PERFORMANCE OF PLAIN CONCRETE RUNWAY PAVEMENT

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ABSTRACT: This paper investigates the causes of poor performance of plain cement concrete pavement, the most common type of construction for airfield pavements. Plain concrete pavements are generally cost-effective and durable. The runway at Zia International Airport at Dhaka (Bangladesh) is a plain concrete pavement, which failed rather prematurely. Thin longitudinal cracks occurred in the slab panels even before the runway was opened to traffic. With the operation of air traffic, cracks in the pavement became wider, fragmenting the slab panels into several pieces. This paper is aimed at identifying the causes of poor performance of the plain cement concrete runway pavement at Zia International Airport. A critical review of the various available documents supported by experimental and numerical investigations is presented to unearth the real causes of failure. It is shown that improper spacing of the longitudinal and transverse joints and existence of high temperature stresses resulted in cracking of the slab even prior to application of any air traffic loading. This was aggravated with the application of aircraft loadings heavier than those anticipated in the design of the runway.

INTRODUCTION AND BACKGROUND

Runways as well as major highways are often designed as plain unreinforced concrete pavements relying on the flexural strength of concrete. Early concrete pavements used to be built continuous and without joints. For control of cracks, plain cement concrete pavements are currently provided with both longitudinal and transverse joints. Although steel-fiber reinforced concrete pavement offers a potential economic advantage over conventional unreinforced concrete pavements (Rollings 1993), the latter is still the most common type of construction for runway applications. The runway pavement at Zia International Airport (ZIA) in Dhaka, Bangladesh, is a plain cement concrete (PCC) runway, which suffered cracking even prior to application of the air traffic load. The writers were recently engaged in the rehabilitation of the damaged runway, and from their exposure to the problem, this paper attempts to identify the causes of failure of the runway pavement.

The runway at ZIA was designed in the 1960s. Although the construction of the airport was completed in 1968–1969, routine flight operation did not start until 1980–81. The runway and the aircraft traffic areas were not designed for the operation of heavy and wide body aircraft like the Boeing 747, DC-10, L-1011, and Concord. However, operation of wide body aircraft like the Boeing 747 and DC-10 has been taking place since 1981 at ZIA.

The pavement subgrade was a compacted fill of thickness ranging from 0.9 m (3 ft) to 4.25 m (14 ft). A 150 mm (6 in.) lean concrete subbase underlying a PCC slab with a thickness of 250 mm (10 in.)–325 mm (13 in.) at locations was used (Fig. 1). The runway has an overall length of 3,200 m (10,500 ft) and a width of 46 m (150 ft) with 7.6 m (25 ft) shoulders on either side. The PCC slabs have longitudinal joints spaced at 7.6 m (25 ft) and transverse joints at 7.6 m (25 ft) in the chainage between 0 and 152 m (500 ft) and at 6 m (20 ft) in the chainage between 152 m (500 ft) and 3,200 m (10,500 ft). The PCC slabs, therefore, have dimensions of 7.6 m (25 ft) by 7.6 m (25 ft) in the noncritical zone and 7.6 m (25 ft) by 6 m (20 ft) in the critical zone of the runway.

During the country's Liberation War of 1971, the runway was damaged at various locations by aerial bombing. The damages were subsequently repaired by filling and resurfacing the craters.

Many cracks have developed on the pavement of the runway (see Fig. 2 for a typical crack). Cracks have also occurred in the taxiway and in the aprons. Portions of the runway that are unlikely to have experienced any aircraft loading also contain thin longitudinal cracks. It has been reported that such cracks did exist in the runway even before the runway was opened to traffic in 1981. In the course of repetition of heavy aircraft load, progressive development of cracks, both in number and size (width), has taken place. The Civil Aviation Authority of Bangladesh (CAAB) has been routinely repairing various types of cracks by adopting different techniques. Fig. 3(a) shows large-size non-interconnected relatively straight cracks with saw cut marks on either side. Usually a 150 mm (6 in.) wide and 75 mm (3 in.) deep trench is cut around the cracks and filled with asphalt concrete during the course of repair work. Fig. 3(b) shows random and interconnected wide cracks where trench cutting, similar to that shown in Fig. 2, is not feasible, and any attempt of groove cutting may cause extensive damage to the runway slab. In such cases, usually 50 mm (2 in.) diameter holes through the entire slab on 0.6 m (2 ft) centers along the cracks are drilled [see Fig. 3(b)] and filled with surface course asphalt concrete under pressure.

