Usage of pavers in aircraft pavements

by

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This paper reviews the use of pavers in aircraft pavements worldwide. It first examines the use of pavers at Luton Airport and draws conclusions from the experience at that airport. It then reviews the principal paver installations in the UK and throughout the world. Conclusions are drawn regarding the future usage of pavers from the experiences reviewed.

Experience at Luton Airport

The first use of pavers on aircraft pavements was at Luton International Airport (now London Luton Airport) in October 1981. Initial trials comprised two rectangular panels each of dimensions 9m x 2m constructed on aircraft stands directly beneath undercarriage gear positions. The pavers were used as an inlay in place of bituminous material and were found to remain stable under aircraft loads. Propeller wash and jet blast occurred from time to time on these initial trial areas and some loss of jointing sand was observed.

In May 1982, a second trial area of 10m x 2m was installed using a proprietary shaped paver on the Eastern Turning Circle in order to assess the suitability of pavers in areas subjected to the turning action and jet blast associated with aircraft taking off. This trial area remained in service until it was overlain as a result of a runway strengthening project which commenced in November 1983. It has been estimated that this Eastern Turning Circle trial was subjected to approximately 25,000 heavy commercial aircraft movements during its 18 months service. Because some of the jointing sand had been eroded by jet blast and propeller wash on the initial trial, the Eastern Turning Circle trial incorporated lime stabilised joints between the pavers. This form of stabilisation did not prevent erosion and some concern was felt regarding the effect of the lime on aircraft.

In January 1983, nine 13m x 23m rectangular areas of pavers were installed on the main aircraft stands and these areas have remained in service with little or no maintenance to date. In each of these nine areas, 200mm x 100mm x 80mm thick rectangular pavers were use.

The success of the use of pavers on the main Luton stands together with the positive results from the Eastern Turning Circle trial led to the use of pavers on the turning circles at each end of the runway as part of the strengthening project. The Eastern Turning Circle was surfaced with 5000m^2 of 200mm x 100mm x 100mm thick rectangular pavers between November 1983 and March 1984 and the Western Turning Circle was surfaced with 5000m^2 of 200mm x 100mm x 80mm thick pavers between December 1984 and February 1985. On both of these turning circles, periodic inspections revealed progressive erosion of jointing sand (the joints comprised sand stabilised with either lime, cement or bentonite, none of which proved effective). An incident occurred in July 1987 in which an area of 2m^2 bulged upwards to a height of approximately 100mm when one of the 100mm thick rectangular pavers on the Eastern Turning Circle was discovered

beneath its neighbours, presumably having been forced there by the exhaust blast from the engine of an aircraft taking off. As a result of the joint erosion culminating in the above failure, a liquid pre-polymer was developed specifically to stabilise the jointing sand and was applied to both turning circles in October 1987 and joint erosion ceased.

During the period November 1988 to February 1989, reprofiling of the runway necessitated the burial of the 100mm thick rectangular pavers laid during the winter of 1983-1984 on the Eastern Turning Circle and the installation of 5500m^2 of 80mm thick pavers at the new level. A proprietary shaped paver was selected in order to facilitate mechanical installation so as to speed up the construction process. The pavers were installed by a European contractor familiar with the mechanical installation system selected. The contractor elected to lay the pavers onto a bed of 6mm grit rather than the more conventionally graded sand. Those pavers on the Western Turning Circle were unaffected by the level changes to the runway.

In March 1989, an incident occurred on the Eastern Turning Circle one month after the new pavers entered service when approximately 100m^2 proprietary pavers were removed from the surface and carried a distance of up to 30 metres. In each of these two cases, a mechanically laid non-rectangular paver was used as the surfacing material. The disturbed pavers were associated with the edges of mechanically laid clusters where joints are frequently wider than those obtaining in hand laid rectangular pavers. The paver joints had not been stabilised and very heavy rainfall was recorded for three days prior to the failure. It is likely that the laying course material was inundated at the time of the failure.

