7)**

Product	Chemical type	Manufacturer Supplier	Pre-1990 structures		Post-1990 structures	
			Number	Year of Application	Number	Year of application
Bimasil 100	Isobutyl trimethoxy silane	Bimark			1	1992
Dynasytan BH	Proably isobutyl triethoxy silane	Dynamit	2	1984		
Dynasytan BSM	Details not published	Epichem Kestral	3	1998 to 2005		
Episilane 100	Isobutyl trimethoxy silane	Epichem			10	1992
Funcosil silane 100	Isobutyl trimethoxy silane	Remmers (UK)	26	1991 to 2005	4	2003 to 2004
MCI 2020	Water based penetrating corrosion inhibitor	Sika	1	2001		
Nitocote SN511	Isobutyl triethoxy silane	Fosroc	2	2001		
Pavix	Breathable pore blocker	ASI	2	2004 to 2005		
Resicote WB2	Flexible epoxy based coating	Not known	1	1995		
Not known		Hulls (UK)	2	1992		
		Goldschmidt			20	1995
Not known			69	1990 to 2005	3	1999 to 2003

One of the aims of the survey was to assess the effectiveness of impregnant treatment. This requires some monitoring of how structure condition changes with time: ideally quantitative information on chloride levels or corrosion activity. Monitoring data was reported to be available for 247 of the structures but it was not possible to assess the likely usefulness of such data within the current project. Some data would be expected for pre-1990 structures as that would have been used to help decide whether to carry out treatment. Further monitoring on such structures should give some indication on the effectiveness of impregnant treatment. However it was apparent that it would require significant additional effort for data to be extracted and analysed.

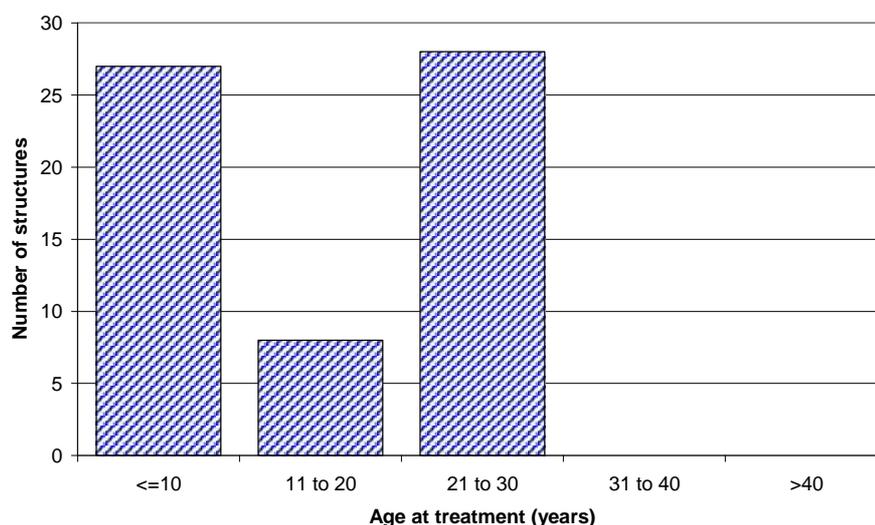
#### 4.2.3 Area 9

The agents for Area 9 were responsible for 87 post-1990 structures but they had no information whether or not any of them had been treated with impregnant. There were 571 pre-1990 structures and it was known that 63 of these had been treated. However for the remainder it was not known whether or not they had been treated. Hence it was not possible to estimate the extent of impregnant application for Area 9.

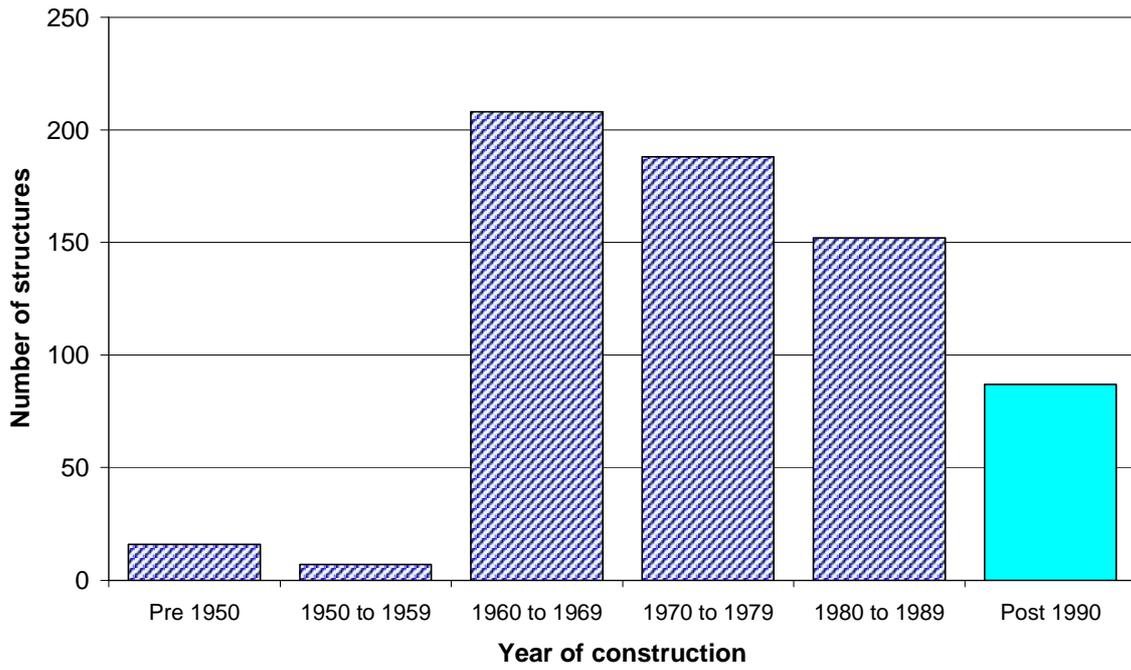
Where structures were known to have been treated, the age of the structure at treatment ranged from less than 10 years to 29 years (Figure 7). The relatively higher number of younger bridges treated reflects the less extreme construction age distribution for Area 9 (Figure 8) when compared to Area 7. Treatment was carried out mainly in 1991 and 1992 (Figure 9).

