FAST TRACK CONCRETE PAVING: STUDY VISIT TO IOWA, USA

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The views expressed in this report are not necessarily those of the Department of Transport

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ABSTRACT

As part of a collaborative research and development agreement between the Department of Transport and the British Cement Association, a study tour was made in Iowa, USA to gain first hand experience of the Fast Track Concrete Paving system and to examine the feasibility of introducing this form of construction into the UK. In addition to the Department of Transport and the British Cement Association, two major contractors, Balfour Beatty Construction Ltd and Laing Civil Engineering, experienced in road pavement construction were represented on the visit in order that a balanced view could be formed.

During the study tour a visit was made to a reconstruction contract in progress at Cedar Rapids, Linn County where the Fast Track paving process was used both for the main carriageway construction and for intersections and entrances to side roads. The intersections were constructed and opened to traffic within a 12-hour period. Various other completed projects were inspected and information on these and the impressions of the visiting party are outlined in the report.

1 INTRODUCTION

The use of conventional concrete mixes in concrete pavement construction and maintenance generally means that concrete roads cannot be opened to traffic for several days until such time as they have gained sufficient strength. Conversely, roads constructed of bituminous materials can be opened to traffic as soon as compaction has been completed. The consequence of this is that, in the UK, concrete is rarely used for over-laying old pavements, reconstruction or new single carriageways because of these unacceptably prolonged curing periods.

In the USA, and the State of Iowa in particular, these problems have been addressed and a new Fast Track Concrete Paving system has been developed over the last three years or so. This system covers the materials, techniques and plant needed to construct concrete roads quickly and economically yet be able to open the concrete pavement to traffic within 24 hours if necessary. This FTCP system has been developed jointly by the members of the Iowa Concrete Paving Association and the Iowa State Department of Transportation.

In order to investigate the FTCP system and its applicability to the UK conditions, the Department of Transport and the British Cement Association jointly undertook a collaborative research and development programme. The first phase comprised a literature search and desk study of FTCP together with a short feasibility study tour in Iowa.

This report gives an account of the tour and includes details of an FTCP contract visited during construction. Appendices to the report give information on the organisations visited during the tour, on completed FTCP projects, on other details of concrete paving engineering practice in the State of Iowa and an abstract of the desk study.

In order to obtain a balanced view of the FTCP it was considered necessary to have representatives from contractors organisations in addition to representatives from BCA, DTp, and TRRL. Contractors Balfour Beatty and John Laing agreed to send one representative each on the tour. The members of the visiting party are listed in Appendix A. The one-week study tour was arranged through the Iowa Concrete Paving Association (ICPA) in association with the Iowa Department of Transportation (IDOT).

2 BACKGROUND TO FTCP

2.1 HISTORY OF DEVELOPMENT

In the State of Iowa, USA, the paved road network has been substantially completed using a large proportion (probably in excess of 75 per cent) of concrete. The only forms of construction of any significance that are now taking place are reconstruction, overlays and widening of existing roads. It was realised in Iowa that if concrete was going to compete with bituminous materials in many of these situations it was necessary to develop a concrete mix that would allow concrete roads to be opened as quickly as that achieved by bituminous materials. With this in mind, in 1985, the Iowa Department of Transportation (IDOT) in association with the Iowa Concrete Paving Association (ICPA) developed the Fast Track Concrete Paving technique.

Although the reconstruction market was available, the time necessary for concrete curing made it unattractive compared to other techniques unless this time could be reduced.
The objective of Fast Track paving was to construct a pavement of equal durability to a conventional concrete pavement that could be opened to traffic within 24 hours. This objective has been successfully achieved by the use of modified PQ mix designs, but still using conventional paving plant. Further variations have been developed including Fast, Fast Track paving which allows traffic to re-use a road within 12 hours of its closure.

2.2 PRINCIPAL FEATURES OF FTCP
The essential features of FTCP are:

(a) the selection of an appropriate cement to suit the required time of opening to traffic.

(b) the use of insulation blankets laid as soon as possible after the application of the curing membrane, to maintain a high concrete temperature.

(c) The use of conventional concrete paving equipment.

(d) The sealing of joint grooves very shortly after they have been sawn.

Of these, the most noteworthy feature not normally considered for road paving was the use of insulation blankets.

The purposes of the insulation blankets are to:

(i) Assist in preventing moisture loss thus maximising the rate of hydration and minimising shrinkage.

(ii) Promote a more uniform temperature gradient through the slab thus reducing the possibility of cracking due to thermal and warping stresses.

(iii) Induce a higher temperature thus accelerating the early maturing of the concrete and achieving a higher strength at early ages.

3 DETAILS OF FTCP SYSTEM
The concept of Fast Track paving hinges on the use of a concrete mix of high early-strength coupled with curing at high ambient temperature.

The Fast Track mix is based on a standard pavement-quality mix with certain additional requirements.

3.1 MATERIALS
The Iowa DOT specifies concrete mixes by recipe. The type of cement used is a selected Type III (similar to UK Rapid hardening cement). A minimum mortar strength of 1300 lb/in² (9N/mm²) at 12 hours is specified by the IDOT. The IDOT will permit the use of ordinary Portland cement in situations where time constraints are less demanding. Also, the use of specialised high early-strength cements has been considered but to date has not been pursued. The cement content of the Fast Track mix is specified as 710 lb/yd³ (421 kg/m³). At locations where opening is required within 6 hours after construction a Fast, Fast Track mix (designated as an FF mix) is used with a content of 825 lb/yd³ (489 kg/m³) of Type III cement.

Flyash may be used as a cement replacement for up to 10 per cent of the 710 lb/yd³ (421 kg/m³) in Iowa except during the winter period. It is a more reactive type (Type C) compared with that used in the UK, consequently concretes with flyash have the same rate of strength increase as concrete with only ordinary Portland cement. Flyash is used in concrete mixes as a means of increasing workability and reducing water content. The relative price of cement in the USA and the UK is comparable but flyash in the USA is about 20 per cent of the price of cement whereas in the UK it is about 40 per cent of the price of cement.

The use of water-reducing admixtures and air-entraining agents are mandatory. Although accelerators such as calcium chloride have been tried in the past their use has now been discontinued.

Sawn joints are mandatory and the use of limestone coarse aggregate which is predominantly available facilitates early joint sawing. The use of a natural sand rather than crushed rock fines is found to aid early strength gain.

The design method for Fast Track mixes has been improved in the USA as a result of better proportioning of the 10 mm to 5 mm aggregate fraction to achieve good workability together with the required strength. In the USA, the aggregate grading is normally a product of 20 mm down coarse aggregate and sand (5 mm down), the exact combined grading has varied depending upon the naturally occurring fraction below 10 mm in the coarse aggregate. This fraction has always played a more important part in a UK mix because the aggregate is batched from separate stockpiles of 20 mm and 10 mm coarse aggregate and sand.

The requirement for concrete strength before new construction may be opened to traffic is 500 lb/in² (3.45 N/mm²), (using the 3 point flexural test). However, because of the rapid build up of strength with Fast Track mixes additional gains are anticipated between testing and opening, consequently the test criteria is reduced to 400 lb/in² (2.76 N/mm²).
In order to confirm the results of laboratory tests, the construction of advance trials has been favoured in Iowa to avoid the possibility of failures in a main scheme which would lead to a public reaction against the use of Fast Track Concrete Paving.

3.2 TEMPERATURE AND CURING

For Fast Track paving concrete is maintained at the highest temperature practicable. To achieve trafficking in less than 12 hours it has been found necessary to specify a minimum concrete temperature at laying of 85°F (29°C). However, concrete with a temperature exceeding 95°F (35°C) may result in rapid stiffening and loss of workability and finishability. In practice the contractor keeps a supply of chilled water in order to ensure that concrete temperature remains within specified limits.