A second disturbance in the area of proprietary shaped pavers took place in November 1990 when approximately 150m^2 were displaced a distance of up to 50m. The airport authority considered that both of the disturbances were a result of the paver/mechanical installation system and so replaced the pavers in the displaced area with rectangular pavers. Initially, an expedient repair was undertaken comprising 200m^2 rectangular pavers surrounded by the original proprietary shaped pavers and in March 1991, all of the remaining proprietary pavers were replaced by rectangular pavers. This means that from March 1991 onwards, the Eastern Turning Circle comprised a small area of rectangular pavers surrounded by a larger area of similar, but newer, pavers. The interface between these two independently installed zones was formed using back to back special edge units ("Bishop's hats") such that a continuous straight line joint was created across the paved area.

This system behaved satisfactorily for a further 18 months until 22nd September 1992 when a significant disturbance occurred and approximately 200m^2 pavers were displaced by a departing aircraft. Some of the pavers were lifted to a height exceeding 5m and damaged the skin of the elevators and the tail fin of the departing aircraft. By coincidence, both turning circles were inspected by John Emery, formerly engineer at Luton Airport on 17th September 1992, five days prior to the accident and he reported that the pavers on the Eastern Turning Circle sounded hollow, as if they were not in intimate contact with the underlying laying course material. He also reported the absence of jointing material on both turning circles and commented particularly upon the apparent weakness in interlock along the boundary between the two zones of neighbouring rectangular pavers on the Eastern Turning Circle.

Emery's report to the consulting engineer appointed by Luton International Airport to investigate the 22nd September 1992 accident states:

"On the Eastern Turning Circle, back to back "Bishop's Hat" pavers have been used presumably to tie in separate areas of block paving. This will provide a line of weakness and militate against good interlock"

Table 1 Summary of principal events in the use of pavers at Luton Airport

DATE	EVENT	AREA	PAVER TYPE
October 1981	Initial stand trials	$36m^2$	65mm & 80mm thick rectangles
May 1982	Turning Circle trial	$20m^2$	80mm thick "SF" shape
January 1983	Nine stands paved	$2,700m^2$	80mm thick rectangles
November 1983	Eastern Turning Circle paved	$5,000m^2$	100mm thick rectangles
December 1984	Western Turning Circle paved	$5,000m^2$	80mm thick rectangles
May 1987	Trial area laid on taxiway	$20m^2$	75mm thick "G-Block" paver
July 1987	Single paver displaced on Eastern Turning Circle		100mm thick rectangular paver
February 1989	Eastern Turning Circle re-paved	$5,500m^2$	80mm thick "Coloc" shape
March 1989	Pavers displaced on Eastern Turning Circle	$100m^2$	80mm thick "Coloc" shape
November 1990	Pavers displaced on Eastern Turning Circle, replaced with rectangles	$150m^2$	80mm thick "Coloc" shape
March 1991	Remainder of Eastern Turning Circle repaved	$5,300m^2$	80mm thick rectangles
September 1992	Pavers displaced on Eastern Turning Circle	$200m^2$	80mm thick rectangles
November 1992	All pavers removed from turning circles	$10,500m^2$	80mm thick rectangles
June 1993	Pavers used on New Freight Facility	$6,000m^2$	80mm thick rectangles

The pavers laid in May 1987 comprised an inconclusive trial of 20m^2 "G-Block", a paver with non vertical sides, on a taxiway. The pavers were removed in July 1987 following disintegration of the concrete around the perimeter of many of the pavers. The concept of non vertical sides incorporated in "G-Block" prevents an individual paver from being removed from the pavement and needs to be developed further. Full scale long term trials may demonstrate that inclined face pavers can eliminate entirely paver disturbance.

Analysis of Luton Airport events

From Table 1, it can be seen that the events at Luton fall into three periods, viz.:

1) *October 1981 to May 1982*
Trials undertaken to establish the suitability of pavers for aircraft pavements.

2) *January 1983 to July 1987*
A period of four and a half years during which rectangular pavers performed satisfactorily on stands and on both turning circles

3) *July 1987 to November 1992*
The failure of rectangular pavers in July 1987 was followed by the failure of "Coloc" pavers laid on Eastern Turning Circle on two occasions. They were replaced with an initial rectangular paver inlay, followed by complete replacement with rectangular pavers. A final failure of the replacement rectangular pavers led to the removal of all turning circle pavers

The following conclusions can be drawn from the experience at Luton.

