A REVIEW OF CONCRETE BLOCK PAVEMENTS AT PORTS IN THE UK

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SUMMARY

The paper examines the performance of concrete block paving at seven port areas in which the pavement is trafficked either by container handling plant or by Roll-on / Roll-off traffic. These pavements are between twelve and three years old and they have been subjected to various degrees of maintenance. The following sites are described:

(a) Poole Harbour (1975) (b) Dover Harbour (1976) (c) Port of Sunderland (1980)
(d) Portsmouth Harbour (1982) (e) Port of Blyth (1983) (f) Tilbury Container Services (1985)
(g) Russell Davies Limited/ Felixstowe (1985)

In each case, the pavement construction materials are described and the type of loading is quantified. The level of maintenance carried out during the life of the pavement is shown and the maintenance costs are stated as a cost per annum per square metre. In cases where maintenance has been significantly high or low, the particular reasons for this are discussed. It is concluded that concrete block paving is particularly suitable for port applications and in the great majority of sites, the material has preformed well. It is also concluded that maintenance costs are low or zero.

1. INTRODUCTION

The first substantial area of concrete block paving to be constructed in a port in the UK was Phase 1 of the Freight Ferry Terminal at the Port of Poole in 1976. This comprised an area of 18,000m2 at a time when the UK output of concrete block paving was 450,000m2 per annum. Since then, concrete blocks have been used in over 20 UK ports and the material has become the orthodox surfacing material for heavy duty pavements. Because of this, there is now sufficient data available to allow conclusions to be drawn regarding the long term maintenance requirements of concrete block paving. Much of the data in this paper was obtained during visits to each of the ports mentioned during Duly 1987. Before this data is presented, a brief account of the introduction of concrete blocks to UK ports is provided and the reasons why port engineers adopted the material are discussed.

2. INTRODUCTION OF CONCRETE BLOCK PAVING TO UK PORTS

In The Netherlands and West Germany, a concrete block paving industry developed during the 1950's and the 1960's. In The Netherlands, concrete blocks had replaced paving brick and in West Germany, they had replaced granite setts. Britain had replaced nearly all of its brick and sett roads with asphalt during the period 1920 - I960 so that there was no small sized unit which concrete blocks could replace in the UK. For this reason, the material was not introduced to the UK until the late I960' s, 20 years after it became available in The Netherlands and West Germany (it had been used before the Second World War in Belgium, but not in inportant quantities). Luring the period 1968 - 1972, four UK companies introduced a shaped concrete block, two shapes were licenced from West German organisations, one was an imitation of one of those and the forth was a "castellated" shape developed in the UK. They were being marketed as a decorative surfacing material and combined annual production was less than 100,000m2.

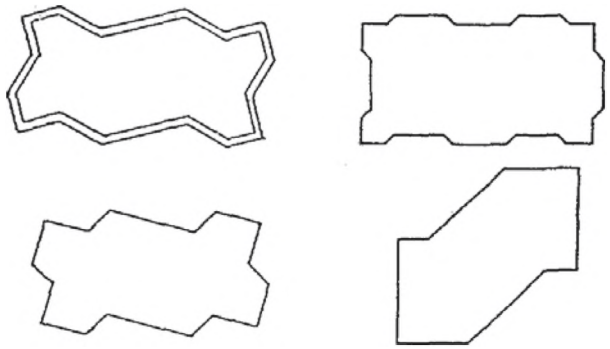


FIGURE 1: THE SHAPES OF CONCRETE BLOCKS MANUFACTURED IN UK IN 1972

A change in the perception of concrete block paving occurred in the UK in 1973 when the Cement and Concrete Association initiated a development programme which resulted in design methods becoming available for many categories of pavement, although Cement and Concrete Association specifically avoided developing design methods for port pavements. The Cement and Concrete Association's technical programme was supported by a promotional campaign which brought the material to the attention of UK highway pavement specifiers.

During the early 1970s port engineers were beginning to address their paving problems as they were becoming acute following the introduction of container handling equipment. Most ports had roads and hardstandings designed for highway loadings of up to 12t fully load whereas front lift trucks were then being introduced with axle loads of 70t. Discussions between manufacturers, who recognised that ports could become a major new market, and port engineers lead to the initial projects at Poole.

An inportant factor contributing to the growth of concrete block paving in ports was the publication of the British Ports Association (BPA) heavy duty pavement design Manual in 1983. This developed from the port engineers' concern mentioned above and is of particular relevance to the block paving industry as it became (and still is) the only pavement design manual in the world which accorded concrete block paving similar status as rigid concrete and asphalt. Most other concrete block paving design procedures were developed by the industry as a promotional medium, whereas the BPA manual was produced by the ports themselves.

A second inportant factor was the success of the areas of concrete block paving at Europe Container Terminus (ECT) in Rotterdam. ECT's combination of technical innovation and efficient publicity had brought the benefits of concrete block to the attention of UK engineers, many of whom had visited ECT, specifically to observe their paving solutions.

An interesting factor in the use of concrete block paving by ports has been the switch from shaped pavers to rectangular ones. Between 1973 and 1987, the UK block paving market changed from being 100% shaped to 80% rectangular. Public authorities often resisted the introduction of block paving during the mid-1970's for fear of being linked to one manufacturer. The standard 100mm x 200mm rectangular block has become the predominant material. The only exception to this is in those ports where blocks were introduced prior to rectangles becoming widely available. In order to avoid creating a patchwork quilt those ports have continued with their original shapes (e.g. Poole and Dover) whereas newer projects have usually employed rectangles (e.g. Tilbury, Exxtor).

3. PORT OF POOLE

The Freight Ferry Terminal at the Etort of Poole, on the south coast of England was the first large UK industrial area to be surfaced with concrete block paving. Phase 1, comprising 18000m2 was completed in 1976. Between 1979 and 1982 a further 7500m2 was constructed and 22500m2 was constructed during 1985. Resulting in an total area of 48000m2. The area is trafficked by 70000 commercial vehicles per annum and by ferry passenger and importation car traffic.