A range of elements had been treated with crossheads being the most common (Figure 10). Area 9 includes elevated roadway sections where a single structure could include a substantial number of individual crossheads – sometimes 20 or more. In many cases only a proportion of the total number of cross heads in a structure had been treated. Overall 122 cross heads out of a possible 521 had been treated in the 33 structures reported. In addition in some cases treatment had been carried out at different times.

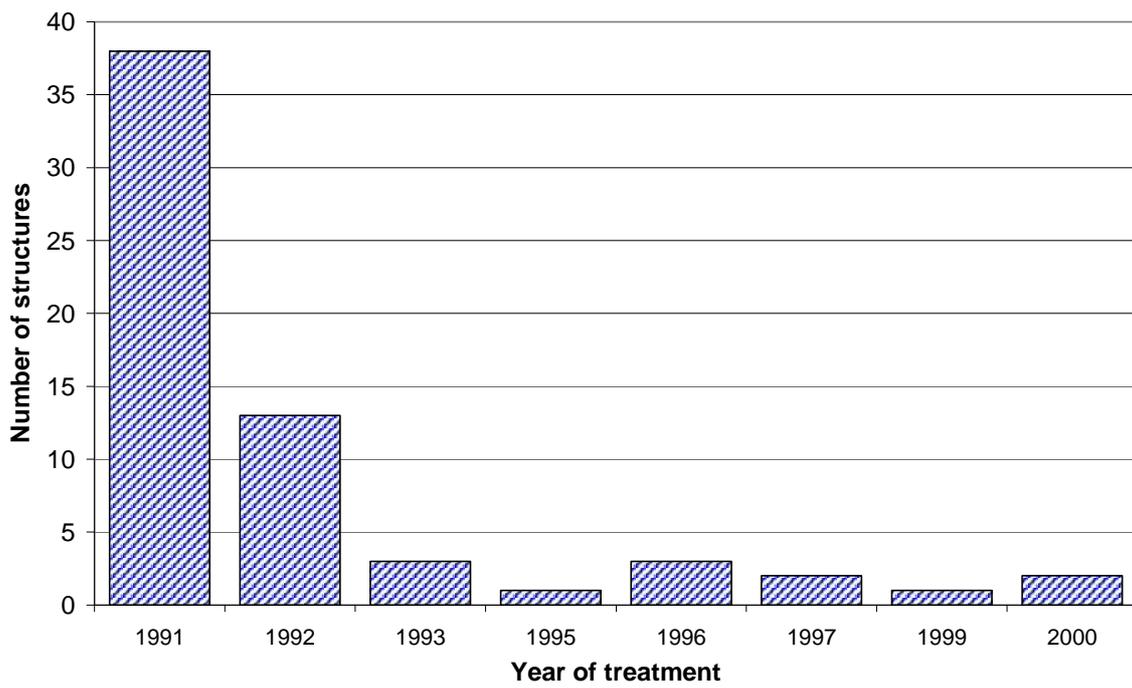
In terms of whether structures would be classed as overbridges or underbridges, 50 of the 63 treated structures were classed as underbridges.



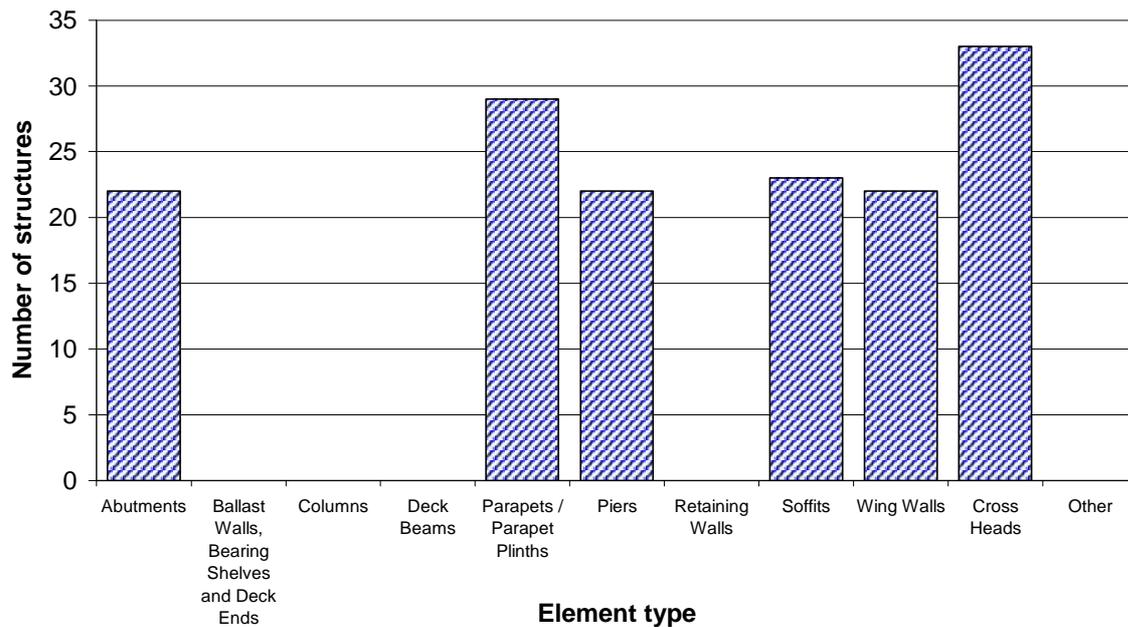
**Figure 7: Age at which treatment was applied: Area 9**



**Figure 8: Year of construction of structures in Area 9**



**Figure 9: Number of structures treated in each year: Area 9**



**Figure 10: Number of structures where particular elements were treated: Area 9**

The products used for treatment of structures in Area 9 are given in Table 4. Two application dates were given for 10 of the treated structures in Area 9. These structures were part of the Midland Links viaducts and multiple applications actually refer to treatment of different crossheads within single structures at different times. These have been separated in Table 4, hence the total number of applications is 73.

