AN EVALUATION OF THE PERFORMANCE OF CONCRETE BLOCKS ON AIRCRAFT PAVEMENTS AT LUTON AIRPORT

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Summary

The paper presented by the author at the 1984 Delft Conference reported on how the original concrete block trial areas compared with the desirable properties for aircraft pavements. This paper will discuss further developments that have taken place since these early tentative trials. Nine apron stands and the two runway end turning areas have now been resurfaced with concrete blocks (approximately 13000m^2) and are performing successfully. Investigations into the problem of the erosion of jointing sand due to jet blast are also discussed and recommendations given for resisting this severe form of erosion. During the resurfacing of one of the runway end turning areas a series of plate bearing tests, using a 70 t. rig were made to measure the apparent contribution the concrete blocks made to the overall strength of the pavement. The results and an interpretation of the results are discussed.

1. Introduction

The use of concrete blocks for surfacing aircraft pavements is now well established at Luton Airport and is increasingly being introduced at other civil and military airfields in the UK. Most aircraft using Luton Airport now take-off from concrete blocks which have been laid at both ends of the runway. Additionally, the majority of the larger passenger aircraft park on stands which have been similarly surfaced.

Trial areas using this form of surfacing were laid in 1981 and after two years in use, the conclusion made was that concrete blocks appeared to provide a high strength, durable, flexible surfacing that satisfied the properties required of an aircraft pavement. The performance of these trial areas was reported at the last conference.(1)

This paper reports on the performance of areas of concrete block paving which have been laid since the original trials and discusses; (i), the problem of erosion of jointing sand in areas of paving subjected to jet blast and; (ii), the strength of pavements after resurfacing with concrete blocks.

2. Resurfacing Works Using Concrete Blocks

2.1 Apron Stands

Early in 1983 nine apron stands were resurfaced (approx 2700m^2) using 80mm rectangular blocks laid on a 20mm thickness of bedding sand. The boundar of the damaged bituminous surfacing was defined by a line cut with a diamond saw, the cut being taken full depth in the surrounding undamaged material and the vertical face of this material used to provide the edge restraint for the concrete blocks.

2.2 Runway Turning Areas

The turning area at the east end of the runway was resurfaced during November 1983 (approx 5000m^2) using 100mm thick rectangular blocks. A similar resurfacing contract was carried out one year later on the turning area at the west end of the runway, this time using 80mm thick blocks on a 65mm thickness of bedding sand (See Figure 1.). To minimize disruption to aircraft the work was carried out at night with aircraft landing and taking-off over the work in progress. Despite heavy frost and rain, work continued with few interruptions and was completed on schedule.

A total area of 13,000m^2 of concrete blocks has now been laid at the airport and has proved to be an efficient and cost effective means of rehabilitating damaged aircraft pavements.

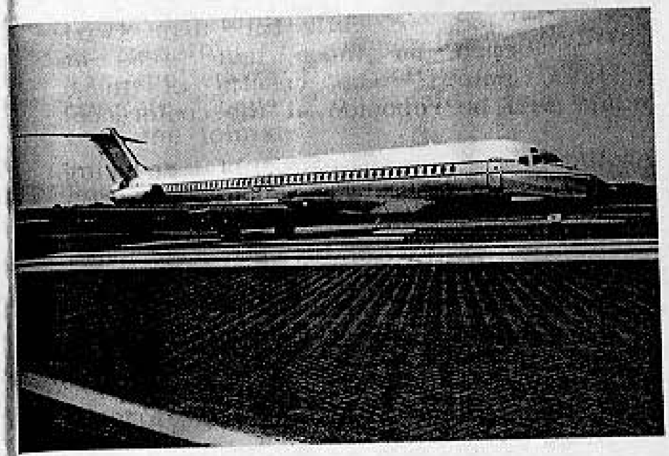

Figure 1 - Resurfaced Runway Turning Area

2.3 The use of Concrete Blocks at Other Airports

Figure 2 gives some indication of the increasing use of concrete blocks on aircraft pavements at other airports

Airport	Where Used	Approx. Area - m²
R.A.F. Abingdon	Aircraft parking stand	50
Blackpool	Helicopter pads & runway ends	5000
British Aerospace Dunsfold	Runway end	1000
London - Heathrow	Taxiway trial areas	5000
R.A.F. Lyneham	Proposed apron and taxiway	3500
R.A.F. Northolt	Aircraft parking stands	3000
Qualitair Aviation Ltd. Stansted	Proposed hangar parking area for Boeing 747s	35000
R.A.F. Wood Vale	Aircraft parking stands	5000

Figure 2 - Airports in the U.K. Using Concrete Blocks.

in the UK. A good example of this being at Blackpool Airport where concrete blocks have been used for surfacing helicopter pads - see Figure 3.