The site was reclaimed from Ftoole Harbour just prior to construction. The reclamation work comprised the pumping of dredged sand fill which was then consolidated hydraulically. This material developed negligible settlement. The pavement construction comprised 150mm well-graded limestone granular base material, 50mm laying course sand and 80am blocks.

After 12 years trafficking, the pavement remains in good condition and has settled uniformly by approximately 30mm. This has lead to the need for some remedial laying on rescreeded sand around gulleys, manholes and inspection chambers. The cost of this work, expressed in terms of unit area of pavement, is negligible and the pavement can be considered to be maintenance free.

In an experimental area, the 150am base was emitted. Owing to layout changes this was trafficked less heavily than anticipated but additional settlement has occurred and the signs are that this would not be satisfactory under heavy use.

An area of concrete block paving has been constructed at the Port's general cargo area, New Quay, on land which was reclaimed over 50 years ago, using uncontrolled fill material. In this area, concrete block paving has been laid over either 300mm or 150mm granular base material, directly over the fill. The traffic comprises regular 25t capacity fork lift trucks, having a laden front axle load of 53t.

The area was completed in 1978 and 25% has been relaid. Of the remainder,- there is deformation up to 150mm and most of the blocks are cracked and spalled. Approximately 75% of the area would require remedial work to bring the area to good condition.

A third area of concrete block paving was constructed at Bulwark Quay in 1979 over an area used to handle steel strip. The blocks suffered impact damage and were overlaid with a 50mm single course of hot rolled asphalt. There is no evidence of crack propogation through the asphalt.

From Poole Harbour, the following conclusions can be drawn:

a. Relatively thin granular bases are suitable over hydraulically placed fill material for Ro/Ro traffic. Maintenance is confined to resetting gulleys and other hard products

b. Care should be taken with heavy fork lift trucks over uncontrolled fill. The use of granular base material will lead to high levels of maintenance with the majority of blocks requiring replacement within 10 years.

c. 50mm thickness hot rolled asphalt can be used to overlay abraded block paving.

4. DOVER HARBOUR BOARD

There are several significant areas of concrete block paving at Dover

They are as follows and are shown in Figure 2.

	Name	Size (m2)	Construction	Year
a.	Import Freight Area Phase 1	40,000	280mm lean concrete	1977
b.	Nos. 5 & 6 Berths	27,000	280mm lean concrete	1979
c.	Camber Reclamation	40,000	250mm lean concrete 300mm shale	1984
d.	Import Freight Terminal Phase 2	50,000	400mm blastfurnace	1985
e.	Berth No. 3	8,000	300mm lean concrete	1987

A further 50,000m2 is being constructed during 1987 to be commissioned in 1988.

Each of the sites is on reclaimed land within the Eastern Docks complex and is subject to Ro/Ro traffic. The reclamation material comprises Goodwin Sand. This is a single sized fine sand punped ashore and won from sandbanks in the Straights of Dover. It is consolidated hydraulically and develops little long term settlement. It settles by up to 50mm during the first 12 months after placing and then by one or two millimetres per year.

The Dover Harbour Board engineer has undertaken several trials during the last 12 years. In one, a moisture susceptible base material was used. The pavement failed immediately and the base material was rejected. In a further trial, stabilised minestone was used in place of lean concrete. It was discontinued for two reasons: firstly, the material had been laid in 4 metre wide strips and the joints exhibited significant deterioration. Secondly, the material showed no cost benefit when compared with lean concrete.

Perhaps the most interesting trial at Dover was the omission of a base, the block paving being constructed directly over imported single sized sand fill. This trial performed satisfactorily and the possibility remains of progressing this further.

All of the areas with the exception of Phase 2 of the Import Freight Terminal used a similar block, a "wiggely brick" type of unit. Phase 2 used a block comprising three hexagons joined by grooves in the surface to give the impression of three Independent hexagons. The other major difference between this section and the others is the use of an unstabilised base Instead of lean concrete. During an inspection in Duly 1987, it was evident that none of these hexagon blocks had cracked whereas in seme locations the original shape had cracked. The Author considers that this difference in shape has lead to the reduced occurrence of cracking.

The major conclusion to be drawn from Dover is that pavement maintenance has been almost eliminated since the introduction of concrete block paving. Prior to 1977, pavement maintenance (reinforced concrete and asphalt) had been a major item of spending. The engineer responsible for the paving considers that concrete block paving has been a major positive factor in reducing surfacing costs at the Eastern Docks, Dover. In each section, there has been no first cost premium required. None of the areas appears to be approaching serviceability failure and the port is intending to continue with the material

5. PORT OF SUNDERLAND

The South Foreshore Container Park at Sunderland Port Authority was constructed during 1980 and opened for container handling in 1981. The area is used for the storage of 40ft and 20ft laden containers which are delivered and retrieved by highway trailers. Containers are lifted by a Clark Y800D front lift truck applying a front axle load of 90,000kg. The site comprised a redundant shipyard which had beem demolished to ground level. The subgrade comprised compact ballast with a CBR of 20%. In seme areas, existing concrete slabs were broken and the pavement was constructed directly over either the ballast or the broken slabs. The pavement comprises 200mm granular material, 300mm lean concrete, 50mm sharp sand and 80mm blocks.

The park has an area of 22,000 m2 and was the first pavement to be designed by the British Ports Association heavy duty pavement design method. Because of this, it was the subject of a monitoring exercise over a three year period during which surface deformation was measured. Five areas were selected, each subjected to a different type of loading and the details of these areas shown in Table 1.

Description	Type of Use	Size (m)	Number of points monitored
A	Little used (control)	5 x 5	144
B	Front lift trucks with light loads	6.4 x 6.4	225
C	Highway trailer turning	12.8 x 12.8	225
E	Container comer castings	5 x 2.25	72
G	Front lift trucks with heavy loads	6.4 x 6.4	225

TABLE 1: AREAS MONITORED AT SUNDERLAND CONTAINER PARK.

Figures 3 to 7 show isometric projections of pavement deformation after a period of 20 months use. Table 2 shows the maximum and typical deformation in each case.

Area Designation	Maximum Deformation (mm)	Typical Deformation (mm)
A	3	1
B	2	1
E	24	12
G	6	4

TABLE 2.