**Table 4: Impregnant products used and date of application: Area 9**

Product	Chemical type	Manufacturer Supplier	Pre-1990 structures	
			Number	Year of Application
Bimasil 100	Isobutyl trimethoxy silane	Bimark	28	1991 to 1999
Feb sylane	Notknown	Feb Ltd	8	1991
Episilane 100	Isobutyl trimethoxy silane	Epichem	13	1992
Funcosil silane 100	Isobutyl trimethoxy silane	Remmers (UK)	13	1991
Tegosilan 100	Not known	TH Goldschmidt Ltd	7	1996 to 1997
Resicote WB2	Flexible epoxy based coating	Not Known		
Not known			4	1997 to 2000

### 4.3 Additional Information

TRL obtained data when the preliminary questionnaire was circulated from principal inspections of 46 bridges on the A38. An evaluation of testing data within Area 7 was carried out to assist in the development of a preventative maintenance strategy. The bridges considered were commissioned between 1967 and 1983 and had been designed by various civil engineering consultants; most post 1975 bridges had been treated 'in-service' with silane between 1991 and 1994. The object of the testing was to confirm that treated structures were performing adequately, and to identify the condition of currently untreated structures with a view to treatment. Some further analysis of the data was undertaken by TRL to demonstrate how information obtained from the follow up questionnaire could be used to assess the extent and effectiveness of impregnation.

Testing was carried out between 1996 and 2002. The measurements taken were:

- half cell potential
- resistivity
- chloride content
- cover to the reinforcement
- carbonation.

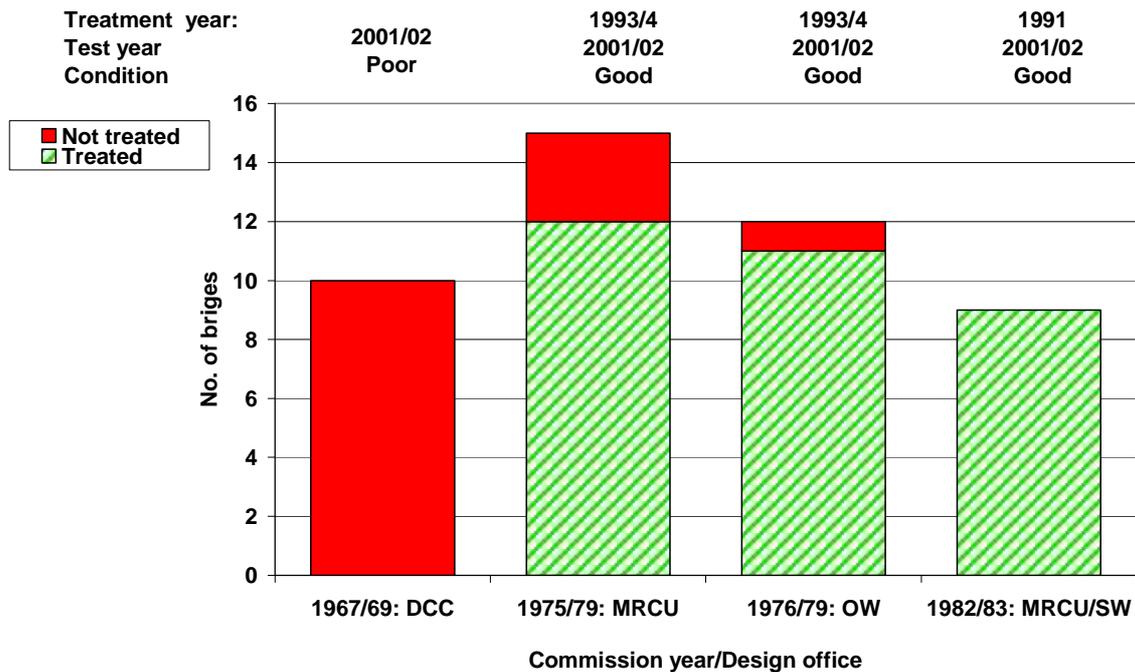
Interpretation of results was based mainly on condition indicators given in BD 43/03, supplemented by guidance on chloride levels given in Concrete Society Report 26 (1984) and standard interpretation of resistivity and carbonation measurements. Only a summary of the results was given in the report available to TRL but more detailed information on individual bridges should be available.

Figure 11 shows a summary of the year of construction, design office, treatment and testing dates, and general condition for the bridges covered in the survey. Note that bridges classed as 'Not treated' were, to be exact, bridges where no record of treatment had been found.

MRCU/SW bridges built 1982/83 and OW bridges built in 1976/79 were generally in good condition. MRCU bridges built in 1975/79 were also mostly good but slightly worse than the OW bridges from the same period. No preventative maintenance was required for any of the bridges but further monitoring was recommended at Principal Inspections with some bridges, both treated and untreated, highlighted for specific tests at that time.

DCC bridges built in 1967/69 were the oldest structures and gave the poorest results, however it was considered that in fact results were not particularly poor for bridges of that age. These bridges had not been treated so treatment was recommended where appropriate. Some further investigations (eg limited concrete break out) along with improving drainage and essential concrete repairs were also recommended.

This report shows that at least some 'in-service' structures have been treated and the effectiveness of the treatment in controlling corrosion is being monitored. In some cases there appears to be treated and untreated bridges of similar age and location; a more detailed analysis of the test results for individual bridges could provide a more direct comparison of relative performance of treated and untreated structures.



Key: DCC - Derbyshire County Council  
MRCU - Midland RCU  
MRCU/SW - Midland RCU/Scott Wilson  
OW - Sir Owen Williams and Partners

**Figure 11: Summary of year of construction, design consultants, impregnant treatment and condition of bridges along A38 in Area 7**

## 5 Discussion

The results from the surveys and discussions with the maintaining agents have demonstrated that the amount of information on impregnation of the bridge stock is very variable between the different areas in England and it is generally very limited. For bridges built since 1990, information is likely to come from the as-built drawings but these may not always show the elements that have been treated. Frequently, the drawings have not been passed on to the incoming agents when new contracts are let. Other possible sources of information are maintenance manuals, health and safety files and correspondence. The amount of information and the way it has been stored is also very variable, and this has made the data retrieval exercise required for this study much more difficult than was originally envisaged. It was somewhat disturbing that the five of the agents admitted that they did not know which of their structures had been treated. There has been relatively little treatment of pre-1990 bridges, this is a result of the low priority given to such work.