White pigmented curing membrane is used at 50 per cent greater than the normal dosage rate.

Thermal insulation blankets are used to cover the concrete at the earliest opportunity, i.e. as soon as the concrete can stand the weight. The blankets are specified to have a resistance to heat movement (R) greater than 0.5 Btu⁻¹/hr/ft²/°F; those observed consisted of two layers of hessian with a plastic coating to each side.

The purpose of these blankets is to retain the heat generated by hydration and assist the curing membrane in retaining moisture. They help maintain a uniform temperature gradient through the pavement thus preventing unequal stresses due to warping etc whilst giving a curing environment of high temperature and humidity (the best possible combination for curing).

3.3 PAVING PLANT PROCEDURES

No changes have been found necessary to the normal batching and laying techniques used in Iowa. However, it should be noted that the ‘normal’ method of laying is by slip-form paver and that sawn joints are mandatory.

Plant manufacturers have investigated the design of ‘zero clearance’ pavers to aid reconstruction work. The term ‘zero clearance’ describes slip-form paving plant which does not extend outside the laid width of the pavement. To date the market place demand has not pushed this development very far. Zero clearance pavers are not yet in general use but plant manufacturers have produced prototypes. One of the problem areas with zero-clearance pavers could be a provision for the insertion of tie-bars.

It was noted that the use of rapid hardening cement, high cement contents and high temperature mixes had not required Contractors to alter their techniques significantly for transport, laying or finishing. ‘Working time’ for the concrete was still found to be approximately 90 minutes.

The finished surface is textured by means of a sheet of ‘astro turf’ dragged longitudinally to raise coarse sand particles followed by a transverse tine machine. The tines are made from metal strip and are 4 in × ¼ in × ½ in or ⅛ in (100 mm × 3 mm × 0.8 or 1.6 mm) and are spaced at regular intervals of ⅛ in (38 mm). The depth of impression into the surface is approximately ⅛ in (3 mm).

The sequence of the joint forming operation is to first make a cut with an abrasive disc at 5 hours while the concrete temperature is rising, followed immediately by a widening cut with dry diamond blades (2 blades set parallel and spaced apart). Hot applied sealants are usually placed in FTCP 36 hours after construction although only two suppliers recommend their materials for sealing this early (1 hot poured, 1 silicone). The type of joint sealant normally used is a soft, hot-applied sealant containing polymers and complying to ASTM 3405. Compression seals are used for FF Fast Track mixes that are intended for opening in 6 hours.

Sealing and white lining is normally done before opening to traffic although Iowa DOT and ICPA are not yet convinced of the advisability of sealing at this early date. Due to the presence of the curing membrane, the initial application of white lining wears off faster than normal, but this is accepted by IDOT. Inset reflecting studs are not used in Iowa.

4 VISIT TO FTCP CONTRACT AT CEDAR RAPIDS

During the study tour the visiting party were able to view a reconstruction contract in Cedar Rapids, Linn County. This scheme involved the reconstruction of 1.8 miles of the west bound carriageway of the Collins Road dual 2-lane carriageway. This contract was carried out in 2 stages. Stage 1 was to repair the existing east bound concrete carriageway and to strengthen a diversionary route for the diverted west bound traffic that would be needed for stage 2 of the scheme.

Stage 2 was to demolish and remove the existing 10 in (254 mm) thick jointed concrete road and sub-base, reconstruct the sub-base and construct a new 10½ in (267 mm) concrete carriageway, 24 ft (7.3 m) wide, with additional widening for turning traffic at traffic lights. Removal of the existing road and construction of the new one were to be completed in 30 working days.
There were 9 intersections and entrances to side roads which could only be closed for periods not exceeding 12 hours, the time of day for period closure was generally 6 pm to 6 am. After removal of the existing road, the contractor elected to provide a temporary running surface for traffic using the intersections until they were paved with an FF mix. The first two of the nine intersections were paved during the evening of the study visit.

Main line paving was carried out by a conventional CMI slip form paver with a Rex concrete spreading machine (Figure 1). Concrete was batched at a nearby central batching plant and delivered by end tip trucks.

Concrete was side loaded into the spreader. Concrete remained workable for up to one and a half hours.

Concrete for main line paving was a Class F mix (rapid hardening) as defined by the IDOT Specification, which was to achieve a flexural strength of 400 lb/in² (2.76 N/mm²) at 12 hours. The concrete used at intersections was a Class FF mix which had to attain a flexural strength of 400 lb/in² (2.76 N/mm²) at 6 hours. The contractor had considered the use of a proprietary high early-strength cement (Pyrament) as an alternative source of cement but in the event used a selected Type III cement.

Concrete was textured longitudinally with artificial grass (Astroturf) with subsequent transverse grooving with tines (Figure 2).

In all cases during main line paving and paving of intersections concrete was textured longitudinally with artificial grass (Astroturf) with subsequent transverse grooving with tines (Figure 2).

The rate of application of white pigmented curing membrane applied to concrete surfaces was 50 per cent greater than the normal dosage.

Insulating blankets made of two layers of hessian protected by a white plastic cover, was laid soon after applying curing membrane (Figure 3). The blankets were manufactured by the Max Katz Bag Co of Indianapolis under the trade name of Bur Lene.

Joints were sawn at right angles to the centreline of the carriage with an abrasive saw at 3 to 5 hours. This was followed by dry sawing of sealing grooves with twin diamond impregnated saw blades. This was followed soon after by sealing of the grooves with hot poured sealant complying with ASTM 3405.

The first intersection was opened to traffic on time at 6 am (Figure 4) after checking that the flexural strengths of the test beams had obtained a flexural strength greater than 400 lb/in² (2.76 N/mm²). For the second intersection the first beam tested at 5.50 am gave flexural strength less than 400 lb/in² (2.76 N/mm²). The opening of the intersection was delayed therefore and a second beam was tested at 6.45 am which showed that the flexural strength was then adequate. The second intersection was then opened to traffic at about 7.00 am. A full timetable for the construction and opening of the two intersections is given in Table 1.

Details of the concrete control beams that were cured and tested on site to determine compliance with opening requirements are given in Table 2.
Fig. 2 Textured surface of slab

Fig. 3 Placing the insulation blankets
Fig. 4 Trafficking of intersection the morning after construction

TABLE 1
Timetable of the construction and opening of intersections

| Intersection 1 | Excavation of temporary material | 6.00 pm to 8.30 pm |
| Place dowels on cages | 8.15 pm to 9.00 pm |
| Concrete — main | 9.00 pm to 10.30 pm to 11.00 pm |
| — finishes | |
| Saw cut and seal | 5.00 am to 6.00 am |
| Intersection 2 | Excavation of temporary material | 8.00 pm to 10.45 pm |
| Place dowels on cages | 10.30 pm to 11.00 pm |
| Concrete — main | 11.00 pm to 12.15 am to 12.45 am |
| — finishes | |
| Saw cut and seal | 6.00 am to 7.00 am |

TABLE 2
Strength of site cured beams

<table>
<thead>
<tr>
<th>Beam No</th>
<th>Made</th>
<th>Tested</th>
<th>Age</th>
<th>Flexural strength (lb/in²)</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.6.89</td>
<td>23.6.89</td>
<td>8hr 30m</td>
<td>435</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>9.10 pm</td>
<td>5.40 am</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>22.6.89</td>
<td>23.6.89</td>
<td>6hr 40m</td>
<td>317</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>11.10 pm</td>
<td>5.50 am</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>22.6.89</td>
<td>23.6.89</td>
<td>7hr 35m</td>
<td>428</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>11.10 pm</td>
<td>6.45 am</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There was a financial penalty of $3,000 per working day for every day exceeding the 30 days stipulated for the completion of the contract.