Table 2 shows that significant deformation has occurred only in areas E and 6 i.e. at corner casting locations and where heavily laden front lift trucks run. Typically, container castings have Indented the pavement by 12mm which is the amount by which comer castings project beneath the container underside. Area 6 is the one subjected to the pavement's full design load and it can be seen that a deformation of 4irm has occurred typically over a period of 20 months.

It is concluded from this monitoring exercise that heavy duty concrete block pavements can be expected to settle in loaded areas by a few millimetres per year. This settlement has not lead to any maintenance requirement and the pavement has been wholly maintenance free. It is also concluded that where heavy containers are stored, concrete block paving will form depressions beneath the container corner castings. These comer castings project 12nm below the container underside, although manufacturing tolerances bring this figure to 20mm or more in seme cases. Therefore, depressions up to 25mm can be expected in local areas. These depressions have no adverse effect on the pavement and appear to result from the lateral migration and degradation of the laying course sand. A further effect of container storage is the development of "star" cracking as shown in Figure 8. This has occurred when containers have been dropped onto the pavement. The cracks emanate from a point and run towards perimeter recesses. It is postulated that this occurs only in blocks which Include recesses. It does not appear to lead to further degradation of the surface.

The conclusions from Sunderland can be summarised as follows. On a very heavily loaded pavement, some local surface damage may occur but providing a cement stabilised base is used as the major structural component, there should be no regular maintenance required. The pavement has now been in service for six years, although during the last two years, loading has been light.

6. PORTSMOUTH HARBOUR FERRY TERMINAL

The traditional fill material in the Portsmouth district is chalk. It was used to reclaim land from the sea for the first stage of the development of the cross channel ferry terminal. To prevent frost heave in the chalk, the pavement construction chosen was 500mm thick, made up of 40mm hot rolled asphalt on 60nm dense bituminous macadam or 250mm lean mix concrete on 150mm granular sub base.

Later phases of the development saw changes in both the reclamation material and the surfacing. Ballast-as-dredged from the sea replaced the chalk, and the 100mm deep bituminous material was replaced by concrete block paving. After experimenting in 1977 with various permutations of base and sub-base types, including no base and sub-base at all, a large area has since been constructed comprising 80mm blocks on 50mm laying course sand directly on the ballast-as-dredged.

A feature of this site is the construction of &n wide granular fill Islands with precast concrete kerb perimeters. Following a fatal accident, the port authority was required to construct these islands to prevent back to back parking trailers from touching each other. The 250mm high kerbs are glued to the block paving surface. Sometimes, kerbs are dislodged by trailers and a lower 200mm kerb is gradually replacing the 250nm units.

During 1986, it was observed that blocks were cracking and spalling on those parts of the area subjected to severe trailer screwing loads. An 80m2 trial was constructed in the worst area in which 100mm x 200mm British Standard rectangular blocks replaced the previous "wiggely brick" unit. Both types were of similar concrete thickness and plan area. Also similar construction materials and methods were adopted. The trial area shows no cracking whilst the non-rectangular blocks continue to crack.

From Portsmouth Harbour, the following conclusion can be drawn:

a. A stabilised roadbase is unnecessary for well consolidated fill sites subject to normal highway and Ro/Ro traffic.

b. A change in block shape, all other parameters remaining constant, can have a significant Influence on block cracking. The rectangular block is less susceptible to cracking than blocks of the shape used.

It is interesting to consider that in seme

countries, national recommendations issued by concrete masonry promotional bodies suggest the use of "wiggely brick" type blocks for this application and consider that rectangular blocks be not used. The Author considers that such recommendations are at variance with the observed performance of concrete block paving.

7. PORT OF BLYTH

Three types of concrete block pavements have been constructed at South Harbour, Blyth, UK. In December 1983 a general cargo storage area was constructed using 80mm thick concrete blocks on 50mm sand over 450mm thickness of granular base material. The subgrade comprises fill material of variable density. This area has settled uniformly by up to 30mm over a period of four years. This is a result of settlement of the fill material. Two further areas were constructed on the same fill material. The first was subjected to 13t capacity front lift trucks applying individual wheel loads of 12t. This comprised blocks and sand over 300mm thickness of lean concrete. The third area was similar but was trafficked by highway vehicle and the lean concrete thickness was reduced to 250mm. Neither of the stabilised base pavements has settled. The conclusion to be drawn from Blyth is that for industrial areas on fill sites, either granular or stabilised bases may be specified. With granular bases, settlement can be expected, although this should not be excessive. It should be noted that none of the areas at Blyth are subjected to severely channelised traffic and most of the loads are those which are associated with a Ro/Ro operation.

There has been no maintenance spending at Blyth. The settlement is regarded as acceptable and no plans are in hand to relay the blocks.

8. TILBURY CONTAINER SERVICES

A pavement comprising 100mm asphalt over 250mm lean concrete on sand fill had been constructed surrounding a straddle carrier maintenance workshop. Much of the asphalt was degrading owing to the spillage of mineral oil from a fleet of 13 straddle carriers. In 1985, an area of 9,000m2 was overlain with 80mm thick concrete block paving laid on 50mm thickness of sharp sand.

After two years, the pavement remained in excellent condition and no maintenance spending had been undertaken. The eight wheeled straddle carriers have individual wheel loads of 6,000kg in their unladen configuration, which is the usual situation in the maintenance area and apply individual wheel loads of up to 10,000kg. In some places, these loads will have been amplified when straddle carriers turn or brake. Turning can increase loads on the outer wheels by 30% and braking can Increase front wheel load by 25%.

From this application, it can be concluded that flexible pavements in which the surface has degraded can be overlain with concrete blocks and that the resulting pavement should be maintenance free, even a very heavy load situations. It is also concluded that concrete block paving is suitable in locations where severe oil spillage occurs.

9. RUSSELL DAVIES LIMITED. FELIXSTOWE

A 16,000m2 container storage yard had been constructed in 1979 using 200mm thickness reinforced concrete over a granular sub-base on clay subgrade with a CBR of 3%. By 1983, the concrete had cracked and spalled to such a degree that much of the pavement was unserviceable as shown in Figure 9.