Detailed information had only been obtained from one area – Area 7 - which showed that, in most cases, post-1990 structures had been treated compared with a much smaller proportion of pre-1990 structures. Based on general comments from the other areas it seems likely that there has been relatively little treatment of pre 1990 bridges in general, partly as a result of the low priority given to such work.

Some agents were in favour of the water based products which are more environmentally friendly than the isobutyl trimethoxy and ethoxy silanes specified in BD43/90. These products can be used

provided that they are compliant with requirements of the new European Standard Test Methods and acceptance criteria given in Appendix 2 of BD/03. There are a number of advantages in using these products as they are more environmentally friendly and hence are easier to apply as less stringent health and safety measures are required.

A number of alternative hydrophobic impregnants have been independently tested and have now been accepted by the Highways Agency under specification departure procedures, as specified in Clause 8.1 of BD43/03 (2003), and according to the test methods given in Appendix 2. These materials are generally more environmentally friendly, and use water and cream based silane technology. A further impregnant has been used and is described as being "a material that lines the pores with, strong tightly adhering crystals that deliver a combination of hygroscopic hydrophilic and hydrophobic actions'. Long term effectiveness is still to be fully proven for all these materials and it is therefore recommended that the Highways Agency undertakes tests to assess performance of all currently marketed impregnants, that are available for use in the UK.

The requirement to treat concrete structures with hydrophobic pore lining impregnants has now been in place for 15 years. It is important that this investment in impregnants is assessed directly in terms of effectiveness in improving durability, and in relation to alternative protection methods and strategies. The survey indicated that monitoring information relevant to such assessment exists within the area records but it is not easily accessible. It was not possible to obtain and assess such information within the current project but it would be certainly be desirable to do so at some stage.

Recording information on where and when structures have been treated, and with what material, should be a basic requirement of structures management but unless such information is easily accessible it is of limited use. Periodic changes in responsibility for structure management only exacerbates the problem. The current survey has illustrated the difficulties of obtaining even the most basic information on the implementation of a major HA strategy to improve durability. It is acknowledged that it would be difficult to set up a system for storing such information retrospectively for existing structures. However it is highly desirable that such a system is established for future construction. SMIS would offer an appropriate medium for recording such information in a consistent and accessible form. It will be necessary to decide the way in which such information should be recorded, and how specific it should be – for example it could relate to any surface treatment of a structure not just the use of surface impregnants. It is strongly recommended that such a development should be considered.

## 6 Summary and Conclusions

Early consultation with maintaining agents demonstrated that it would be very difficult to obtain the detailed information originally specified on the application of impregnants to concrete highway structures.

The project was therefore divided into two parts:

- A preliminary questionnaire was sent to all 14 maintaining agents requesting their views on general issues on impregnation and the availability of detailed information on structures within each area
- The main questionnaire was sent to two of maintaining agents that indicated that they could complete provide the information requested.

The maintaining agents in all 14 areas completed and returned the preliminary questionnaire. The following conclusions were drawn:

- Most of the agents considered that impregnation was an effective method of improving durability of concrete structures although there were some concerns regarding the health risks involved in application.
- The standard has been generally followed for new construction and in most cases repairs and remedial work, but it is unlikely that many in-service structures have been treated.
- Generally, the agents reported that they were able to implement the standard, but some experienced operational difficulties.
- Only nine of the agents had information as to which bridges in their area had been impregnated. Eight claimed that they had details of the treatment but collated information was only available for three areas. Eight agents were confident that they would be able to complete at least some of the main questionnaire.
- Half the agents had pre/post treatment monitoring data.

The maintaining agents for Area 7 and Area 9 completed the main questionnaire. Detailed information was supplied for Area 7 which showed that over 90% of the post-1990 structures had been treated compared with 30% for the pre-1990 structures. Information from Area 9 showed that some of their pre-1990 structures had been treated. No information was supplied for the post 1990 structures.

Additional information obtained from Area 7 demonstrated that some in-service structures had been treated in that area and the effectiveness of the treatment in controlling corrosion was being monitored. The report received only gave a summary of the data, although more details were available. A more detailed analysis of the data was outside the scope of the current project.

The results from the survey have highlighted the limitations in the record keeping of impregnation and associated monitoring. It is considered that it would be highly desirable for HA to set up a system which requires maintaining agents and authorities responsible for new construction to record impregnation to assist with planning future maintenance strategies. The information should be in a form that can be easily entered into SMIS.

## **7 Acknowledgements**

The work described in this report was carried out in the Infrastructure and Environment Division of TRL Limited. The authors are grateful to Dr RJ Woodward who carried out the quality review and auditing of this report.

The authors wish thank all the staff of the maintaining agents who provided the information used in this survey and gave their opinion on the policy. Without their assistance, this study would not have been possible. The help of Mike Hill for providing contact details for the 14 maintaining agents is also acknowledged.

## 8 References

**Concrete Society (1984).** *Repair of concrete damaged by reinforcement corrosion.* Concrete Society Technical Report TR26. Concrete Society. Slough.

**Department of Transport (1990).** *Criteria and material for the impregnation of concrete highway structures.* Departmental Standard BD43/90. London.

**The Highways Agency, the Scottish Office Development Department, the Welsh Office (Y Swyddfa Gymreig) and the Department of the Environment for Northern Ireland (2003).** *Manual of Contract Documents for Highway Works. Volume 2: The impregnation of reinforced and prestressed concrete structures using hydrophobic pore-lining impregnants.* Departmental Standard BD 43/03. The Stationery Office, London.

## **Appendix A.      Introductory letter and paper**

Draft letter to be sent to Managers at Maintaining Agents and copied to the Technical Appraisal Group

Dear Sir

### **Survey of surface impregnation protection of concrete highway structures**

The Highways Agency (HA) have commissioned TRL to collect and compile information concerning the extent of use and the in-service effectiveness of impregnants, such as silane, on improving the durability of highway structures. The publication of BD43/90 and BA33/90 in 1990 contained provisions to utilise impregnants on concrete highway structures, and these requirements were incorporated in the Specification for Highway Works. This guidance was updated in 2003 through publication of BD43/03.

For structures constructed since 1990, it has been a requirement that all at risk concrete structures or structural elements are protected from the ingress of de-icing salts by treatment with hydrophobic pore-lining impregnants such as silane (or equivalent alternatives) at the time of construction. Older bridges were to be treated depending upon their condition.