Also, for each additional hour in excess of the 12 hour period specified for constructing intersections, a financial penalty was stipulated, $500 per hour for the first hour and $100 per hour for each succeeding hour. Although the time period for completion of the second intersection was exceeded no financial penalty was imposed due to the fact that the delay occurred through no fault of the contractor.

The main line paving work was supervised by foremen who take on more organisational responsibility than their UK counterparts. During the paving operation all the work was controlled by the foreman who, when problems arose, discussed with his opposite number on the client's site (the clerk of works) and they reached joint agreement on a course of action. There were no engineers (setting out/section or otherwise) around the paving operation and no sub-agents or ARE's actively participating in the production. The work on the intersection was more closely supervised because this was the first time that opening to traffic had been required as early as 6 hours after construction.

It was also interesting to note the importance of Public Relations expressed by the Resident Engineer on the Cedar Rapids Project.

5 OBSERVATIONS AND IMPRESSIONS

Two days of the visit period were devoted to reviewing a number of completed projects three of which had been constructed using FTCP and six others were major strengthening or rehabilitation projects. Detailed information on these is given in Appendix B. In the course of this review, involving a total journey of 1,100 miles, the travelled road surface was predominantly concrete and many aspects of road condition, layout and maintenance strategy were noted.

5.1 GENERAL

Experience in Iowa has confirmed that the concept of FTCP is practicable and provides an alternative to asphalt for paving on reconstruction, strengthening and widening schemes.

Concrete mixes can be designed which will gain sufficient strength to allow full trafficking within hours rather than days or weeks. 'Normal' laying techniques can be used and problems of shrinkage and thermal cracking can be avoided. Thus, concrete pavement can be laid without undue disruption to the general public.

In considering the viability of FTCP for a project, the greater expense of paving with FTCP is compared to the reduced cost of traffic delays.

In the UK, although there is close liaison between DTp and BCA on matters concerning concrete paving, there is no equivalent organisation to the ICPA existing in the UK. UK contracting organisations and other organisations that have an interest in concrete paving, tend to operate in disparate ways. Consequently new developments in concrete paving take a longer time to be implemented in the UK than would be the case if there was co-ordination between all interested parties.

General observations were that a quality product is provided by the US contractors and that a smooth ride is generally achieved. Tyre noise resulting from the regular transverse grooving specified was not noticeable inside a bus-type vehicle but was noticeable inside a private car.

5.2 CONSTRUCTION

The pavement construction season is similar to that in the UK although extremes of temperature are more severe. The paving takes place at significantly higher temperatures than in the UK, air temperatures in the shade of up to 39°C suggest temperatures in direct sunlight of up to 50°C.

Conventional hot and cold poured sealants are not recommended for joint sealing until some days after forming joints although compression seals can be used. Further information could be usefully obtained from the USA on the type of poured sealants used in Fast Track contracts.

No particular performance or maintenance problems have been noted with Fast Track projects although long-term performance is obviously as yet untested, and most projects viewed have been subjected to relatively low traffic volumes in their short lives.

It was stated that the use of the extra curing compound was to counteract the drying effect of the wind and retain all of the mix water thus minimising the possibility of shrinkage cracks.

The contract at Cedar Rapids showed the importance of informing the general public of the type of road reconstruction and traffic management being carried out in order to ensure that a new road could be built in the shortest possible time thereby minimising traffic delays. The general public were very receptive and welcomed IDOT's public relations exercise in
keeping them informed of the reasons why the work was being done.

5.3 APPLICABILITY OF FTCP TO THE UK

Fast Track Paving techniques could be used in the UK both under normal contract arrangements and for lane rental contracts. The mix design and constituents, including cement, are available but the early strength levels could be hard to achieve in the lower ambient temperatures normally experienced in summer in the UK. There are a number of other aspects of construction that need careful evaluation before deciding to specify Fast Track paving in the UK.

UK quality control strength tests would have to be modified in order to simulate strength gain in the concrete slab either by curing cubes in an identical manner to the slab or by temperature matched curing.

Also in the UK, sub-bases for concrete pavements are constructed in cement-bound materials with a 7 day strength requirement of 10 N/mm². In order to take fullest advantage of Fast Track paving a Fast Track approach will also be required for sub-base materials.

If required, the water reducing agent would need to be agreed with the specifying body.

Hand lay or machine lay techniques can be utilised (with slightly modified equipment if required).

Where FTCP is used for thin overlays, the normal use in the UK of inset studs for lane markings would lead to induced cracking; alternative forms of marking would be necessary.

It is uncertain whether or not the current UK brush texture would withstand early trafficking. The American ‘Astro Turf’ drag mat plus transverse tining apparently works but random tine spacing would be more in line with present practice in the UK.

It would be preferable to use limestone or granite aggregates to reach early strength levels more readily and to allow joints to be sawn at an early age. Concretes containing some gravel aggregates can also be sawn but the cost is significantly greater than that of sawing limestone or granite aggregates. Alternatively wet-formed joints could be used with gravel aggregates.

The overriding factor that will ultimately decide the introduction of FTCP into the UK will be cost. With present practice, any economic benefits resulting from the early opening of a concrete construction, within a similar timescale to that set for flexible construction, will in general be those perceived by the contractor. However, the increase in lane rental contracts and the application of whole-life appraisal rather than initial costs in selecting between tenders, could influence the competitiveness of the two forms of construction.

The type of paving where Fast Track would be applicable could include:

(a) Complete carriageway reconstruction.
(b) Partial replacement by an inlay of one or more lanes.
(c) Strengthening of existing bituminous and concrete pavements by an overlay.
(d) Maintenance processes where the American approach of ‘close the road and open to full traffic within 2 days’ may be attractive.
(e) Airfield pavements.

The benefits of the application of FTCP in such situations would include:

(a) A reduced contract period thereby reducing the cost of the contract overhead.
(b) Trafficking the pavement at an early age.
(c) Minimising the use of expensive concrete paving plant and traffic management systems.
(d) Reduced traffic delay costs.

6 CONCLUSIONS AND RECOMMENDATIONS

Fast Track Concrete Paving techniques could be used in the UK both under normal contract arrangements and for lane rental contracts. In order to determine suitable criteria for UK conditions it is recommended that the following work should be undertaken.

(1) Laboratory trials using UK materials to test suitable concrete mixes and estimate the likely material costs.
(2) Pilot-scale curing trials are required to check on early-age strength gain and temperature gradients under UK ambient temperatures.
(3) Laboratory and full-scale trials on the formation and sealing of joints in early-age concrete paving.
(4) Comparative studies on the durability of American (tined) and British (brushed) techniques for surface texturing to establish rates of wear after opening to traffic at early ages.
(5) Specification trials at selected sites where the consequences of under performance are not too severe.
From what was learnt during the visit to Iowa the following arrangements appear to benefit both the introduction of innovative techniques and the achievement of high standards in concrete pavement construction.

(1) Collaboration between a Contractors Association and Clients on plans for technical developments.

(2) The provision for financial incentives and disincentives related to the quality of the finished product.

7 ACKNOWLEDGEMENTS

The work described in this report was carried out as part of a collaborative research and development agreement between the Department of Transport and the British Cement Association. The work forms part of the programme of research of the Materials and Construction Division (Division Head: Mr D M Colwill) of the Highways Group of the TRRL.