During period two, rectangular pavers performed satisfactorily for a period of four and a half years during which it is estimated from data published by the airport authority that 31,000 commercial aircraft used the Eastern Turning Circle at take-off and 11,000 commercial aircraft used the Western Turning Circle at take-off. The above figures are derived from the published Air Transport Movement (ATM) data which indicates that between 27,000 and 33,000 ATM's occurred each year during this second period.

All of the Luton incidents occurred on the Eastern Turning Circle. The initial failure occurred in the 100mm thick rectangular pavers, two occurred in the "Coloc" pavers and the final failure occurred in 80mm thick rectangular pavers. By comparing the events which took place in this third period with the uneventful previous period, it can be seen that a significant reduction took place in the serviceability of the Eastern Turning Circle from July 1987 onwards. The failures in the third period cannot be attributed to the additional age of the pavement - the Western Turning Circle is estimated to have sustained 32,000 commercial aircraft take-offs during the nine years of periods two and three without incident whereas the repaved Eastern Turning Circle failed on three occasions within a three years period during which it sustained 31,000 commercial aircraft take-offs between February 1989 and November 1992. A study of the photographs and the events leading to the incident in September 1992 indicates that the most likely cause of the disturbances is as follows.

In each of the Eastern Turning Circle failures, there has been reason to question the stability of the paver joints. An assessment of the pressures which can be developed by jet exhaust impinging on the surface of a pavement indicates that it is unlikely that the pavers were removed by suction from the surface. Pressure has built up in the laying course by jet exhaust gases entering the paver joints until the net positive pressure beneath a paver is sufficient to counter the weight of the paver plus the interlocking effect. It is likely that the surface had been lifted on previous occasions but the interlocking nature of the pavers had prevented an individual paver from becoming displaced. The fatigue effect of regular lifting of the pavers eventually reduced the interlocking effect to zero so that the jet efflux pressure needed only to counter the weight of a paver to lift it from the pavement. In the case of the two failures of "Coloc" pavers, the unusual grading of the laying course material may have contributed to the failure since its open textured nature may have exacerbated the development of positive pressure beneath the pavers.

It is unlikely that the breakdown of the jointing material would be occasioned by the jet exhaust. Rather, the regular turning and braking (not accelerating) of aircraft would apply large horizontal forces to the pavers such that the horizontal interlock generated by the jointing material would eventually fail. For example, a Boeing 737-300, the most common aircraft using the turning circles, has a maximum takeoff weight of over 56,000kg and one main gear wheel applies 13,000kg vertically to the pavement. It would seem reasonable to assume that turning and braking could lead to lateral or longitudinal accelerations of 0.3g so that lateral forces of over 4000kgf(40kN) can be applied and probably were commonly. A Boeing 757-200 would apply approximately the same horizontal force and a dual tandem gear wide body aircraft would apply approximately twice this load. The Boeing 737-300,-400 aircraft has particularly low slung engines which apply their centre of thrust within 2m of the pavement surface

A lateral force of 40kN applied to pavers repetitively would be sufficient to disturb even an elastomeric polymer stabilised joint. (Research at Luton Airport has shown this type of joint to be more resistant to erosion than any other type of joint). It is likely that the jointing material became debonded from the sides of the pavers in areas of large joint width - say over 5mm - and in positions where penetration of the polymer had been less than the normally attained value of 25mm published by the manufacturer. Once debonded, the progressive erosion of the material would eventually lead to the removal of pavers.