The objectives of the present survey are:

- To determine the proportion of new and in-service structures within the current stock that have been treated
- To assess the effectiveness of the impregnation of new and in-service treated structures.

The information obtained will assist future policy decisions regarding improvements to durability of concrete structures, and influence national and regional maintenance planning and budgeting. It is expected that some of the collected information will also be subsequently included in the Structures Management Information System (SMIS), and be used by Agents and HA to assist future maintenance programmes for individual structures.

TRL have been tasked to prepare an electronic questionnaire designed to collect the necessary information. This questionnaire along with full instructions on how to complete it will be sent to every HA Managing Agent (MA) or Managing Agent Contractor (MAC) via their SMIS co-ordinator during May 2005. This letter gives early warning and some background information.

The questionnaire has been prepared to simplify the task for Agents as much as possible, and will include a list of structures downloaded from SMIS. However it is accepted that the information gathering may not be easy, and involve a search of maintenance manuals, but ask that reasonable efforts be made to obtain the data and complete as much of the questionnaire as possible. As an absolute minimum, a simple confirmation that a structure has been treated would be helpful, however the supporting details are also important. If structures have not been impregnated then no further information is required. It is stressed that this information

should also be helpful for future structure management. Further details of the survey are provided in the short paper enclosed.

Unfortunately we are not in a position to repay actual costs for compiling the questionnaire data, but it has been agreed that TRL can make a discretionary payment of up to £500 to a Managing Agent upon receipt of the completed questionnaire within the period of 2 months allowed.

I am enclosing a short paper which outlines the task in more detail and gives guidance on how to fill in the questionnaire. Please could you pass this letter and paper on to your SMIS administrator and your member of your Bridges Group who will be responsible for completing the questionnaire.

I would like to offer thanks in advance for your cooperation and contribution, on behalf of the HA and TRL.

If you have any detailed queries on the questionnaire please contact myself, Alec Calder (email: [acalder@trl.co.uk](mailto:acalder@trl.co.uk) or phone: 01344 770687) or Neil Anderson at TRL (email: [nanderson@trl.co.uk](mailto:nanderson@trl.co.uk) or phone: 01344 770459) . Neil Loudon is the HA Project Sponsor for the survey and can be contacted via email at [neil.loudon@highways.gsi.gov.uk](mailto:neil.loudon@highways.gsi.gov.uk).

Yours faithfully

## Survey of surface impregnation of concrete highway structures

### 1. Introduction

Since 1990, with the publication of BD43/90 and BA33/90 'Criteria and material for the impregnation of concrete highway structures', there has been a requirement to utilise hydrophobic pore-lining impregnants to provide additional durability to newly constructed Highway Agency structures subjected to aggressive conditions; primarily arising from the use of de-icing salts. There has also been the requirement to apply impregnants to older in-service structures provided that their pre-existing condition was suitable.

HA consider that the use of impregnants, such as silane is a major contributor to increasing the durability of concrete structures. It is important that the investment in impregnants can be justified directly in terms of their effectiveness, and in relation to alternative protection methods and strategies.

This paper describes the information that is being gathered on surface impregnation of concrete structures in order to inform future policy decisions about the role of impregnation in the maintenance and management of highway structures. It also gives early warning of a questionnaire that will be sent to Maintaining Agents who will be asked to collect the data. It is planned that such information will be incorporated into the SMIS inventory.

### 2. Background

The material specified in 1990 for impregnation is monomeric alkyl (isobutyl) trialkoxy silane with a minimum active content of 92%, which is marketed under various trade names. More recently other materials have come on to the market, and with developments of European Standards, the Highways Agency has updated its guidance in the form of BD43/03 'The impregnation of reinforced and pre-stressed concrete highways structures using hydrophobic pore-lining impregnants'.

It is assumed that impregnants have been applied to all bridges constructed since 1990 in accordance with HA policy. It is now necessary to test this assumption.

For structures built before 1990, the policy is to evaluate each structure on the basis of visual surveys, half cell potential mapping and chloride profiling. These tests and observations are designed to show whether the reinforcing steel is corroding or is likely to start corroding in the near future. Structures showing indications of reinforcement corrosion should be scheduled for repairs and upon their completion the structure should be treated with impregnant. Structures showing no indication of reinforcement corrosion should be impregnated without any preceding remedial works. Information is required to check the extent to which structures built before 1990 have been treated.

The HA considers the time is now appropriate to compile lists of bridges constructed before and after 1990 that have been impregnated. The information is to be collected via a questionnaire and presented in a format suitable for direct entry into the SMIS inventory, which will be modified to accept these data. Data are also required on the effectiveness of such treatment.

TRL has undertaken extensive research on behalf of the Highways Agency into the use of silanes as impregnants and a trial site on the M25 continues to be monitored periodically. Results show that silane is highly effective in delaying the initiation of reinforcement corrosion by suppressing the ingress of de-icing salts into the concrete. Nevertheless there are still criticisms of the use of silane in terms of its effectiveness, and other issues such as health and safety are often raised. It is the aim of this survey to address some of these issues.

### 3. Questionnaire

The questionnaire will be designed to provide data to address:

- The proportion of the pre 1990 and post 1990 structures that have been treated.
- The factors that have prevented treatment with impregnants.
- The types of impregnant that have been applied.
- Health and safety issues that have arisen during treatments.

The current version of the evolving structures database (SMIS) used by the Highways Agency and its Agents does not currently hold data on where impregnants have been used, or the particular materials applied. It is planned that the information gathered in the questionnaire will be uploaded into SMIS. This will enable HA to decide future policy and for Maintaining Agents to plan and budget for impregnation maintenance treatments.

TRL will analyse the results from the survey in terms of the effectiveness and extent of use of impregnants, and the age and structure condition of those impregnated.

It is intended that the analysis will quantify the significance of factors such as:

- Structure age when treated
- Type of structural elements treated
- Type of impregnant used
- Difficulties in using the impregnation standard
- Health and safety issues

These findings will provide guidance to inform updates to BD43/03, Specification for Highway Works and Notes for Guidance. They will also provide information for decisions on whether more older bridges would benefit from impregnation and help to plan and budget for re-treatment of the newer bridge stock due over the next decade, given the expected 15 year life of impregnant treatments.