The study group is indebted to all the engineers from the Iowa Concrete Paving Association, the Iowa Department of Transportation and the Gomaco Corporation for their co-operation and efforts in ensuring the success of the study visit. In particular, thanks are due to Mr Gordon Smith of the ICPA for his rôle in organising the arrangements and the itinerary for the visit.

The authors, who constituted the Working Group under the collaborative agreement, also acknowledge the invaluable contribution made by Mr D Lloyd of Laing Civil Engineering and Mr P Hollands of Balfour Beatty Construction Ltd in providing a contractor's viewpoint during the study visit and in the preparation of this report.

APPENDIX A

CONTACT LIST

Visiting Party
R E Franklin — TRRL
J Mercer — R E Division, DTp
B J Walker — British Cement Association
D Lloyd — Laing Civil Engineering
P Hollands — Balfour Beatty Construction Ltd

Federal Highway Administration
Dr A Shafi — Demonstration Division

Iowa Department of Transportation
R Humphrey — Head of Highways Department
B Brown — Materials Engineer
O J Lane — Testing Engineer

K Dirks — Design Engineer
J Grove — Paving Engineer

American Concrete Paving Association
M J Knutson — President

Iowa Concrete Paving Association
G Smith — Executive Vice President
R H Given — Associate Engineer (ex IDOT)
G Hardy — Associate Engineer

Gomaco (USA)
G L Godbersen — President
B Schwartzkopf — Sales Director—International

Gomaco International Ltd
D E Willis — Managing Director

APPENDIX B:

TOUR OF COMPLETED SCHEMES

B.1 FTCP PROJECTS

Nine Fast Track paving projects were completed in the state of Iowa in 1987. No information is available for 1988. Ten Fast Track paving projects are planned for 1989.

B.1.1 US Highway 71—Storm Lake—Buena Vista County

This was the first Fast Track paving contract carried out on a public highway. The scheme which was 7 miles long involved overlaying and widening from 20 to 24 ft (6.1 to 7.3 m) the existing jointed reinforced concrete road constructed in 1937. The overlay was 4 in (100 mm) thick with full depth widening at the edges and bonded to the existing pavement.

The old pavement was shot blasted with steel pellets to clean off surface contamination and unsound material. To ensure adequate bonding of the overlay, a cement grout was sprayed immediately in front of the concrete paver.

The concrete mix was a Class F mix with Type III cement (rapid hardening) and fly ash. The water cement ratio was about 0.44, and the mix had an entrained air content of 6.5 per cent, a slump of 1½ in (38 mm) and incorporated a water reducing agent. The aggregate proportions were 55 per cent coarse limestone and 45 per cent sand.

The specified concrete strengths were a flexural strength of 350 lb/in² (2.4 N/mm²) and a compressive strength of 2500 lb/in² (17.2 N/mm²), both to be achieved within 24 hours.
Due to the ambient temperature exceeding 90°F (32°C), the mix attained the specified flexural strength in under 8 hours and the specified compressive strength in under 12 hours. At 24 hours the flexural strength was 604 lb/in² (4.2 N/mm²) and the compressive strength was 3467 lb/in² (23.9 N/mm²); at 28 days the respective strengths were 830 lb/in² (5.7 N/mm²) and 5900 lb/in² (40.7 N/mm²). The bond strength was 302 lb/in² (2.1 N/mm²) at 24 hours and 359 lb/in² (2.5 N/mm²) at 29 days.

The overlay was constructed in two halves, whilst one half was constructed, traffic ran on the other half. A modified slip-form paver laid the concrete. As soon as concrete reached the required strength, traffic was permitted to run on the pavement.

Prior to overlaying, a survey of joints was carried out. It was found that not all the joints appeared to be functioning. As a consequence of this it was decided only to saw contraction joints in the overlay at positions where the joints in the existing pavement were functioning. As a further inducement to encourage movements only at the overlay joint positions, the overlay was locally debonded either side of the overlay joint positions. The joints were sawn the full depth of the overlay.

In the event, all the joints in the existing pavement reflected through the overlay manifesting themselves by hairline cracks.

The profilometer readings complied with the specification requirements at a value of less than 7 inches/mile.

The lesson to be learned from this project is that to minimise reflective cracking, joints should be sawn at all positions in the overlay where a joint has been sawn in the original pavement.

### B.1.2 Greenbrier Estate Road—Dallas County

This is a lightly trafficked, minor, county road that carries up to 400 vpd with very few commercial vehicles. The road is 1.03 miles long 22 ft (6.7 m) wide and 6 in (150 mm) thick and forms the only access from the State highway network to a residential area.

In order to minimise the period of restricted access the road was closed to traffic at 7.30 am on the day that construction started and opened to traffic at 5 pm on the following day. The residents whose properties fronted the road, even though it was closed for nearly 2 days, welcomed the programme of construction.

The road was constructed full width using a slip form paver as specified. The surface was textured longitudinally with a burlap drag (artificial grass) and grooved transversely with metal tines. The grooves were 3 mm wide, 3 mm deep and spaced at 20 mm.

A curing membrane was applied at a rate that was 50 per cent in excess of normal requirements and followed by the immediate placement of insulating blankets with a resistance to heat movement (R) greater than 0.5 Btu⁻¹/hr/ft²/°F.

Joints were sawn at an angle of 1:6 (82°) to the longitudinal axis and sealed as soon as the concrete had attained a flexural strength of 350 lb/in² (2.41 N/mm²).

The cement used was a Type III cement (rapid hardening) to produce a minimum mortar compressive strength 1300 lb/in² (9 N/mm²) when tested at 12 hours using a 50 mm cube specimen. The mix was made with limestone coarse aggregates and included a water reducing agent.

The profilometer reading was 9.43 inches/mile which indicates an excellent road surface evenness and hence riding quality.

### B.1.3 Industrial Road—Boone County

A brief inspection of one Fast Track pavement was made in Boone County leading off US Highway 30, west of Ames. The road was constructed in 1987 and was 2 miles long, 22 ft (6.7 m) wide and 7 in (178 mm) thick. The road formed an unbonded, jointed concrete overlay over the existing jointed concrete road. The pavement was constructed on a Friday and Saturday in time for opening to lorry traffic on Sunday.

In order to minimise the period of restricted access the road was closed to traffic at 7.30 am on the day that construction started and opened to traffic at 5 pm on the following day. The residents whose properties fronted the road, even though it was closed for nearly 2 days, welcomed the programme of construction.

The road was constructed full width using a slip form paver as specified. The surface was textured longitudinally with a burlap drag (artificial grass) and grooved transversely with metal tines. The grooves were 3 mm wide, 3 mm deep and spaced at 20 mm.

A curing membrane was applied at a rate that was 50 per cent in excess of normal requirements and followed by the immediate placement of insulating blankets with a resistance to heat movement (R) greater than 0.5 Btu⁻¹/hr/ft²/°F.

Joints were sawn at an angle of 1:6 (82°) to the longitudinal axis and sealed as soon as the concrete had attained a flexural strength of 350 lb/in² (2.41 N/mm²).

The cement used was a Type III cement (rapid hardening) to produce a minimum mortar compressive strength 1300 lb/in² (9 N/mm²) when tested at 12 hours using a 50 mm cube specimen. The mix was made with limestone coarse aggregates and included a water reducing agent.

The profilometer reading was 9.43 inches/mile which indicates an excellent road surface evenness and hence riding quality.