3. Erosion of Jointing Sand Due to Jet Blast

3.1 The Problem of Erosion

A concern felt by many potential users of concrete blocks on areas subjected to jet blast is the possibility of erosion of jointing sand, which, if removed, would prevent the development of full interlock. This problem was initially investigated by the UK Ministry of Defence (MOD)[2] and British Aerospace [3] who, in seeking alternative landing and take-off pavements for Harrier V/STOL aircraft, considered the use of concrete block paving. Laboratory trials included the use of various

Figure 3 - Helicopter Pads at Blackpool Airport

materials for joint filling/sealing a surface covering of blocks and subjecti them to a jet efflux pressure of 3 k Pa and temperatures of up to 550° A full scale test was also carri out in which trial areas of bloc were subjected to the exhaust bla from a tethered Harrier V/STOL aircra The conclusions drawn from the trials were (i) the concept of sm element paving was feasible for Harr aircraft (ii) further trials were necess to prove the stability of the sm element paving under repeated h and blast effects.

It should be pointed out that t type of military aircraft prese far greater problems on paveme than do conventional civilian aircra For example, the Harrier V/STOL airc may have an exhaust gas temperat of approx. 1200°C and a vertical exha velocity of 1000 m/s.

This compares with, for examp a Boeing 737 (300) aircraft, wh has an exhaust temperature of 30 and an exhaust velocity of 300 m where they impinge on the gro surface.

3.2 Methods of Reducing Erosion Problems

At Luton Airport, some loss of join sand from the two runway ends evident, though this was gener confined to the top 1cm of the joi Various joint filling materials now been tested at Luton Airport it is felt that for aircraft paveme consideration should be given amending the jointing sand specifica given in the current British Standard for Concrete Block Paving[4] to include a small percentage of finer particles. This may be achieved by the addition of bentonite, an expansive montmorillonite clay widely used in civil engineering [5], which is cheaply and readily available in the UK. This has been found to be effective in sealing joints and reducing erosion problems.

To determine the effectiveness of sealing joints in concrete block paving, a series of constant head permeability tests were made on different joint filling mixtures. These tests were carried out in accordance with a method devised by the Transport and Road Research Laboratory [6]. Figure 4 gives the results of these tests.

Jointing Material	Permeability (k) m/sec
Jointing sand	1.7×10^{-4}
Sand: Bentonite (6:1 by wt)	3.3×10^{-10}
Sand: Bentonite (15:1 by wt)	1.85×10^{-10}
Sand: Lime (10.1 by wt)	2.2×10^{-4}

Figure 4 - Results of Permeability Tests

The main advantage of the addition of bentonite to the bedding sand is its dramatic effect on the permeability of the jointing sand, reducing it to a value that is typical of concrete. This may prove to be useful for concrete block pavements having moisture susceptible sub-bases and/or subgrades. It may also allay the fears of those who still consider that there is a danger of a build-up of explosive gases and liquids in the bedding sand under block paving subjected to fuel spillages.

The addition of various polymers to the jointing sand appears to be the most effective means of avoiding erosion problems. Polymers, which are available in liquid form may be poured onto the surface of the block paving and allowed to penetrate the jointing sand. On samples of the jointing sand the penetration of the polymer was found to be in excess of 2 cms, i.e. well below the zone affected by erosion. It is important that the sand and polymer do not cure to a rigid state as this could affect the flexible properties of the block paving. Various trials are in progress on 600mm x 600mm test areas of block paving which have been subjected to high pressure water and air jets. Pull out tests will be performed on these test areas at a later date. The results of these trials will be reported at the conference.

Another possible means of reducing jet blast induced erosion problems on concrete block pavements now under review at Luton, is the use of blocks without chamfered top edges.