### 4. Information required

The questionnaire will be supplied and should be completed electronically. It will be in the form of an Excel spreadsheet. The data for bridges constructed since 1990 and before 1990 will be stored on separate sheets within the spreadsheet. All the information required for each structure will be entered on a single row. The structure key, name, road number, structure type and date commissioned for each structure will be entered into the spreadsheet when you receive it. Although the exact details of the questions have not yet been finalised, examples of the type of questions that will be asked are given below:

- Has the structure been impregnated?
- Which elements were impregnated?
- When was it first impregnated?
- What type of impregnant was used?
- If the structures has not been treated, give reasons
- Have any half cell potential or chloride measurements been made since impregnation?
- Were any difficulties encountered understanding the standards (BD43/90, BA33/90, BD43/03)? please list
- Were any health and safety problems encountered during impregnation?

It is anticipated that the sources of this data will include

- As built drawings
- Maintenance manuals
- Health and safety files
- Correspondence files

It is important to indicate if you do not possess any of these documents.

## **5. Summary**

This paper provides information relating to the survey of the impregnation of the Highway Agency's structures and the proposed upgrade of the SMIS inventory.

The information required will be obtained via a questionnaire designed by TRL to be completed by Maintaining Agents.

The upgraded version of SMIS will enable the HA to make improved policy decisions about impregnation and to obtain a national picture about the extent to which structures are protected by impregnants. It will also enable Maintaining Agents to enhance their management of the structure asset by improved maintenance planning and budgeting.

## Appendix B. Original draft questionnaire

### Instruction sheet:

Area 8		
Total Bridges included	629	
Post 1990	132	
Pre 1990	497	Note: Bridges with no record of date commissioned are included in Pre-1990 bridges
<b>What to fill in:</b>		
Please provide general comments on your experience of using impregnants on the 'general issues' sheet		
Please provide information specific to each structure on the two subsequent sheets (for structures built since 1990 and structures built before 1990)		
Guidance for answering the questions is given below		
Most of the questions require a short answer (either a single letter or one or two words). The questions marked with an asterisk (*) may require a more detailed answer. Therefore larger fields have been created to the right on the sheets as indicated by arrows in the information boxes		
Where a list of treated/repaired elements are required; please enter letters for each element into the cell e.g. ACR for Abutments, Columns and Retaining Walls		
<b>For structures built since 1990 (Post 1990 sheet)</b>		
<b>Initial Treatment</b>		
Treated before opening	Yes/No/Don't know	(Y/N/D)
Treated after opening	Yes/No/Don't know	(Y/N/D)
Date treated	Year structure was treated	
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
Reasons not treated *	Give reasons why the structure was not treated	(Free Entry)
<b>Retreatment</b>		
Retreatment	Has any retreatment been carried out: Yes/No/Don't Know	(Y/N/D)
Retreatment Details *	Give details of Retreatments(s)	(Free Entry)
<b>Treatment following repairs</b>		
Repaired	Has structure been repaired: Yes/No/Don't know	(Y/N/D)
Date repaired	Year structure was repaired	
Reasons for repair *	Give reasons why repair of the structure was necessary	(Free Entry)
Repair details *	Give details of repair methods	(Free Entry)
Elements repaired	Enter codes for elements that have been repaired	See Table 1
Repairs Treated	Were the repairs treated: Yes/No/Don't know	(Y/N/D)
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
<b>Monitoring</b>		
Corrosion monitoring	Have any half cell potential surveys or chloride measurements been carried out since construction: Yes/No/Don't know	(Y/N/D)
<b>For structures built before 1990 (Pre 1990 sheet)</b>		
<b>Monitoring</b>		
Monitored	Have any half cell potential surveys or chloride measurements been carried out since 1990: Yes/No/Don't know	(Y/N/D)
Suitable	Did the results of the monitoring indicate that the structure was suitable for treatment: Yes/No/Don't know	(Y/N/D)
<b>Treatment</b>		
Treated	Yes/No/Don't know	(Y/N/D)
Pre-Treatment Repairs	Were repairs carried out before treatment?	(Y/N/D)
Date treated	Year structure was treated	
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
<b>Treatment following repairs (since 1990)</b> This refers to repairs other than those carried out at time of first treatment		
Repaired	Has structure been repaired: Yes/No/Don't know	(Y/N/D)
Repairs Treated	Were the repairs treated: Yes/No/Don't know	(Y/N/D)
Date repaired	Year structure was repaired	
Reasons for repair *	Give reasons why repair of the structure was necessary	(Free Entry)
Repair details *	Give details of repair methods	(Free Entry)
Elements repaired	Enter codes for elements that have been repaired	See Table 1
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
<b>Monitoring</b>		
Measurements Since	Have any half cell potential surveys or chloride measurements been carried out since retreatment/repairs: Yes/No/Don't know	(Y/N/D)
<b>Retreatment</b>		
Retreatment	Has any retreatment been carried out: Yes/No/Don't Know	(Y/N/D)
Retreatment Details *	Give details of Retreatments(s)	(Free Entry)

Code	Element
A	Abutments
B	Ballast Walls, Bearing Shelves and Deck-Ends
C	Columns
D	Deck Beams
L	Parapets / Parapet Finishes
P	Piers
R	Retaining Walls
S	Soffits
W	Wing Walls
X	Cross Heads
Q	Other

**General issues:**

**General Issues Relating to the use of Impregnants**  
Please give your views on the use of Impregnants:

Do you believe Impregnation is an effective method of improving durability?

To what extent are you implementing BD43/03 on structures?

What, if any difficulties have you experienced in impelmenting BD43/03?

Other Comments

**General Health and Safety Issues**  
Please provide details below of any Health and Safety issues you have encountered relating to the use of Impregnants

## Appendix C. Letter sent to maintaining agents and preliminary questionnaire

Dear

### Survey of surface impregnation protection of concrete highway structures

The Highways Agency (HA) has commissioned TRL to collect and compile information concerning the extent of use and the in-service effectiveness of impregnants, such as silane, on improving the durability of highway structures. The publication of BD43/90 and BA33/90 in 1990 contained provisions to utilise impregnants on concrete highway structures, and these requirements were incorporated in the Specification for Highway Works. This guidance was updated in 2003 through publication of BD43/03.