The remedial scheme comprising a concrete block overlay was undertaken in 1983. The kerbs and drainage were raised by 130mm and 80mm blocks were laid over 50mm sharp sand. Prior to this, approximately 12% of the existing slabs were renewed, mainly because spalling had become so severe that sand thickness would have been too variable. Also, corner cracking had lead to some of the slabs rocking and punping the sub-base material to the surface.

Strips of filter fabric were laid over the joints prior to sand screeding in order to prevent sand from entering the joints. The overlain area is shown in Figure 10.

When the overlain pavement had been in service for 12 months, it was observed that block settlement had taken place along the line of a few of the joints in one corner on the yard. The blocks were removed and it was found that much of the laying course sand had disappeared over those joints. The remainder of the sand was removed to reveal the filter fabric which had been placed over the joint to the joint to prevent sand loss. The material had degraded to the consistency of horse hair and chemical tests were undertaken to verify that the material was the filter fabric originally specified. The tests confirmed that it was the specified non-woven melded fabric.

An investigation into the degradation of the filter fabric concluded that the affected area had a high water table and the material had been moist permanently. The traffic loads had caused the sharp laying course sand to abrade the material and this had lead to the loss of bond between individual fibres.

Remedial work comprised relaying the lines of blocks and substituting polythene for the filter fabric. This appears to operate satisfactorily.

From this project, it is concluded that delapidated concrete pavements can be overlain with concrete block paving but special care should be taken at joints. In particular, the ability of filter fabric to maintain its integrity beneath laying course sand should be established positively. In the absence of any other data, it can be assumed that in areas of high water table, filter fabric should not be used to prevent the ingress of laying course sand into rigid concrete joints below.

Owing to the ease and speed with which concrete block paving can be taken up and replaced, the remedial work was undertaken at little cost and inconvenience. Approximately 500m2 was re laid during a period of one weekend by eight men. Most of the time was taken in removing and cleaning the blocks. The blocks which were removed were rectangular with 3mm wide spacers. In order to facilitate relaying, new rectangular blocks of similar size, but without spacers were installed. The remainder of the area has been maintenance free, other than replacing broken blocks when containers have been dropped accidentally.

10. Trinity Terminal. Felixstowe

The largest single UK port block paving project is the Trinity Terminal, Felixstowe which was constructed 1985 and 1986 and includes 150,000m2 of concrete block paving. Pavement construction comprised the in-situ cement stabilisation of 400rrm thickness of as-dredged ballast, with 100mm thick rectangular concrete blocks, 200mm x 100mm in plan dimensions on 500mm thickness of sharp sand. The pavement is subject to individual wheel loads of up to 64,000kg applied by rubber tyred grantry cranes. Multiple wheeled gantry cranes were developed to permit free movement over the entire pavement. Previously, the port's rubber tyred granty craneshad been confined to runway beams with container stored on asphalt paving.

As yet, there is no quantitative data available regarding maintenance costs. This project demonstrates that rubber tyred granty cranes can run freely over concrete block paving.

11. CONCLUSION

a) In Ro/Ro areas, where the subgrade comprises controlled fill, concrete block paving can be laid directly over the fill. This will lead to differential settlement between the paving and fixed structures and some maintenance will be required at these locations. However expressed as an annual cost per square metre of paving, these costs are minimal. A figure of £ UK 0-04 /m2 /annum is suggested as the maintenance expenditure to be allowed for this type of pavement. Usually hydraulically placed fill material is suitable but in cases where the material has insufficient shear strength, a granular sub-base may be provided. Typically 200mm - 300mm thickness of such material will suffice and the maintenance spending is as stated above.

b) For pavements constructed over fine grained material (clay usually), a stabilised base is usually required both for Ro/Ro traffic and for the heavier load associated with container handling. If a granular base is used there is the likelyhood that both deflexionand deformation will occur at the surface. Deformation will lead to rutting and ponding, which will allow water to percolate through the surface and weaken the granular material. Excessive deflexion will lead to block spalling and breakage. It is consideredthat a granular base over fine grained soils will have an unacceptably high maintenance requirement.

A cement or bitumen stabilised base acts to strengthen the pavement and prevent the ingress of moisture in the subgrade. Experience indicates that pavements with a correctly designed stabilised base should have a zero maintenance requirement over a life of 10 years or more.

c) Concrete block paving can be overlain with bituminous material and the block pattern does not reflect through the asphalt. Only one example of this technique has been undertaken at a British port and so far, it has required zero maintenance.

d) For pavements on stabilised bases, the type of block used does not affect the performance of the pavement. Experience at Portsmouth Harbour indicates that there may be differences where pavements are constructed with granular bases. In particular, rectangular blocks have preformed satisfactorily in all cases, whereas cracking has occurred with profiled blocks.

e) When existing concrete pavements are overlain, care needs to be taken to ensure that laying course sand does not enter the joints. This can be achieved by a combination of filter fabric, joint sealant and polythene.

Local depression of concrete blocks along joints has occurred on sone sites, leading to ponding and spalling. Remedial work is relatively simple and inexpensive when expressed as a unit cost for the total area of paving.

f) Concrete block paving is suitable in areas of substantial oil spillage. At Tilbury, concrete blocks have becorre covered in oil dropped by straddle carriers and this has not adversely affected the concrete. Indeed the oil repells moisture and reduces the ingress of water into the laying course sand.

g) The overlain area at Poole was damaged by inpact owing to heavy setting down of steel coil weighing 25t. Blocks were shattered but no great loss of thickness occurred. The overlay was carried out as soon as areas started to loose their integrity.

h) At several sites, blocks had been removed to gain access to utilities. In all cases, it had proved more difficult to reinstate than had been anticipated. Invariably, the last few blocks would not fit and part blocks had been inserted. In one situation, painted blocks had been removed and it had been impossible to reinstate the original pattern, with the result Illustrated in Figure 11.

i) At one port, the engineer felt that the introduction of concrete block paving has been the most important construction innovation for 20 years. It has virtually eliminated the need for pavement maintenance which had been a major item of spending prior to the introduction of concrete blocks. Previously unreinforced concrete slabs had been used commonly and the maintenance regulrement had been substantial

12. SUMMARY

Each of the projects described in this paper has been in service for several years and some have been in service for over 10 years. Added together the pavements described have an area of 350,000 m2 and have been subjected to total use of l,700,000m2 - years. In view of this the low level of maintenance spending has been surprising. Where maintenance has been required it has been possible in each case to identify a specific fault. Often, this has been a question of pavement detailing at kerbs, manholes, gulleys and similar obstructions. Overlain pavements have performed satisfactorily and concrete block paving can be considered as a suitable pavement overlay material.