The CAAB has recently taken initiatives to repair the runway and to do resurfacing work. With this aim, the writers, along with their colleagues, were engaged in evaluating the existing condition of the surface and preparing technical specifications for the repair and the overlay construction. The information presented in this paper is based on the detailed survey carried out by a team of researchers from the Bangladesh University of Engineering and Technology, Dhaka. Numerical experiments were conducted using the finite element method to substantiate the probable causes of poor performance of the runway.

CRACKING PATTERN IN RUNWAY PAVEMENT

The PCC slabs of the runway suffered severe cracking. The cracks were longitudinal linear cracks spread over the entire length of the runway. Most slab panels near the runway center line underwent multiple cracks, with some of the panels shattered near the touchdown and takeoff areas of the runway. It was reported that cracks of relatively narrow width existed years before the runway was put into operation. Over the years, after being put into service, aircraft wheel loads led to a progressive widening of the cracks as well as development

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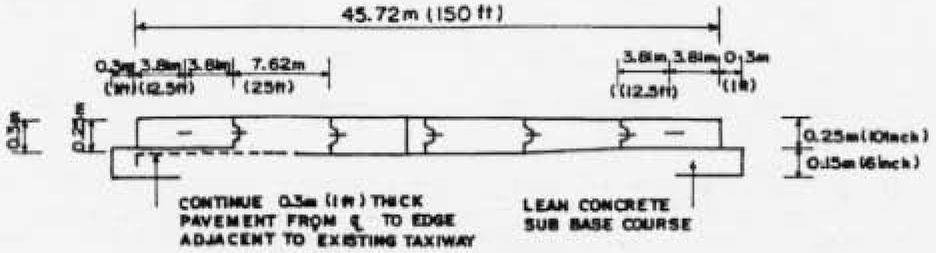
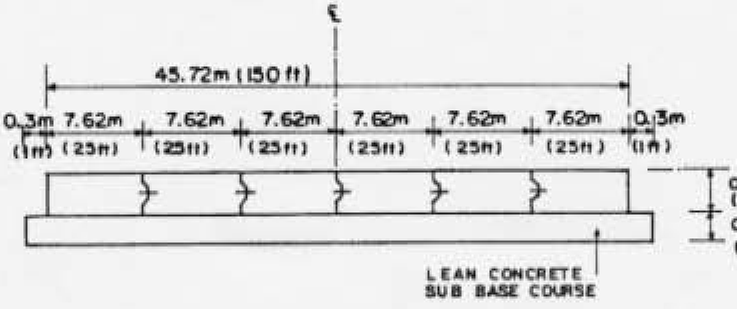


RUNWAY [BETWEEN 152.4m (500ft) AND 3,048m (10,000ft)]



RUNWAY [BETWEEN 0–152.4m (500ft) AND 3,048m (10,000ft) –3,200m (10,500ft) FROM THE SOUTH END]