4. The Structural Value of Concrete Block Paving

The resurfacing of the western end turning area provided an opportunity to carry out an investigation into what contribution the concrete blocks make to the overall strength of the aircraft pavement in terms of its Load Classification Number (LCN)[7]. This was carried out by the Department of Civil Engineering Services (Airfields Branch) of the Property Services Agency using their 70 t mobile plate bearing test rig.

4.1 Description of the tests

The tests were carried out in three stages

Stage 1: on the original bituminous overlay which comprised 40mm grouted open-graded macadam on 85mm Marshall asphalt

Stage 2: on the underlying 250mm thick pavement-quality concrete, i.e. after removal of the bituminous overlay

Stage 3: on the 80mm concrete block surfacing

Ten Plate bearing tests were carried out at each stage. This number of tests was considered to be the minimum for statistical analysis and the maximum that could be completed in one day, allowing for disruption from aircraft movements.

The basic test method was the rigid centre test, as described in reference 8, which uses a 457mm dia. plate. Every test was carried out on an individual 5m x 5m concrete bay to ensure that results were not influenced by cracks caused by tests to a previous stage. However, the ten locations chosen for stages 2 and 3 were adjacent to the earlier ones in order to minimise the effect of such variables as subgrade strength, concrete strength and variations, in layer thicknesses. As far as it is possible to determine, the load was applied to the centres of underlying concrete bays to avoid interference from the joints.

4.2 Results

The method of obtaining LCN values from plate bearing tests is described in reference 8, and the LCN values determined for the three stages are shown in Figure 5.

4.3 Interpretation of results

A comparison of the results indicates that the concrete block surfacing has given a 14% increase in the value of

	Stage 1	Stage 2	Stage 3
Pavement construction	Bituminous surfacing 250 mm PQ concrete 100 mm dry clean concrete	250 mm PQ concrete 100 mm dry clean concrete	80 mm concrete blocks Sand 250 mm PQ concrete 100 mm dry clean concrete
Mean of safe loads ($\bar{x}$) (based on 10 tests)	240·25 kN	223·25 kN	255·58 kN
Standard deviation (SD)	26·89 kN	28·18 kN	14·28 kN
Working load ($= \bar{x} - \frac{SD}{2}$)	226·81 kN	209·20 kN	248·44 kN
Coefficient of variation	11%	13%	6%
LCN	64	60	73

PQ pavement quality

Figure 5 - Results of Plate Bearing Tests.

the LCN over that of the original bituminous surfacing, and a 21.7% increase over that of the original 250mm thick rigid pavement. However, the LCN value obtained during the stage 1 tests is perhaps not as great as one would normally expect from a 100mm Marshall asphalt overlay on a pavement-quality concrete base. This might be accounted for by the fact that the top 40mm of the bituminous surfacing was a grouted macadam, which probably has a lower strength than the underlying Marshall asphalt.

5. Conclusions

It is considered that the concrete blocks used at Luton Airport have been a success. From the tentative trials of 1981 to the more recent resurfacing of the runway turning areas, concrete blocks have demonstrated advantages over the pavement quality concrete and asphaltic surfaces normally used for aircraft pavements. For example, concrete blocks may be put into use immediately after they have been installe[d]; the strength of the concrete used fo[r] blocks is considerably greater tha[n] pavement quality concrete; block pavin[g] is unaffected by spillages of oils an[d] aviation fuels as are asphaltic surfaces; they are not seriously damaged whe[n] aircraft are jacked-up for urgent whee[l] changes. In the language of today they are 'abuser friendly'.

Improvements can still be made [t]o the performance of concrete block[s] on aircraft pavements. Rideabilit[y] may be improved by using blocks withou[t] chamfered edges and erosion problem[s] may be eliminated by the use of additiv[es] to the jointing sand.

The contribution the blocks make [to] the strength of the overall paveme[nt] is still not yet fully understood a[nd] would provide a suitable field f[or] research at an establishment havi[ng] the resources available.

Concrete blocks for surfacing aircra[ft] pavements is a concept that is gaini[ng] acceptance by civilian and milita[ry] airport operators in the United Kingd[om] and other countries and is an applicati[on] that can be expected to grow consideral[bly] over the next few years.

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