REFERENCES

1. Knapton J. (1983) "The Structual Design of Heavy Duty Pavements for Ports and other Industries". British Ports Association, London.

FURTHER INFORMATION

Further information regarding the sites described in this paper can be obtained as listed below:

1. Port of Poole

Poole Harbour Commissioners
Harbour Office
Town Quays
Poole
Dorset
BH15 1HG

Contact: Mr R Appleton (Chief Engineer)

Tel: 44 202 685261

2. Dover Harbour Board

Harbour House
Dover
CT1 9BU

Contact: Mr 3 Gerrard
(Director of Engineering)

Tel: 44 304 240400

3. Port of Sunderland

Port of Sunderland Authority
Barrack Road
Sunderland
Tyne and Wear

Contact: Mr R Stapleton

Tel: 44 90 5140411

4. Portsmouth Harbour Ferry Terminal

Portsmouth City Council
Civic Office
Guildhall Square
Portsmouth
Hants

Contact: Mr C A Maber

Tel: 44 705 822251

5. Port of Blyth

Blyth Harbour Commissioners
79 Bridge Street
Blyth
Northumberland
NE24 2AW

Contact: Mr I Robertshaw
(Chief Engineer)

Tel: 44 670 352066

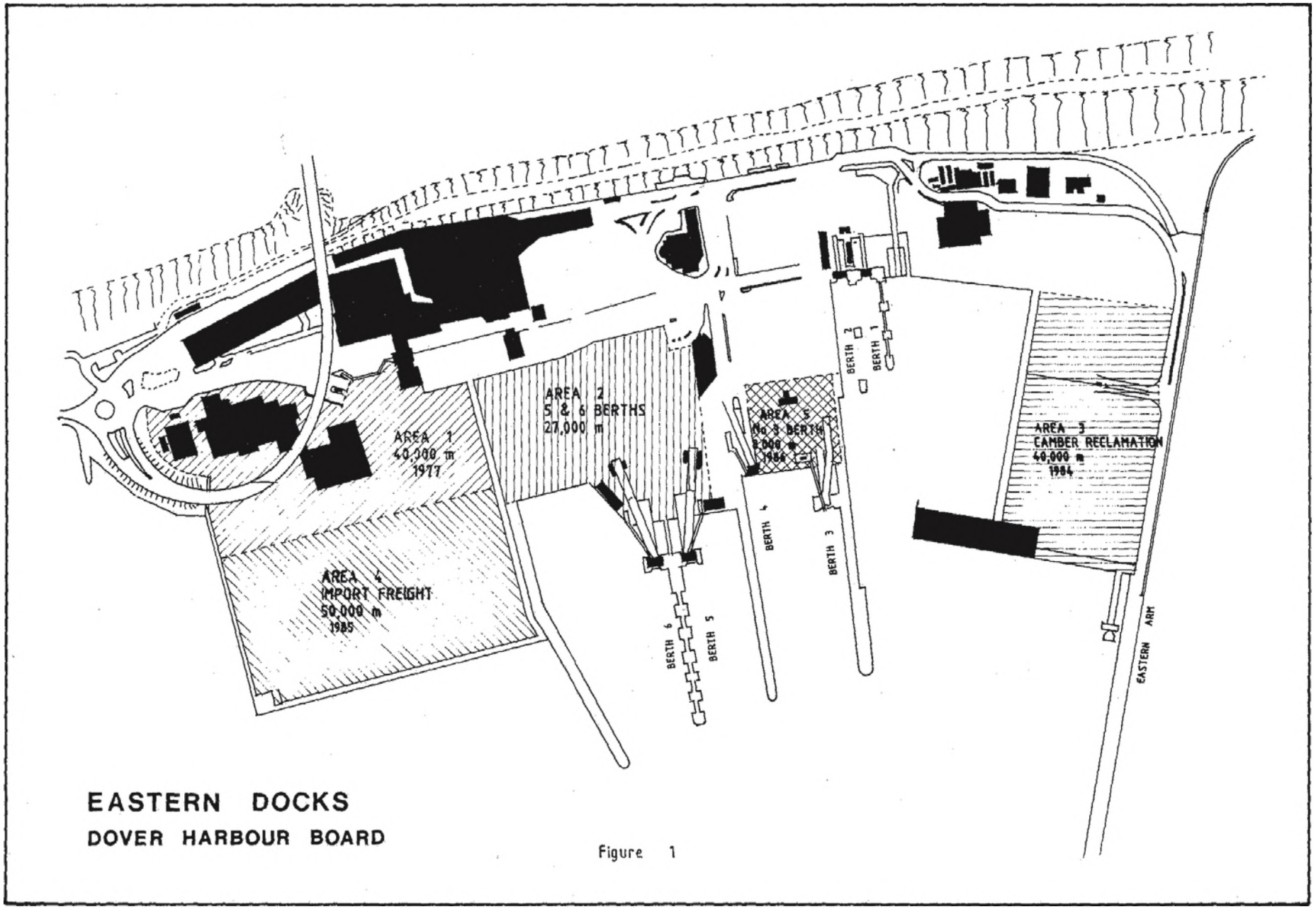

AREA 1
40,000 m
1977
AREA 2
5 & 6 BERTHS
27,000 m
AREA 3
CAMBER RECLAMATION
40,000 m
1984
AREA 4
IMPORT FREIGHT
50,000 m
1985
AREA 5
No 3 BERTH
8,000 m
1984
BERTH 1
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BERTH 3
BERTH 4
BERTH 5
BERTH 6
EASTERN ARM
EASTERN DOCKS
DOVER HARBOUR BOARD