From the above, it can be concluded that the Luton Airport Eastern Turning Circle incidents occurred as a result of the use of pavers in a critical location where the combination of large horizontal forces and severe pressures applied over long periods (the aircraft would be travelling slow) led to the gradual reduction of interlock so that ultimately only the weight of individual unconnected pavers prevented failure. The peculiar bedding material, the laying of the pavers by mechanical means in clusters, the failure to ensure joints were sealed and the straight line joint through the failed area have each contributed to the failures. Emery's comments following his inspection of the turning circles on 17th September 1992 led to the conclusion that workmanship and detail design were a factor at least in the 22nd September 1992 failure. Effectively, the following factors acting simultaneously created conditions which were conducive to the loss of pavers:

1 Severe lateral loads on a turning circle

2 Full thrust engines when aircraft are lined up for takeoff

3 Trafficking by Boeing 737-300,-400 aircraft with low slung engines

4 Inadequate regular inspection and recording of integrity of pavers or jointing material

5 Abnormal paver joint widths, either around clusters in the case of the mechanically laid "Coloc" system or along the straight interface between two areas of separately laid rectangular pavers in the case of the September 1992 failure. The quality of workmanship in the control of these abnormal joint widths made a significant contribution to the failures.

By considering the successful performance of the stands, the successful performance of the Eastern Turning Circle during period two and the successful performance of the Western Turning Circle throughout its life, the following conclusions can be drawn from the Luton experience.

1 **A correctly designed and constructed pavement surfaced with pavers can withstand over 30,000 passes by a mix of heavy commercial aircraft even in the onerous conditions associated with a turning circle.**

2 **The following factors are crucial in the successful performance of an aircraft pavement surfaced with pavers and each one needs to be addressed explicitly for each proposed area of pavers:**

a) design of the pavement structure to be undertaken rigorously.

b) detailing of the surfacing to ensure full interlock is developed throughout the pavement.

c) construction to be to a high standard, including supervision. Mechanical laying of pavers to be permitted only when cluster effects are absent

d) particular attention to be paid to all aspects of laying course

e) joints to be resistant to erosion and ingress of liquids

f) regular inspection system including abnormality recording

g) maintenance to be carried out expeditiously

Pavers have been used for many categories of aircraft pavements and in most cases they have performed satisfactorily. The principal examples where pavers have entered service are now described. It is estimated that 700,000 m2 of pavers are in service on aircraft pavements in the following proportions:

Apron stands	84%
Helicopter pads	6%
Taxiways	4%
Runway ends	3%
Fuelling areas	3%

Review of Pavers in UK Airports

Blackpool Airport

This aerodrome was one of the earliest to make use of pavers following the Luton trials and in 1982 surfaced two helicopter pads with a third being surfaced in 1992. Each helicopter pad was approximately 17.5m x 17.5m, i.e. an area of 920m^2. In 1987 the 10 and 28 ends of the runway were constructed with a paver surfacing. The pavements were of flexible construction, comprising:

80mm rectangular pavers
50mm sand
150mm lean mix concrete base course
granular sub-base (thickness unknown)

The mix of aircraft using Blackpool is typically light general STOL transports and BAC 1-11s. The number of aircraft movements using the runway where the pavers are in use were given as approximately 10,000 per year. The aerodrome has experienced no problems with the pavers. As a matter of precaution, following the Luton experience, they replaced 40-50 pavers on the runway ends.

Coventry Airport

In 1987 the 23 threshold/turning area (3000m^2) was constructed as follows

80mm thick rectangular pavers
50mm sand
300mm cement stabilised soil
regulating layer of lean mix concrete

The mix of aircraft using the aerodrome compromises Boeing B-707, Viscount, Vanguard and Lockheed Electra. It has been noted that the B-707 has on occasions landed on the pavers without damage to them. There are up to 25 aircraft movements per day at the aerodrome. The performance of the paver surface was rated as good but there has been some loss of jointing sand and growth of weeds noted in some joints.

Dunsfold Aerodrome.

This aerodrome is operated by British Aerospace (Military Aircraft) Ltd. and is used mainly by Harrier VSTOL aircraft, between 12 and 20 aircraft movements per week. Two areas have been surfaced using pavers, the eastern runway overrun/turning area (750m^2) and an aircraft handling area (1780m^2). The overrun/turning area is thought to have been laid over 250mm pavement quality (PQ) concrete and the aircraft handling

area over lean mix concrete. Some jointing sand loss was encountered which has been remedied by sealing the joints with a polymer sealer.