### Mix Details

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Rapid Hardening Cement</td>
<td>639 lbs (290 kg)</td>
</tr>
<tr>
<td>Fly Ash</td>
<td>71 lbs (32.2 kg)</td>
</tr>
<tr>
<td>Coarse Limestone Aggregates</td>
<td>1402 lbs (636 kg)</td>
</tr>
<tr>
<td>Fine Aggregate</td>
<td>1402 lbs (636 kg)</td>
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<tr>
<td>Water Reducer</td>
<td>28 oz (0.79 kg)</td>
</tr>
<tr>
<td>Air Entraining Agent</td>
<td>—</td>
</tr>
</tbody>
</table>

### B.2 OTHER PROJECTS

A number of sites located throughout six different counties where maintenance, rehabilitation and reconstruction had been or were being carried out were visited. Many of these older roads had been overlaid with thin layers, usually 2 to 4 in (50 to 100 mm) bonded or thicker layers 5 to 7 in (127 to 178 mm) unbonded.

Overlays often involved widening at the same time. The widened edge was constructed to the
combined depth of old and new slab and tied to
the old pavement edge by pre-inserted bars.
Where practical it has been found advisable to
saw a longitudinal joint above the step in the new
slab to prevent reflective cracking.

Brief details of the projects are given as follows:

Interstate Highway 80 Adair in Mjadison
County—The westbound carriageway was built in
the early 1960's. The slow lane was
reconstructed with concrete in 1979 using an
11 in (280 mm) thick jointed unreinforced slab of
(non-Fast Track) conventional construction. Joints
were sawn at right angles. Texture was applied by
a burlap drag longitudinally for micro-texture and
then transversely grooved for macro-texture.

Audubon County—Project at Kimballton, M66 in
Audubon County:— An unreinforced, undowelled,
5 in (127 mm) thick slab with joint spacing
unmatched to original was laid on a sand asphalt
slurry coat.

The underlying concrete was badly cracked,
principally as 'D' cracking.

Pottawattamie County—The eastbound carriage
had been overlaid with a 150 mm thick, jointed,
unreinforced overlay constructed on top of an
existing CRCP road that had been widened
adjacent to the fast lane in jointed unreinforced
concrete. The joints in the unreinforced widening
generated sympathetic cracking in the adjacent
CRCP.

On the westbound carriageway the CRCP
pavement had been overlaid with a bonded,
unreinforced, unjointed slab 3 in (75 mm) thick to
restore the riding quality. Performance here was
only satisfactory where the original pavement was
in good condition—badly cracked areas would
have been better reconstructed as an 'inlay'
rehabilitation. The CRCP on both carriageways
was over 20 years old, the overlays were
constructed in 1979.

Other lengths of Interstate Highway 80 also were
being reconstructed. The existing jointed
reinforced concrete pavement was being broken
up with a resonating breaker that broke the slabs
up very neatly so that the reinforcement could
easily be separated from the concrete. The
resonator was manufactured by Gurries Resonant
Breakers of Las Vegas, Nevada.

Interstate 280 Davenport—CRCP pavement built
1970. Because of a problem with 'punch outs',
full depth repairs are being carried out prior to the
construction of an overlay with 6 in (150 mm)
thickness concrete. Other than the 'punch outs',
the pavement was in relatively good condition with
transverse cracks at 6 to 9 ft (2 to 3 m) centres.
Epoxy coated reinforcement was fixed over repairs
in order to prevent reflective cracking in overlay.
On this contract, the contractor was proposing to
construct the overlay by carrying out contra flow
working. This was at the insistence of his
insurance company, although it was noted that
the full depth repairs were being carried out with
traffic running in the adjacent lane.

Oskaloosa Highway 137—An 18 ft (5.5 m) wide
jointed concrete road constructed in 1935 was
overlaid and widened to 30 ft (9.15 m) in 1980.
Transverse joints in the overlay coincided with
joints in the old road, three longitudinal warping
joints were provided. The road looked to be well
constructed and in good condition.

Greene County—Road E-53 east of Jefferson. A
3-mile length of badly deteriorated pavement that
originally formed part of the Lincoln Highway,
US 30, laid in 1922 as an unreinforced, 8 in.
(200 m) slab without joints, had been overlaid and
widened from 18 ft (5.5 m) to 22 ft (6.7 m) in
1973 with various forms of overlay as a major
IDOT experimental project. The overlay consisted
of 33 test sections of fibre-reinforced concrete, 4
sections of CRCP and 2 sections with dowel bars.
The variables included slab thickness, fibre
content and comparisons between a bonded and
an unbonded interface. Condition reports had been
produced in 1978, 1983 and 1988 and results of
these evaluations were provided by the IDOT.

APPENDIX C:
ROAD CONSTRUCTION PRACTICE IN
IOWA

C.1 GENERAL
A rolling 5-year plan is established by the State
and is based upon the total projected road
construction money. A 'rating of urgency' is
produced by IDOT for reconstruction work based
upon the projected truck traffic proportion and the
projected annual maintenance costs.

Currently there appears to be little expenditure on
new 'green field' roads as Iowa seems to have all
the main roads it needs for current and forecast
traffic. Road improvement, widening,
strengthening and reconstruction are the main
areas of expenditure. A high priority in the
rehabilitation spend is currently on bridges in the
form of structural improvements, width improvements or deck resurfacing.

Currently, up to 50 per cent of the total expenditure is on road reconstruction, with priority given to class A and B of the four classes of State roads (see Appendix F).

The State decides on a cost/benefit basis, the type of construction, noting that the cost/benefit includes the cost of delays due to construction (hence the viability of Fast Track Paving).

There is emphasis on the first year or two of the 5 year rolling programme. However there is a short ‘lead in’ time for contracts of a reconstruction nature which creates organisational problems, and in practice the programme extends beyond 5 years.

It was noted that the majority of other states operate in a similar fashion to Iowa.

C.2 ORGANISATION OF HIGHWAY PROJECTS

In general, concrete pavement works are carried out by small specialist contractors. The IDOT divides major projects into their constituent parts (ie earthworks, structures, pavements etc.) and lets each as a separate contract. Thus, the IDOT itself acts as overall ‘Management Contractor’ and uses specialist sub-contractors to carry out the work. Forthcoming contracts are advertised and the IDOT normally expects 4 to 6 contractors to submit tenders.

The IDOT considers a poorly constructed and engineered highway scheme reflects badly on the civil engineering profession. For this reason, to ensure a good standard of construction the IDOT has informal liaison meetings with the ICPA and the contractors to discuss ways and means of building concrete roads which are of a good standard of construction and can be built at the cheapest possible price. It was considered to be in everyone’s interest, including the public’s, that all sides of industry should co-operate with each other.

It was possible, under the Iowa state system, for all paving contractors to tender for all contracts. It appears, in practice, that each contract only receives about four tender submissions. The ICPA discuss the schemes with the IDOT and, assuming the work is specified as a concrete pavement, the ICPA contacts potential contractors informing them of the scheme.

Client/Contractor relationship is technical and workmanlike. It does not appear to degenerate into contractual/financial arguments or constant referral to specifications.

Claims appear to be dealt with in a similar manner to the UK and as with the UK most Clients and Contractors appear to do everything in their power to avoid having to resort to the Courts to settle their disputes.

Claims are obviously submitted, but the only example mentioned was resolved in 4 hours.

The project at Cedar Rapids, which was inspected while concrete paving was in operation, indicated that the Contractor’s workforce was ‘left to get on with the job’ and work was proceeding in an efficient manner.

However, discussions with the Site Agent indicated that a similar amount of daily paperwork was involved between Client and Contractor to that normally generated in the UK.

The IDOT takes the pragmatic view that their own supervision during the Contract period or the use of ‘Quality Assurance’ would ensure that the finished product can be fully accepted at the end of the Contract period.

The Federal and State authorities appear to have always taken a pro-active attitude towards the provision of an adequate infrastructure for the benefit of the economy.