Figure 1

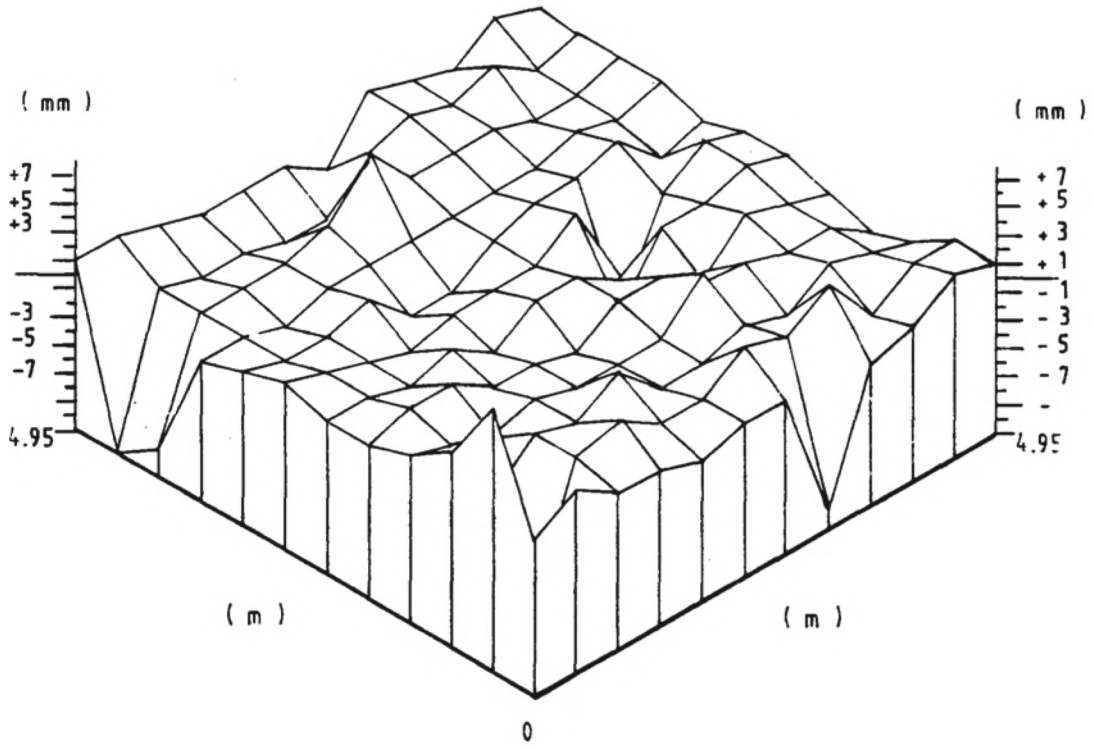


Figure 3

Permanent deformation of control section of pavement at SUNDERLAND CONTAINER PARK after 20 months use. Note the random movement.

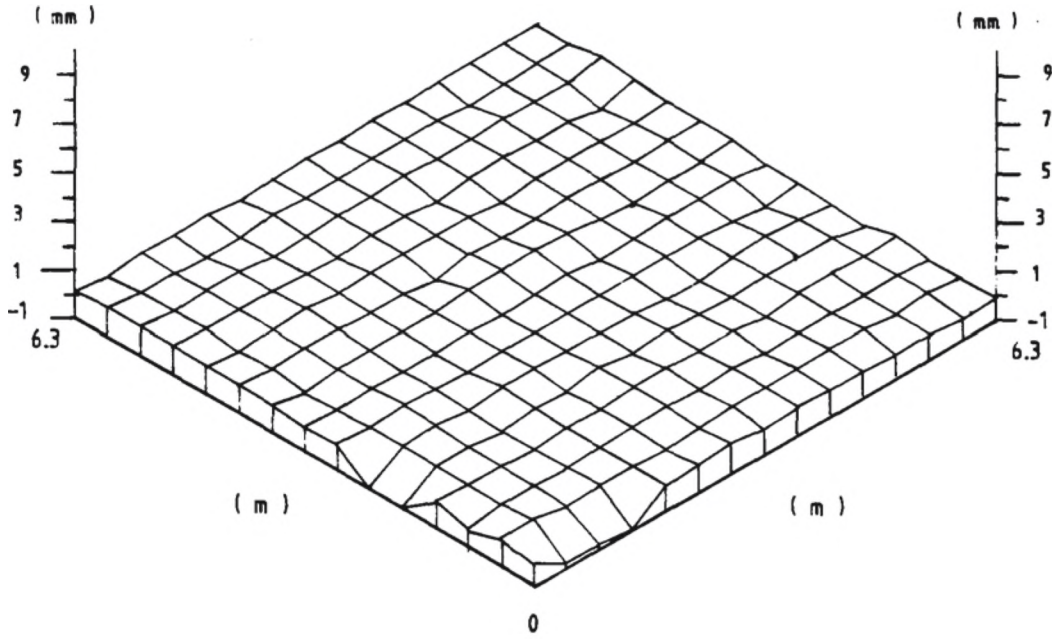


Figure 4

Permanent deformation of pavement trafficked by lightly loaded front lift trucks at SUNDERLAND CONTAINER PARK after 20 months use. The pavement has settled uniformly by 1mm.