For structures constructed since 1990, it has been a requirement that all at-risk concrete structures or structural elements are protected from the ingress of de-icing salts by treatment with hydrophobic pore-lining impregnants such as silane (or equivalent alternatives) at the time of construction. Older bridges were to be treated depending upon their condition.

The objectives of the present survey are:

- To determine the proportion of new and in-service structures within the current stock that have been treated
- To assess the effectiveness of the impregnation of new and in-service treated structures.

As a first stage we are seeking information on general issues relating to the use of impregnants, and to establish the availability of more detailed data relating to the extent and effectiveness of application. **I attach a short preliminary questionnaire (Annex A) which we would be grateful if you could complete by 1 July 2005.**

The second stage of the project will involve a follow-up questionnaire which will be circulated to agents who indicate that they have access to more detailed information. The follow-up questionnaire has been divided into three parts:

- For 'new construction' structures built and treated since 1990
- For 'in service' structures built before 1990
- Retreatment of any structures

Information such as date of treatment, elements treated, impregnant type, any testing carried out to assess performance pre or post treatment, retreatment schedules, would be required for individual bridges. To simplify the task of completing the follow-up questionnaire it would be sent to you in Microsoft Excel format and would include a list of structures for your area downloaded from SMIS. It is acknowledged that information may not be available in all cases but any information would be of value. The questions which will be included in the follow up questionnaire are listed in Annex B. **We are not asking for this information now, but please indicate on the preliminary questionnaire (Annex A) whether you have access to such data.**

I would like to offer thanks in advance for your cooperation and contribution, on behalf of the HA and TRL.

If you have any queries on the questionnaire please contact myself, Alec Calder (email: [acalder@trl.co.uk](mailto:acalder@trl.co.uk) ; phone: 01344 770687). Neil Loudon is the HA Project Sponsor for the survey and can be contacted via email at [neil.loudon@highways.gsi.gov.uk](mailto:neil.loudon@highways.gsi.gov.uk).

Yours sincerely

## ANNEX A: Preliminary Questionnaire

Please complete this questionnaire and return it to Alec Calder electronically ([acalder@trl.co.uk](mailto:acalder@trl.co.uk)) by 1 July 2005

<b>General issues relating to the use of impregnants</b>	
Do you believe that impregnation is an effective method for improving durability?	
To what extent are you implementing BD43/90 and BD43/03?	
Have you experienced any difficulties in implementing BD43/90 and BD43/03?	
Any other comments	
<b>Availability of detailed information</b>	
Do you have accessible information as to which bridges/structures have been treated?	Yes/No
Do you have any information regarding the details of the treatment?	Yes/No
Do you have any pre/post treatment test data (eg half cell potential surveys or chloride ion contents) or any other assessments of effectiveness?	Yes/No
Are you confident that you would be able to complete at least some of the follow- up questionnaire?	Yes/No
Any other comments	

Completed by:

Maintenance area:

Date:

## **ANNEX B: Second stage of project - Follow up questionnaire**

The information that is required for each structure is listed below:

### ***1. For 'new construction' structures built and treated since 1990***

#### **Treatment:**

Date treated

Elements treated

Manufacturer of impregnant

Product Name

#### **In-service issues:**

Comments on the performance of the impregnant including any relevant testing

### ***2. For 'in service' structures built before 1990***

#### **Treatment:**

Was any testing undertaken prior to treatment?

Date treated

Elements treated

Manufacturer of impregnant

Product Name

#### **In-service issues:**

Comments on the performance of the impregnant including any relevant testing

### ***3. Retreatment of any structures***

Has any retreatment been carried out?

Was any testing undertaken prior to retreatment?

Date treated

Elements treated

Manufacturer of impregnant

Product Name

## Appendix D. Instruction sheet for main questionnaire

Impregnant Questionnaire		
<b>Area 7</b>		
Total Bridges included	713	
Post 1990	102	
Pre 1990	611	<i>Note: Bridges with no record of date commissioned are included in Pre 1990 bridges</i>
<b>What to fill in:</b>		
Please provide information specific to each structure on the two subsequent sheets (for structures built since 1990 and structures built before 1990)		
Guidance for answering the questions is given below		
Most of the questions require a short answer (either a single letter or one or two words). The questions marked with an asterisk (*) may require a more detailed answer. Therefore larger fields have been created to the right on the sheets as indicated by		
Where a list of treated/repared elements are required, please enter letters for each element into the cell		
<b>1. For structures built since 1990 (Post 1990 sheet)</b>		
<b>Initial Treatment</b>		
Date treated	Year structure was treated	(Year)
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
<b>"In-service treatment"</b>		
Comments	Comments on the performance of the impregnant including any relevant testing (if available)	(Free Entry)
<b>2. For structures built before 1990 (Pre 1990 sheet)</b>		
<b>Treatment</b>		
Testing	Was any testing undertaken prior to treatment (Yes, No, Don't know)	(Y/N/D)
Date treated	Year structure was treated	(Year)
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)
<b>"In-service treatment"</b>		
Comments	Comments on the performance of the impregnant including any relevant testing (if available)	(Free Entry)
<b>3. Retreatment</b>		
<b>Retreatment</b>		
Testing	Was any testing carried out prior to retreatment (Yes, No, Don't know)	(Y/N/D)
Date treated	Year structure was treated	(Year)
Elements treated	Enter codes for elements that have been treated	See Table 1
Impregnant Manufacturer	Give manufacturer of impregnant if known	(Free Entry)
Product name	Give name of product if known	(Free Entry)

Code	Element
A	Abutments
B	Ballast Walls, Bearing Shelves and Deck Ends
C	Columns
D	Deck Beams
L	Parapets / Parapet Plinths
P	Piers
R	Retaining Walls
S	Soffits
W	Wing Walls
X	Cross Heads
D	Other