FIG. 1. Typical Runway Pavement Cross Section

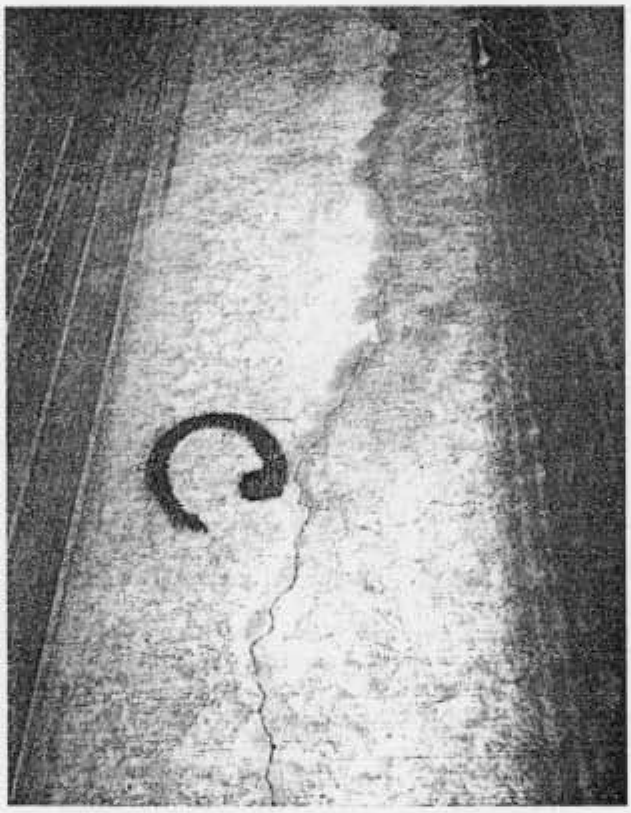


FIG. 2. Typical Crack in Runway Pavement

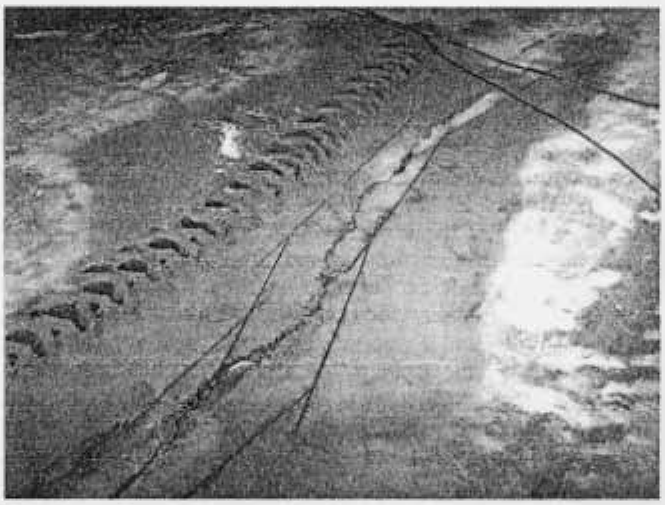


FIG. 3(a). Crack Repaired by Cutting 150 mm (6 in.) by 75 mm (3 in.) Trench in Existing Pavement, then Filling with Asphalt Concrete

of new cracks. The taxiway and aprons also suffered cracking; however, the intensity of such cracking, both in number and in width, was much less than their main runway counterparts.

Several studies have been carried out by different agencies since 1986 as to the extent and causes of the cracks ("Zia" 1986; "Technical" 1986; "Report" 1988; "Summary" 1989). These reports testified that the construction of the runway pavement was done in a proper way and a satisfactory quality of construction was maintained. As of 1986, longitudinal linear cracks spreading over the entire length of the runway were noted in these reports. Taxiway and apron pavement also contained cracks. Table 1 shows the extent of cracks reported in "Zia" (1986).

Nippon Koi Co. Ltd. Engineering Consultants ("Technical" 1986) assessed the extent of cracking through the use of "degree of crack," defined as the length of cracks divided by the relevant area. Degree of crack values of 18.2 cm/m^2 in the runway and 31.7 cm/m^2 in the high speed taxiway were reported. The threshold levels of degree of cracks requiring urgent repair were 5.6 cm/m^2 and 7.6 cm/m^2 for the runway and taxiway, respectively.

To assess the repair needs, an extensive survey of the existing cracks was done in 1993. In this survey, cracks were classified, according to their width, into the following four categories:

FIG. 3(b). Crack Repaired by Cutting 50 mm (2 in.) Diameter Holes at 0.61 m (2 ft) Center to Center Spacing and Subsequently Filling with Asphalt Concrete

1. Less than 6.35 mm (1/4 in.)
2. Between 6.35 mm (1/4 in.) and 25 mm (1 in.)
3. Between 25 mm (1 in.) and 50 mm (2 in.)
4. More than 50 mm (2 in.)

Typical crack patterns for chainages 915 m (3,000 ft)–1,069 m (3,500 ft); 2,134 m (7,000 ft)–2,286 m (7,500 ft); 2,286 m (7,500 ft)–2,438 m (8,000 ft); and 2,896 m (9,500 ft)–3,048 m (10,000 ft) are shown in Figs. 4(a,b) and 4(c,d). Average values of degree of crack for these portions of the runway are shown in Table 2. The central slab panels (two slabs adjacent to the centerline) have been subjected to severe cracks of 25 mm (1 in.) width or greater.

It can be seen from Figs. 4(a,b) and 4(c,d) that most of the cracking took place in the central four panels spread over a width of 30.5 m (4 × 7.625 m), i.e., 15.2 m (50 ft) on either side of the centerline. The panels along the edges are almost free from cracks. This is essentially true when edge slab panels have longitudinal joints spaced 3.8 m (12.5 ft) apart. The location of the wheels for different types of aircraft is shown in Fig. 5. The edge panels were unlikely to experience any wheel load, and as the cracks in the edge panels only occurred in the slabs having longitudinal joints spaced 7.6 m (25 ft) apart, it may be concluded that the initiation of crack was due to improper spacing of the joints in the unreinforced concrete slabs. For central slabs, longitudinal cracks were formed initially in the same fashion as in the case of edge slab panels, and then progressive cracks were developed with the multiple application of heavy loads.