London Gatwick Airport.

During 1989 and 1990 Apron Stands 49 - 52 and Stand 54 were constructed. Half the area was new pavement construction as follows:

80mm rectangular pavers
40mm sand
525mm lean mix concrete
300mm granular sub-base (GSB) Type 1 on a drainage layer

The remaining area comprised a substantial overlay on an existing General Aviation apron and comprises:

80mm rectangular pavers
40mm sand
50mm hot rolled asphalt
225mm dry lean concrete

The aircraft using the stands are mainly Boeing B747 and B737. On average each stand has 2 wide body and 3 narrow body jet aircraft movements per day. A representative of British Airports Authority(BAA), who are responsible for this airport, has given the following comments based on experience at Gatwick:

"....it is not now BAA's policy to utilise blocks (pavers) for new construction. We may consider them for overlay of existing stands but they are not cost effective for new construction and have long term maintenance deficiencies. We do however use blocks on occasions for small scale bay repairs in areas where access for long term repairs is difficult."

Glasgow Airport

Between 1989 and 1991 Stands 14 - 26 at the Domestic Pier were overlain using 80mm thick rectangular pavers in four separate phases. Before laying the pavers the existing PQ concrete construction was regulated using bituminous material. Aircraft using the area range between twin turbo prop and Boeing B757, with approximately 600 aircraft movements per week using the 14 stands. No problems have been encountered with the pavers apart from some minor settlement generally occurring at some of the underlying expansion joints in the PQ concrete.

London Heathrow Airport

During the summer of 1992 Apron Stands 74 to 88, (21000m^2), at the North side of the airport were resurfaced using 80mm thick rectangular pavers on 35mm sand after regulating part of the area with Marshall asphalt. Aircraft using these stands are BoeingB767, B757, and McDonnell Douglas DC-9 and the number of aircraft using each stand is 8-10 per day. The performance of the pavers is stated to be satisfactory. It is understood that local settlement has occurred in areas of pavers beneath main aircraft undercarriage gear and this appears to be associated with saturation of the laying course

sand. A further area of 26000m^2 of rectangular pavers is to be laid in 1994 on the Eastern Apron Development.

Prior to paving the stands, a 150m length of taxiway was paved in 1986. Pavers were laid on a bed of bitumen coated sand and were overlain with bituminous material. Engineers at the Airport had been concerned to reduce the propogation of cracks to the surface of the pavement and wondered whether their paver sandwich would prevent the phenomenon. The experiment was removed after 18 months.

Humberside Airport

During 1986 an apron of 4400m^2 was constructed as detailed below:

80mm rectangular pavers
50mm sand
200mm lean mix concrete on a subgrade having a California Bearing Ratio (CBR) of 6%.

Aircraft using the stands are mainly helicopters and Boeing B737-400. There are approximately 30 helicopter movements per day and two B737s per week. No problems have been encountered with the pavers, apart from the growth of some weeds in joints and the area is said to have been maintenance free.

Southampton Airport

In 1991 and 1992 two apron areas were built in two separate phases, each area having the following construction:

80mm rectangular pavers
40mm sand
2 x 150mm lean mix concrete on a 'Geotextile' layer.

The mix of aircraft using the stands is typically: British Aerospace 146, BN Trislander, Fokker F27 and Saab 340. There are about 60 aircraft movements per day. Phase 1 was found to be *"Generally OK"* and Phase 2 to be *"Excellent - some problems with lean mix thermal movement and jointing"*.

London Stansted Airport

During 1988/1989 as part of the 'Diamond' Hangar construction a 30,000m^2 apron parking and engine run-up area was constructed. Aircraft using the hangar are usually Boeing B747 with typically 4 movements per week.