## Appendix E. General issues relating to the use of impregnants (from preliminary survey)

Area	Do you believe that impregnation is an effective method for improving durability?
1	Yes
2	Yes, if applied to new clean structures at an appropriate age after casting. Unsure of its usefulness/life when applied 20+ years after exposure to dirt and de-icing salts. Would like to see a double blind trial to check effectiveness at stopping corrosion (rather than indirectly the via DRC)
3	Yes, in principle, but this must be as a supplement to good quality construction and concrete. i.e. maintaining specified cover to reinforcement and well compacted concrete.
4	Having seen silane being applied it is highly dangerous to the operative and the public and it is debatable as to the coverage achieved and therefore its effectiveness.
5	Yes
6	We do not have any evidence to prove or disprove the effectiveness of impregnation. We do have lots of historic PI test results (half cells, chlorides and carbonations) but we have not analysed these with a view to determining the effectiveness of impregnation.
7	It can help if the circumstances are appropriate, but should not be seen as a panacea for general degradation.
8	There is no evidence yet from Area 8 structures to support the notion that this treatment does not work. However BD43 seems to support this.
9	Yes. It has a place alongside other techniques.
10	In comparison, structures which have received Silane treatment do show a difference in reduced spalling and reinforcement corrosion. Our current contract encompasses three previous Agencies; Area 10, Area 15 and Area 17, now known as New Area 10. Silane impregnation (to existing structures) in 'Old' Area 10 was not substantially implemented. Area 15 carried out significant applications as did Area 17. It is possible therefore to draw direct comparisons between the two sets of structures.
11	I do not have sufficient information and records to form a view on this.
12	Yes.
13	Yes when applied to new structures. On older structures this obviously depends on the condition of the concrete.
14	No evidence to support the case for or against the use of impregnation protection

Area	To what extent are you implementing BD43/90 and BD43/03?
1	Testing is carried out to all concrete structures at every principal inspection to determine any requirement to impregnate.
2	Patchy compliance. Area 2 was amalgamated from parts of Somerset, Wiltshire, Dorset, Gloucestershire, Devon and Avon. Whilst records of impregnation exist at an individual bridge level, a comprehensive list of all treated structures (and dates on treatment) is more difficult to obtain. Probably 80% of concrete structures treated ( guestimate ).
3	Currently treatment is only to new and remedial works on existing structures, and to all new structures.
4	Treatment has been confined to new works on existing structures and new structures. No impregnation to 'in service' structures as stand alone schemes has been carried out by InterRoute. I have no knowledge (but I doubt) if the previous Agent carried out any impregnation work.
5	We have proposed studies to identify those structures "at Risk", unfortunately at present these works in isolation are not value managed sufficiently high enough to be funded. When specific concrete remedial works to a highway bridge are carried out usually silane is also applied.
6	BD43/90 and BD43/03 are implemented on our major maintenance (hybrid) schemes. Say 2 to 5 bridges per year. We do not currently have funding identified for a rolling programme of impregnation maintenance.
7	We are impregnating structures or elements of structures whilst carrying out other works. We have conducted preventative maintenance studies analysing test data to identify areas for impregnation. There is no programme of general impregnation, or repeat applications.
8	Area 8 is a mixture of mostly old but not ancient structures. All new construction is considered for application but it usually requires a return visit to site following the completion of maintenance works. The HA's 'Customer First' policy clashes with the requirement of the return visit. Limited implementation – has been applied to new structures and strengthening or maintenance schemes. Where exposed components have been replaced on more recent schemes (eg M1 parapet replacement and fender upgrade programme), stainless steel reinforcement has been used as being more cost effective in whole life cost terms and avoids H&S, environmental issues with silane
9	It is being implemented in accordance with the BD. However, earlier treatments on Midland Links substructures did use silane even where positive drainage was provided to the deck joints above.
10	Impregnation is applied to all new structures. Application to existing structures is limited by financial restrictions. There is a target to achieve some treatment each year.
11	For network occupancy reasons we do not carry out specific schemes to silane structures, but do carry out the treatment during all structures schemes and hybrid schemes.
12	Very little new concrete is being cast as part of our current work but all new concrete is being treated. We are planning to review the possibility of treating existing concrete , especially where concrete repairs have been done, in the next few months.
13	Unable to comment. AmeyMouchel as agents for MAC 13 and previously Area 19 have taken over the maintenance of structures which where appropriate would have been silane treated by the previous agents. To date no silane works have been undertaken as part of the commission.
14	Impregnation is undertaken with planned maintenance works where practical and appropriate

Area	Have you experienced any difficulties in implementing BD43/90 and BD43/03?
1	No
2	<p>Yes. Structures in service are covered in dirt which is not easily removed to allow meaningful impregnation to take place. Testing after impregnation on a Wiltshire contract apparently showed zero depth of impregnation.</p> <p>Contract conditions allowing for a dry period before and after application are difficult to monitor/ensure, as is monitoring usage/drum open times. Self certification is not proven to be as accurate as desired.</p> <p>Due to TM restrictions, it is usually necessary to under take the works over a period of nights (usually 3 or 4) one of which will be preceded or followed by rain. Problems have been experienced with gusting winds/vehicle wakes and overspray which has affected nearby vegetation. Recently contractors have generally proposed alternatives (Departures from Standard) to “traditional” spray applied silane.</p> <p>The toxic nature of Silane makes application in a live traffic environment very problematic in terms of methodology to satisfy H&amp;S needs. Weather sensitivity further complicates planning</p>
3	
4	InterRoute took over Area 4 in June 2003 so we will have been using BD 43/03. All new works have included silane treatment.
5	We as an Managing Agent have proposed through Continual Value Management (CVM) Silane impregnation of vulnerable structure, however preventative projects no not score high enough within the CVM process to usually be funded, therefore we have been unable to undertake any Silane impregnation programmes during this commission, unless included with other works.
6	Environmental problems/assessment are now key issues and more environmentally friendly products are favoured (Pavix??)
7	No, see above.
8	See ‘Customer First’ above. It would be difficult to justify application to an older structure unless there was a specific problem with corrosion that we were trying to address. In which case we would either construct a new element and treat as appropriately or carry out a concrete repair, the effect then being somewhat limited. Although application rates are specified and can be controlled/measured, to some degree on site, the rate of impregnation and the lost material is uncertain. Also works can be delayed/affected by weather conditions.
9	Not aware of any.
10	Apart from financial difficulties, No.
11	Carrying out treatment at the correct intervals.
12	No.
13	Unable to comment. AmeyMouchel as agents for MAC 13 and previously Area 19 have taken over the maintenance of structures which where appropriate would have been silane treated by the previous agents. To date no silane works have been undertaken as part of the commission.
14	None with planned maintenance works