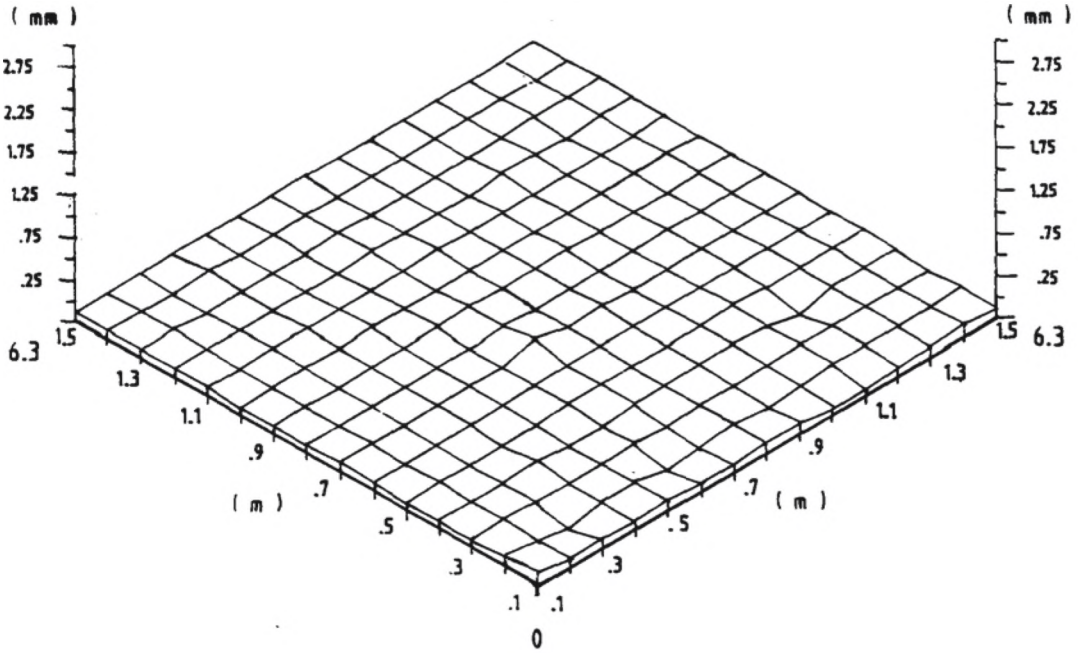


Figure 5

Permanent deformation of pavement trafficked by highway trailers turning at SUNDERLAND CONTAINER PARK after 20 months use. The pavement has settled uniformly by less than 1mm.

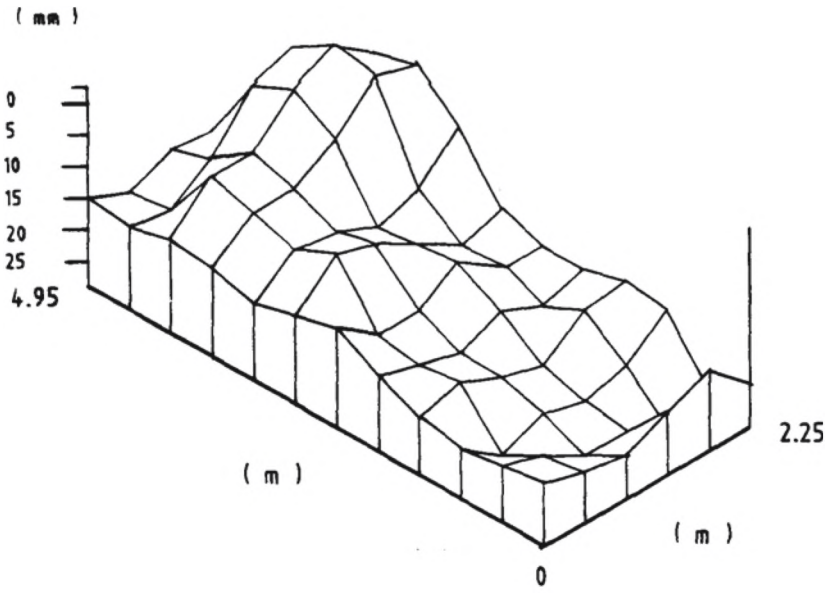
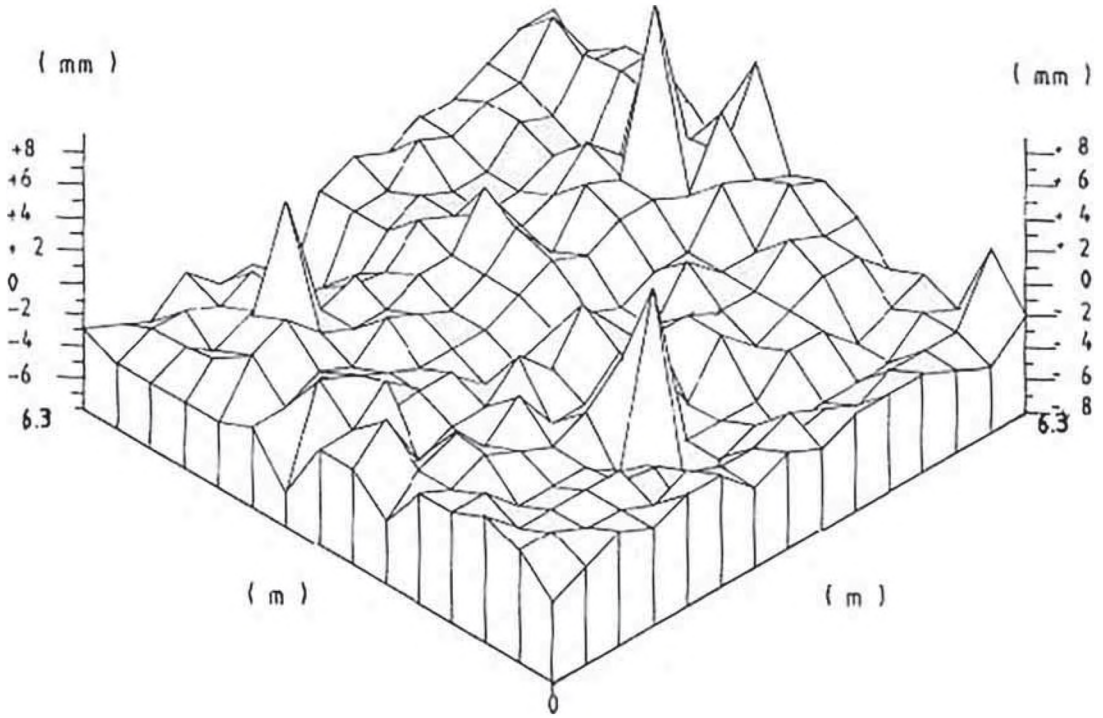


Figure 6

Permanent deformation of pavement beneath corner castings at SUNDERLAND CONTAINER PARK after 20 months use. Settlement of up to 24mm has secured



Figure?