C.3 TRAFFIC MANAGEMENT

Wide differences in traffic management methods were seen on various projects.

The use of solid pre-cast barriers between construction work and live traffic is obviously a very effective safety measure but it was noticeable that these were not used on all projects inspected.

Lower traffic volumes, slower traffic speeds and less aggressive driving must all contribute to a better safety situation than exists in the UK.

An inlay was constructed at Adair on Interstate Highway 80 in which the nearside lane was replaced using a paver that intruded 18 in into the adjacent lane which was being used to maintain traffic flow through the site.

Excavations for pavement repair are carried out immediately adjacent to the trafficked lane, which is contrary to requirements in the UK.

Personnel work on these excavations with heavy traffic passing by at 1 m distance.

On lightly trafficked roads, traffic control is often carried out by Flaggers—frequently women. Cones (or equivalent) are some 30 m apart. Cones at tapers are 5 m apart. In delineating the boundary
of maintenance work contractors very often use short plastic poles with flashing lights.

On heavily trafficked roads, work must proceed behind concrete barriers. The State owns and pays for the barriers whilst the contractor only has to collect, use, maintain and return the units in his tender price.

On an overlay scheme near Davenport on I280 the lower insurance costs implied it was safer to close a complete carriageway and use a contra-flow rather than close one (of two) lane and construct overlay in lane adjacent.

In the UK on dual carriageways the Health and Safety at Work Act would not permit much of the traffic management systems employed in Iowa. For example, on dual carriageways, a 1.2 m safety zone must be maintained between flowing traffic and the lane where work is being carried out; otherwise contraflow procedures must be operated. On single lane carriageways traffic lights or traffic control operatives may be used. This was the system used in Iowa.

C.4 SPECIFICATION

The IDOT Specification is basically a 'Method' Specification detailing fairly fully the materials to be used, methods and plant to be employed, concrete mix designs and finish to be achieved. Very few Contractor options are left open at tender stage. In particular, IDOT decide from the outset whether a project is to be paved in concrete or asphalt. For concrete pavements, recipe concrete mixes are specified rather than leaving the mix design entirely to the Contractor.

Each state is, theoretically, free to write its own specification, but the American Highway and Transportation Office ensure there is general conformity of standards of specification. However, there are 140 standard recipe concrete mixes accepted by the Iowa DOT and by UK standards the cement contents are high. Air entrainment is targeted at 6 to 6½ per cent. This is a high air content to achieve consistently. In the UK the figure is either 2½ to 5½ per cent or 3½ to 6½ per cent depending on the maximum aggregate size.

A maximum 15 per cent replacement of cement by PFA is permitted in standard PQ Concrete. This is reduced to 10 per cent in Fast Track concrete. In Iowa a Class C fly ash is generally used. This is the coarser grade and is probably equivalent to BS 3892 Part II Grade B.

The coarse aggregate in Iowa is predominantly crushed limestone. The sources are in the North and South of the State. Central Iowa contains glacial deposits. Aggregate grading in the State specification divides materials into coarse and fine components. Recently the importance of controlling the 1 in to ¾ in (25 to 10 mm) proportions has been realised and narrower grading bands, to produce higher strengths, has been advocated. The fine aggregates are washed natural sands. The use of crushed fine aggregates has been unsuccessful for concrete paving.

The idea of specifying a smoothness of ride measured by the profilometer sounds attractive and could be one that could be considered for adoption for both asphalt and concrete roads.

Attention is paid to durability of aggregates and sound aggregates are selected by freezing and thawing tests. Some aggregates are affected by sodium and magnesium impurities in the rock salt used for de-icing.

For FTCP the Iowa Specification uses temperature and humidity modified by wind velocity to establish the cut-off point for paving operations.

The paving season in Iowa is considered to be mid-April to mid-October.

C.5 ROAD DESIGN AND CONSTRUCTION

The Iowa Department of Transportation (IDOT) designs are based on AASHTO standards which are accepted by the FHWA for Interstate roads.

The initial design life of concrete roads is 30 years with a concrete bonded overlay constructed at the end of this period to extend the life of the roads to 60 years. This latter period has been found to produce the optimum whole life cost. However, it should be noted that some 60-year old roads are still in service and have not had any strengthening or thin bonded overlays added. A 20-year design life is used for the lower category State roads.

Bituminous roads are designed for an initial life of 15 years with strengthening overlays added to extend their life to 30 years. Once again this latter period has been found to produce the optimum whole life cost.

The life of existing highways has, in practice, been affected by de-icing salts and the history of the older roads shows that some are not achieving their original design lives. Therefore some adjustment to design has been undertaken to compensate for the deterioration caused by de-icing.

The Interstate highways within Iowa are now mainly dowelled unreinforced concrete pavements. Most of the other State roads have undowelled concrete pavements.
It was noticeable that hard surfaced roads in Iowa outside urban areas have a shoulder on both sides (usually unsurfaced) and drainage achieved by side ditches. This compares with most County roads in the UK being kerbed or having a raised verge and thus requiring a positive gully drainage system or some other water discharge provision.

Where services are involved they are generally kept outside the road width allowing road paving to be uninterrupted by boxouts for drainage manholes and other utility access chambers. This situation is further improved by the use of side entry drainage gullies. Where kerbs are used these are generally slip-formed, often integral with the main pavement.

Another basic feature of the pavement design now used in Iowa is the use of a drainable unbound granular sub-base with a specified permeability value.

The top layer requires a permeability of 200–350 ft/day and a base layer requires a permeability of 500–1000 ft/day. Both of these drain to an ‘accelerated drain trench’ (ie a fin drain or similar).

Dowel bars are not used unless the commercial vehicle traffic is above a certain level. Epoxy coated dowel bars with a debonding material have been in use for 10 years and so far the performance has been good.

The standard method in Iowa is for dowel bars to be fixed on cages ahead of the slipform paver. The IDOT does not currently permit use of dowel bar insertion techniques. However, consideration is being given to the Gomaco slipform paving technique which incorporates a dowel bar placer. On jointed concrete construction a slip membrane is not used between sub-base and surface slab.

On heavily trafficked roads minimum slab thickness of 10 in (254 mm) is used.

During a contract the testing of materials is carried out for the contractor by independent materials engineers who certify materials tested. Materials testing is also carried out for the Engineer to verify material quality.

On earthworks, IDOT specifies the source of materials to be used, monitors placement and carries out the necessary testing.

Permeable capping and sub-base are constructed with unbound aggregates. IDOT considers that permeable unbound sub-bases give superior performance to other forms of construction, better even than CBM sub-bases.

Much recycled concrete is used in capping and sub-base. The only equipment allowed to operate on the capping and sub-base layers is that required to construct the next pavement layer. These layers are not allowed to be used as a general haul road.

In Iowa unbound sub-bases are used which means that concrete can be placed on the sub-base as soon as compaction is completed.

Slipform paving will often be mandatory and is in fact the norm.

Water chillers are used to reduce mix temperatures and the use of ice is not favoured.

C.6 PRODUCT QUALITY

An important difference from UK practice is the method by which the IDOT can adjust payments to the contractor based on the quality of concrete pavement achieved.

C.6.1 Pavement thickness

Negative deviations from design thickness will result in a lowering of the payment due to the Contractor; only in extreme cases is the pavement required to be removed and replaced.

C.6.2 Surface profile

Standard of ride is checked by a multi-wheel profilometer. An ‘acceptable’ smoothness of surface (below 36 ins per mile for interestate and major highways) will only attract 77 per cent of the Contract unit price. The Contractor must achieve an excellent surface profile (below 15 ins per mile) to receive 100 per cent payment. It was noted that the expression of the results was on a different basis to that used in the UK.