World-wide use of pavers on civil aerodromes

Ben Gurion International Airport - Tel-Aviv, Israel

In 1990 and in 1992 an apron area of 13,300m^2 was constructed in two phases. Phase 1 comprised 6,300m^2 and Phase 2 comprised 27,000m^2. The construction was similar for both areas, i.e.:

80mm pavers - sealed with polymer sealer
40mm sand
'geotextile' layer
230mm stabilised base
950mm sub-base layer
elastomeric bitumen waterproofing membrane on compacted clay

The mix of aircraft using the area comprises Boeing B747, B707, B727 and McDonnell Douglas DC 10. Performance of the pavers was stated to be; "Very good, with no settlement or any other defects".

Cairns Airport - Queensland, Australia

The first application of pavers occurred in 1988 when a trial was made on a distressed section of the domestic apron. Following the trial about 15,000m^2 of 80mm thick pavers were installed on three aircraft parking bays on the International apron during August and September 1990. The construction of the aircraft pavement, which has a design life of 15 years, is:

80mm non-rectangular pavers - treated with 'Supersand'
20mm sand
5-7mm prime and seal coat
250mm cement bound (2%) fine crushed rock (20mm)
250mm crushed rock sub-base
subgrade CBR stated to be 20%

The mix of aircraft using the apron stands comprises Boeing B747-400, McDonnell Douglas DC10, Airbus A300 and Boeing B767. The forecast number of B747 movements over the design life is 8000. Performance of the pavement is said to be 'excellent'. A major fuel spill of 7500 litres occurred on one section of pavers about six weeks after construction with no visible effect. No loss of shape in wheel tracks or standing positions has been noted to date.

Cayman Brac Airport - British West Indies

A small apron/turning area of approximately 1,000m^2 was constructed in 1987/1988 having the following construction:

80mm rectangular pavers
25mm sand
225 - 300mm crushed rock base on a prepared natural limestone formation

The area is used by light aircraft and a Boeing B727 once a week. The performance of the pavers is stated to be satisfactory apart from some chipping of a few pavers. This is considered, by the aerodrome operator to be due to the fact that the pavers did not have spacer nibs.

Owen Roberts Airport - Grand Cayman, British West Indies

In November 1992 an apron area of 9,800m^2 was constructed as follows:

800mm rectangular pavers - sealed with a proprietary sealer
25 - 50mm sand
150 - 230mm asphaltic base course
175mm crushed rock base

The mix of aircraft using the apron area comprises Boeing B737, B727 and miscellaneous twin engine aircraft. Normally each stand has 1 or 2 aircraft movements per day. Performance of the pavers is stated to be 'very good' although there has been some rutting and cracked blocks which have been replaced. It was further stated that the sealer has not performed satisfactorily.

Dallas/ Fort Worth International Airport - Texas, U.S.A.

During the period September to November 1990 four independent lengths of taxiway having a total area of 24,000m^2 were constructed adjacent to the 18R/36I runway. Details of the construction are:

80mm rectangular pavers - sealed with proprietary polymer sealer
38mm sand
685mm cement treated base
lime/ flyash stabilised clay subgrade

The design life of the taxiway is 20 years. A wide range of aircraft up to Boeing B747 use the taxiways.

Fujairah Airport - United Arab Emirates

Between 1988 and the present time 30,000m^2 of pavers have been laid on:

80mm thick shaped pavers
30mm sand
300mm natural aggregate screened to remove fractions greater than 75mm
The subgrade strength varied widely between 23% and 160% CBR

The areas are trafficked by light aircraft and military helicopters.

Nairobi International Airport - Kenya

Between 1991 and 1992 a 56,000m^2 apron area was constructed. The limited information obtained suggested that the pavement construction comprises:

80mm rectangular pavers
50mm sand
2 layers of lean mix concrete (depth not stated)

The apron is being used by aircraft up to B747

Subang Airport - Kuala Lumpur, Malaysia

Between September and December 1992 an apron area of 68,000m^2 was constructed as follows:

80mm rectangular pavers - treated with 'Supersand'
38mm sand
100mm lean mix concrete
650mm crushed rock

Kristiansand Airport - Norway

During 1990 the existing asphaltic apron stands at this airport were provided with an inlay of 80mm thick shaped pavers. The total area of pavers installed was 6,800m^2 and the joints were treated with a polymer sealer. Aircraft using the stands are mainly Boeing B737-400s