Permanent deformation of pavement trafficked by heavy laden front lift trucks at SUNDERLAND CONTAINER PARK after 20 months use. The pavement has settled by up to 6 mm..



Figure 8

Star[1] cracking resulting from the impact of container corner castings

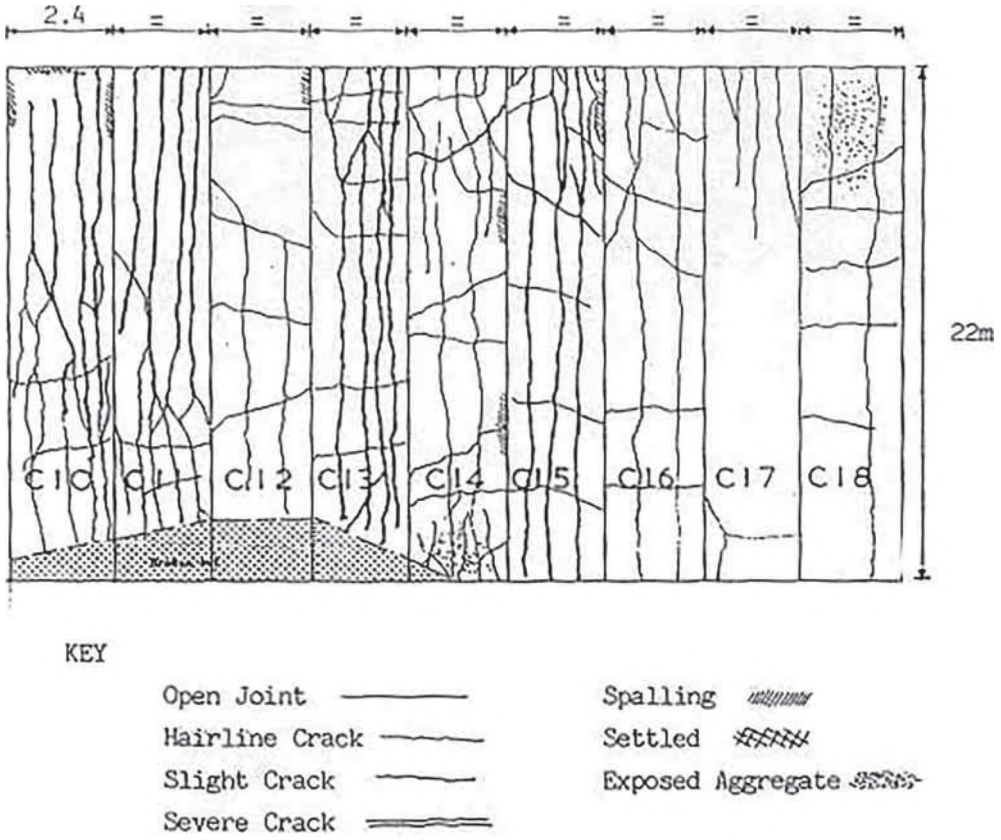


Figure 9

Pattern ofcracking in reinforced concrete slabs at RUSSELL DAVIES, FELIXS7OWE Approximately 12% of the existing concrete was replaced with new reinforced concrete and the whole was overlain with concrete block paving.

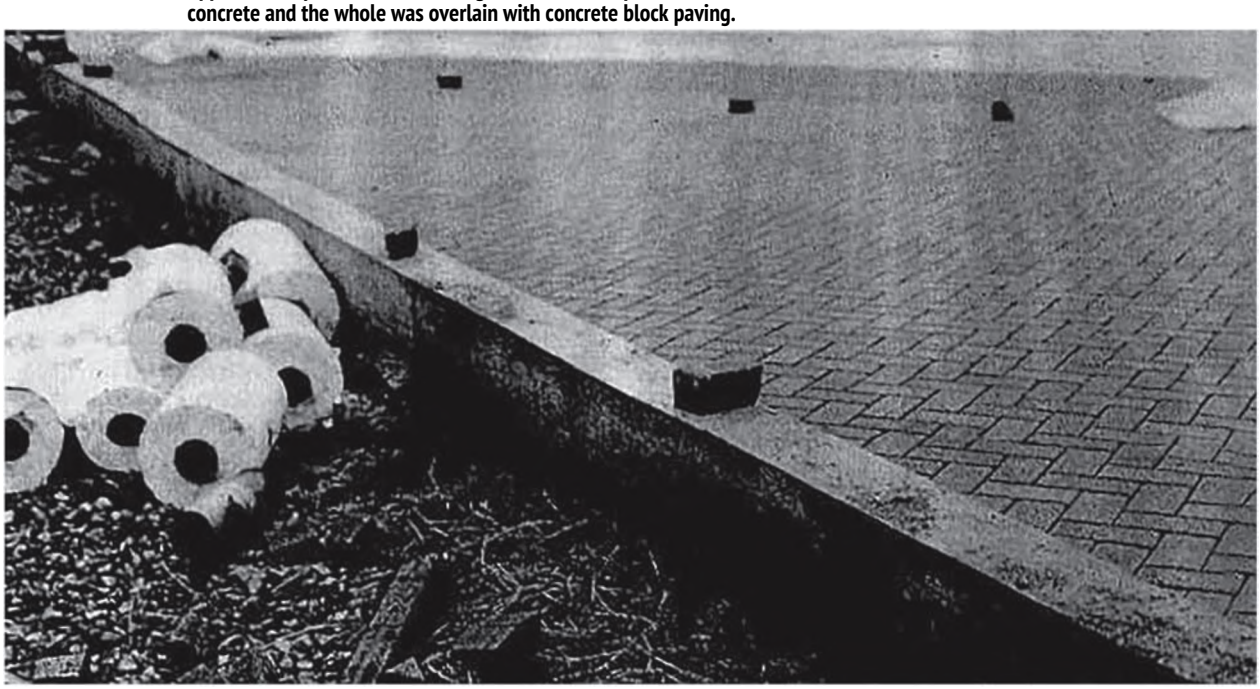


Figure 10

Completed concrete block overby at RUSSELL DAVIES FELIXSTOWE.



Figure 11

Painted blocks demarking a pedestrian route through a RO-RO area were not reinstated In their original position