C.7 CONTRACTUAL ARRANGEMENTS

Pavement projects in Iowa are generally tendered during the winter shutdown period for execution during the following summer. This method allows the client to forecast his expenditure accurately and allows the Pavement Contractors to programme full utilisation of their specialist resources.

Only contractors of proven ability are allowed to tender for IDOT contracts.

There are few contracts of an ‘all inclusive’ nature. The generally accepted contract stages are:

(a) Earthworks and Drainage (one contractor)
(b) Up to 2 years wait (settlement period etc)
(c) Paving & finish verges (a second contractor)
Contractors only have to price for one type of pavement when tendering. The type of pavement that is constructed is decided on the basis of the lowest whole life cost appraisal for each scheme.

Pre-bid conferences and discussions are called between client and contracting industry. These are often initiated through the Concrete Paving Association. This close working contact between client and contracting industry was seen as an important and valuable factor behind the highly successful contracts which operate in Iowa.

The tendering procedure for all contracts is similar and bids are openly invited but only 3–5 tenders are returned usually.

Contracts contain provision for liquidated damages and incentive/penalty systems are used for early/late completion.

Contractors during tendering are generally asked to nominate a period of construction that is beneficial to them. This has advantages for both the contractor and client. A contractor can programme the work that most conveniently fits in with his other commitments. The client gains by a more competitive tender being received and therefore a lower price being offered. Contract start dates appear to be set by mutual agreement. Contract periods are specified in terms of working days and liquidated damages are applied to the overall Contract period and to stages in a similar manner to the UK.

No maintenance period is specified for pavement contracts with IDOT and it would appear that seldom, if ever, has a contractor been recalled to carry out repairs due to 'latent defects'.

Although it is necessarily flexible an average contract would not exceed 10 miles, i.e. a 40-mile project would be split into 4 x 10 mile contracts.

Except at peak work loads, all design and supervision of road construction are carried out by the IDOT.

C.8 MAINTENANCE AND REHABILITATION

Many older roads have been fitted, retrospectively, with longitudinal drains alongside the edge of the pavement. These consist of perforated continuous plastic pipe, about 100 mm in diameter, covered by open graded aggregate (unused % in (10 mm) limestone from roadstone quarries). These drains have been successful in removing water drawn up by frost action during the winter and released in the spring thaw. Their value is starting to reflect in a slower rate of degradation of pavement structures.

Existing concrete slabs are recycled during reconstruction and used as water-bound, continuously-graded, sub-bases. Resonant concrete breakers are used (manufacturers, Gurries of Los Angeles).

The technique of 'crack and seat' is not considered as worthwhile because it results in a greater number of panels under a new undowelled pavement and can rock and create faulting or cracking.

The problem of faulting at transverse joints is due mainly to the use of undowelled slabs. However, some faulting had occurred also on dowelled joints on Highway 30. Where the surface regularity of a concrete slab has deteriorated due to stepping at joints etc, it has been restored by grading at a cost of 1.5 to 2.0 $/yd². This technique has been very effective in restoring the riding quality of concrete roads of more than 20 years old and has been found to be a very cost effective way of rehabilitating the road surface.

The usual method adopted for patching repairs involved the use of concrete containing a high cement content, 600 lb/yd³ (356 kg/m³), and an accelerator (CaCl₂). The finished surface is covered with a plastic sheet and insulating board to accelerate curing and give typical opening times of 5 to 6 hours after completion of the repair.

Strengthening requirements are identified by use of a 'Road rater' that is a form of Falling Weight Deflectometer (FWD) from which an effective thickness is derived using values from a deflection bowl measured by geophones. The overlay thickness is then determined from pavement thickness required less the effective pavement thickness of the existing road.

The IDOT's experience indicates that at least a 20-year life can be obtained from bonded overlays.

Prior to constructing a concrete overlay it is absolutely essential that the existing concrete surface is thoroughly cleaned. The IDOT has tried a number of methods to do this and has found that shot blasting is the most effective method. High-pressure water jetting and sand blasting have been tried but found not to be as good as shot blasting. However, ultra high-pressure water jetting has not been tried.

It is also absolutely essential that a cement grout be applied onto the dry surface of the existing immediately prior to overlaying.

Overlays have been tried without grouting but the bond established between the two layers has not been as good as when grouted.
Shot blasting machines 18 in (0.5 m) wide have been found to give the best results. Being narrow, 3 or 4 machines are required in order to obtain the necessary output. Machines 4 ft (1.2 m) wide have been used but have not been found as reliable as the smallest machine because they constantly broke down. Machines used in Iowa were manufactured by the Neldo Corporation, Kansas City.

Considering the high temperature range experienced in Iowa it was notable that very little distress of concrete slabs occurred due to thermal movements.

Traffic management arrangements for the maintenance and general rehabilitation of concrete pavements, such as concrete overlays, permit contractors to run traffic on lanes immediately adjacent to lanes where work is being carried out or alternatively contraflow working is also permitted.

The IDOT have a philosophy of extending the life of existing pavements for as long as possible before embarking on the major work of reconstruction. The techniques they employ include:

(a) bonded and unbonded overlays
(b) widening slabs dowelled into the edge of existing pavements (usually coupled with (a) above)
(c) Patch repairs
(d) Diamond grinding and re-texturing of pavement surfaces

The use of 'Fast Track' mixes has greatly enhanced the viability of the overlay, widening and reconstruction schemes.

In Iowa concrete paving is carried out by specialist contractors. In order to promote good concrete paving practice and to look after the interests of specialist contractors the Iowa Concrete Paving Association (ICPA) was formed 25 years ago. All members pay a yearly subscription. The ICPA is affiliated to the American Concrete Paving Association.

Other organisations which also have an interest in concrete paving, such as material suppliers, equipment manufacturers, may belong as associate members.

The ICPA gives technical advice to its members and highway authorities. It keeps its members informed of contracts coming up for tender and can assist in tender preparation.

The role of the Iowa Concrete Paving Association is very important to Client/Contractor relationships. The body is funded by membership fees and levies based on the area of pavement laid by each Contractor.

Services provided by the Association include marketing, lobbying for increase in use of concrete, identification of forthcoming Contracts, technical development and liaison with Clients. The development of 'Fast Track Paving' has been eased by the collaborative approach of the Contractors and Clients; with a willingness on both sides to pioneer new techniques.

It was noted that prior to amending the Specification, the IDOT met with the Iowa Concrete Paving Association to discuss proposals. This co-operation has not compromised the competitive approach of Contractors at tender stage, nor the Client's requirement for a quality job carried out on time. The high standards to which this non-profit making organisation aspires are reflected in the following statement of purpose.

'To Counsel, advise and render maximum assistance in the conception and planning of roads and other public installations, recognizing the historical and continuing importance to our society of advancement in such projects for the use and general welfare of the public.

To encourage and promote the use of concrete for and in the paving and construction of highways, streets airfields and other public improvements.

To advance the use of concrete road materials by means of public education, information and research; by dissemination of facts and data relative to the advantages of concrete; by rendering co-operation and aid to local, state and federal authorities in establishing standards for road and pavement construction; and generally for

**APPENDIX D:**

**ORGANISATIONS VISITED**

**D.1 THE IOWA CONCRETE PAVING ASSOCIATION**

A brief visit was made to the offices of the Iowa Concrete Paving Association (ICPA) in Des Moines, Dallas County to meet the senior officials responsible for organising the study visit itinerary. A video presentation was shown on the history of concrete paving in Iowa; a copy of this was given to the visiting party together with various documental information which is listed in Appendix E.
the public welfare and interest to foster the use of concrete for public construction purposes.