Stavanger/ Sola Airport - Norway

As part of the ongoing maintenance scheme the military part of the airport apronage is being reconstructed. Up to the beginning of 1994 approximately 13,000m^2 had been completed. The new pavement construction comprises:

80mm thick shaped pavers - sealed with polymer sealer
30mm sand
140mm crushed stone on a prepared crushed stone formation having a CBR of 12%

Part of the area is used for helicopter parking and the remainder is used by F-16 military transport aircraft. Additionally, a hangar apron has been constructed at this airport with the following construction:

80mm thick shaped pavers - sealed with a polymer sealer
30mm sand
60-240mm crushed stone base on a sandy peat subgrade

The apron stand is used by aircraft up to B737-400

Trondheim Airport - Norway

A 26,000m^2 new apron area is currently under construction. Details of the pavement are:

80mm thick pavers - sealed with a polymer sealer
30mm sand
400-1200mm crushed stone base

Aircraft using the stands will be up to Boeing B737-400

St. Augustine Airport - Florida, U.S.A.

During September 1992 an aircraft parking area was built having the following construction:

80mm rectangular pavers
25 - 37mm sand
150mm crushed aggregate base
300mm stabilised soil sub-base

The pavement is used by single and twin-engined General Aviation aircraft and executive jets. The performance of the pavers is stated to be 'excellent'.

Wellington Airport - New Zealand

Between 1989 and 1991 an apron area of approximately 1,500m^2 was constructed incrementally. The construction is stated to be 80mm pavers on sand on a 60mm base course. Aircraft using the area comprise Boeing B767, B737 and BAe 146. The number of aircraft movements are given as approximately 6,000 per year. Comments have been unfavourable and this may be due to inadequate pavement thickness.

Table 2. United Kingdom use of pavers on aircraft pavements

Airport	**Area of pavers (m^2)**	**Year installed**	**Pavement use**	**Aircraft using pavement**
Blackpool	5,260	1982,1987 & 1992	Runway end Helicopter pads	BAC1-11, General aviation & helicopters
Coventry	3,000	1989	Runway end	Electra, Viscount Vanguard, B707
Gatwick	30,600	1989 & 1990	Aprons	B747 & B737
Glasgow	42,000	1989 - 1990	Aprons	Twin turbos up to B757s
Heathrow	20,000 26,000	1992 1994	Aprons	B767, B757 & B767
Humberside	4,400	1986	Apron	Helicopters B737
Isles of Scilly	2,000	1992	Apron	Helicopters BN Islander
Luton	24,200	1982 - 1993	Runway ends Aprons	B767, B757, B737 & General Aviation
Southampton	30,000	1991 & 1992	Aprons	Light aircraft
Stansted	30,000		Apron Run-up area	B747

Table 3. World-wide use of pavers on aircraft pavements

Airport	Area of pavers (m^2)	Year installed	Pavement use	Aircraft using pavement
Ben Gurion Israel	13,000	1990 & 1992	Apron	B747, B707, B727 & DC10
Cairns Australia	15,000	1990	Apron	B747, DC10, B767 & A300
Cayman Brac B.W.I.	900	1987/ 1988	Apron	Light aircraft & B727
Grand Cayman B.W.I	9,800	1992	Apron	B727, B737 & Light aircraft
Dallas/ Fort Worth U.S.A.	24,000	1990	Taxiways	Up to B747s
Fujairah U.A.E.	30,000	1988 - present	Apron, Taxiway Fuel Area	Light aircraft Helicopters. 3 new stands for B747s
Jomo Kenyatta Kenya	56,000	1991/1992	Apron	Up to B747s
Subang Malaysia	68,000	1992	Apron	B747 & A300
Kristiansand Norway	6,800	1990	Apron	B737
Stavanger/ Sola Norway	13,000	1990 - present	Apron	F-16 military B737
Trondheim Norway	26,000	1993/ 1994	Apron	B737
St. Augustine FL U.S.A	5,000	1992	Apron	Twin engine General aviation
Wellington New Zealand	1,500	1989 - 1991	Apron	B767, B737 BAe 146