To maintain a high standard of workmanship and product by concrete paving contractors and to encourage sound, lawful business practices in the trade for the benefit of the public and contracting authorities; and to encourage those methods of contracting policies and work which relieve the contractor of improper risks.

To interchange views and disseminate useful information among members of the Association in order to establish construction methods and procedures enhancing the efficiency and status of concrete paving contractors.

One of the means employed to disseminate information on new paving techniques and information generally is by the ICPA holding 'Open Houses' (Seminars). These are held at sites where concrete paving of particular interest is being carried out. (This is similar to the site visits that used to be arranged by the C&CA and still arranged by the Concrete Society). The morning consists of papers being presented followed by discussion. The afternoon is taken up with a site visit. During the study tour, the visiting party were able to view a reconstruction contract in Cedar Rapids, Linn County.

D.2 IOWA DEPARTMENT OF TRANSPORTATION

The offices and laboratories of the Iowa Department of Transport (IDOT) are situated in Ames, Boone County. An afternoon was spent with engineers of the Materials, Testing and Design Departments discussing the role of FTCP in Iowa and some of the general requirements of the IDOT specification for concrete pavements. The information is presented in detail in Appendices C and E. A brief tour was made of the laboratories, constructed in 1973, which are comprehensively equipped for the routine testing of materials used in paving contracts and for the monitoring of the State highway system.

D.3 THE GOMACO CORPORATION

The Gomaco corporation is a plant manufacturer that specialises in slip-form paving and kerb-laying machinery. A visit was made to the factory where a range of pavers was in the process of production including a prototype variable-width paving machine. The company has its own training and conference centre where video presentations were shown of recent innovations in pavers. The feasibility and need for ‘zero clearance’ machines for use with the FTCP technique were discussed and problem areas were identified, some attempt at designing and producing such a machine have been made by this company.

APPENDIX E:

LIST OF DOCUMENTS OBTAINED


IOWA CONCRETE PAVING ASSOCIATION (1986). Iowa Fast Track Concrete paving—Open House, Storm Lake, Buena Vista County, Iowa. ICPA, Des Moines, Iowa, USA.


APPENDIX F:

INFORMATION ON IOWA

F.1 GEOGRAPHY

The State of Iowa is made up of 99 counties and is approximately equal in area to England and Wales but with a population of only 3 million people.

The physical features and landscape of Iowa are the result of widespread and repeated glaciation during the Ice Age and subsequent changes brought about by wind and water erosion. For instance, the Western landscape of Iowa was formed from wind-borne silts known as Loess and are known as the Loess Hills. These particular features are only found in Iowa and China.

Very little of the sedimentary rock underlying the glacial deposits are visible at the surface. Where they are, they are predominantly limestone, a major source of aggregate for the construction industry. Other sources of aggregate come from glacial moraine.

F.2 CLIMATE

Iowa's climate is 'Cold-Continental' tending to 'Prairie-Steppe', ie the winter is very cold, the summer very warm and conditions remain similar across the state. The average temperature in January is between 0 and -10 degrees Celsius (UK between 0 and +10°C) and in July between +20 and +30°C (UK between +10 and +20°C). Temperature extremes range from over 100°F (43°C) to -30°F(-39°C). The relative humidity is in the range of 60 to 80 per cent and the annual precipitation is similar to the UK except that the average summer rainfall is marginally higher in Iowa. Overall this leads to shorter, but more consistent 'paving seasons' than can be expected in the UK.

An important part of FTCP is high temperature curing and Engineers in Iowa are therefore fortunate in being able to rely on high summer temperatures throughout the State which assist in this process.

F.3 TRAFFIC

Traffic volumes in Iowa are generally far less than those experienced in many parts of the UK and the present day overall adequacy of the road system has benefited from the forward thinking road transport plans which have occurred throughout the State's history. These plans included the Federal Government's initial road layouts for the 1800's based around the one mile square land Section, the massive funding of hard surfacing in the 1920's and 30's, the road...
widening programme and the introduction of the Interstate system in the 50’s.

Commercial vehicles comply with National standards.

The max. gross weight of vehicles is 80,000 lb (36,300 kg)
The max. single axle weight is 20,000 lb (9,070 kg)
Max. tandem axle weight of vehicles is 34,000 lb (15,400 kg)

Traffic flows on roads in Iowa are considered heavy when they are in excess of 20,000 AADT with 40 per cent commercial vehicles which includes a substantial number of heavy trucks.

The most heavily trafficked roads carry up to 90,000 vehicles per day of which 40 per cent are trucks. The Interstate highways have an average 20 per cent of heavy vehicles.

However, a major difference between Iowa and the UK are the lower speed limits in America, with which drivers comply, together with much less aggressive driving techniques than are common in the UK.

F.4 ROAD CATEGORIES

In the State of Iowa there is over 100,000 miles of road. There are four categories of State road in addition to the Interstate network.

Interstate Highways
These roads carry in excess of 20,000 AADT (two way flow) with up to 40 per cent commercial vehicles.

State Highways
Class A—Major State roads (4000 miles)
Class B—Principle Primary roads
Class C—Low Traffic roads
Class D—Little public traffic roads (many unsurfaced)

The total public road mileage in Iowa is approx. 12,000 miles.

APPENDIX G:

ABSTRACT OF CONSULTANTS DESK TOP STUDY—FAST TRACK CONCRETE PAVEMENT CONSTRUCTION

Many of the States of America contain long lengths of concrete roads, forming parts of the Inter-State Highway network and for linking towns, by means of State and county roads. Many of the roads have been in use for periods up to 50 years and are in need of rehabilitation and are also of inadequate widths to cope with present day traffic. As a result it is necessary to bring these roads up to modern standards of riding quality and surface texture, strength, and also widen them to meet current needs. One State that has long lengths of concrete roads is Iowa, where the cost effectiveness of long term low maintenance concrete roads has made the engineers of their Department of Transportation anxious to retain roads with concrete running surfaces. This has resulted in the development and use of Fast Track Concrete Paving. At the request of the British Cement Association a desk-top study was made in March 1989, relying on available reports and published articles, to consider whether the concept could be applied in the United Kingdom.

Following a study by the Iowa State staff, trade Associations, cement manufacturers and paving contractors the basic requirements for Fast Track concrete overlays were evolved. As a result of the successful construction of a new access road, opened 24 hours after paving, to the Dundee Cement Company works in Des Moines in April 1986, the State let a major contract for the concrete overlaying of 6.8 miles of 49 year old concrete road. The original two lane road was also widened from 6.1 to 7.3 m as a part of the contract which involved a 100 mm thick bonded concrete overlay, constructed as two individual lanes. The bulk of the work was trafficked within 24 hours of casting. Certain local access areas and intersections were trafficked earlier, using concrete with accelerators. This major scheme was constructed in June 1986 and marks the start of FTCP.

The reported success of this work in performance, riding quality and surface texture terms has led to the use of Fast Track construction for a rapidly growing number of projects in Iowa and other States, for both road and airfield pavements.

For the concept to be applied in the UK certain changes would be required to the Department of Transport Specification. Work in the USA also showed that Fast Track Concrete Paving could be economically viable, not just for overlays but also for certain reconstruction and new works. From these preliminary studies a recommendation was made that the Department of Transport, Transport and Road Research Laboratory, British Cement Association and representatives from paving contractors should visit Iowa to assess both completed FTCP and work in progress.
The Consultant responsible for this initial study also concluded that FTCP should be adopted to encourage competition between bituminous and concrete overlays to the benefit of tax-payers generally.