CAUSES OF CRACKING AND DETERIORATION

The various studies conducted on the runway at ZIA indicate that minor longitudinal cracks existed in most of the slab panels even prior to the routine flight operations. It has also been revealed that the extent of cracks has increased over the last few years. The survey conducted in 1993 showed that most of the central slabs [middle 15.2 m (50 ft)] were badly cracked and broken into a number of pieces. The causes of cracking may be manyfold. An assessment of the true cause would involve considerations of the characteristics of the subgrade soil, strength of concrete in the PCC, aircraft loading conditions, pavement jointing system, analysis of stress, and likewise. These features are discussed next.

TABLE 1. Cracks of Slabs for Every 152 m (500 ft) ("Zia" 1986)

	Linear Crack		Multiple Crack		Remarks	
Runway m (ft) (1)	Number of slabs (2)	Percent (3)	Number of slabs (4)	Percent (5)	Size of slabs m (ft) (6)	Total number of slabs (7)
0–152 (0–500)	—	—	—	—	7.6 × 7.6 (25 × 25)	120
152–305 (500–1,000)	14	9.3	9	6.0	6 × 7.6 (20 × 25)	150
305–457 (1,000–1,500)	77	51.3	2	1.3	6 × 7.6 (20 × 25)	150
457–610 (1,500–2,000)	55	36.7	—	—	6 × 7.6 (20 × 25)	150
610–762 (2,000–2,500)	49	32.7	1	1.0	6 × 7.6 (20 × 25)	150
762–914 (2,500–3,000)	53	35.3	—	—	6 × 7.6 (20 × 25)	150
914–1,067 (3,000–3,500)	100	66.7	—	—	6 × 7.6 (20 × 25)	150
1,067–1,219 (3,500–4,000)	48	32.0	—	—	6 × 7.6 (20 × 25)	150
1,219–1,372 (4,000–4,500)	66	44.0	—	—	6 × 7.6 (20 × 25)	150
1,372–1,524 (4,500–5,000)	72	48.0	—	—	6 × 7.6 (20 × 25)	150
1,524–1,676 (5,000–5,500)	28	18.7	—	—	6 × 7.6 (20 × 25)	150
1,676–1,829 (5,500–6,000)	35	23.3	—	—	6 × 7.6 (20 × 25)	150
1,829–1,981 (6,000–6,500)	92	61.3	—	—	6 × 7.6 (20 × 25)	150
1,981–2,134 (6,500–7,000)	97	64.7	—	—	6 × 7.6 (20 × 25)	150
2,134–2,286 (7,000–7,500)	100	66.7	—	—	6 × 7.6 (20 × 25)	150
2,286–2,438 (7,500–8,000)	100	66.7	—	—	6 × 7.6 (20 × 25)	150
2,438–2,591 (8,000–8,500)	100	66.7	—	—	6 × 7.6 (20 × 25)	150
2,591–2,743 (8,500–9,000)	100	66.7	—	—	6 × 7.6 (20 × 25)	150
2,743–2,896 (9,000–9,500)	92	61.3	—	—	6 × 7.6 (20 × 25)	150
2,896–3,048 (9,500–10,000)	31	20.7	—	—	6 × 7.6 (20 × 25)	150
3,048–3,200 (10,000–10,500)	40	33.3	—	—	6 × 7.6 (20 × 25)	150
Total	1,249	40.4	12	0.4	—	3,090

Subgrade Soil Conditions

A soil investigation program was undertaken in 1993 by the CAAB to identify the soil property relevant to the performance of the pavement. The subgrade soils at ZIA are typically silty clays of low to medium plasticity having a soil classification of CL in the Unified Soil Classification System. The possible expansive nature of the soil under a high water table has been ruled out as one of the causes of pavement cracking, since the degree of expansion was found to be low for the subgrade soil (Snethen 1979).

Strength of Concrete in PCC

The strength of concrete in the existing runway pavement was assessed by taking concrete cores from the main runway as well as from the taxiway in 1993. This evaluation was also

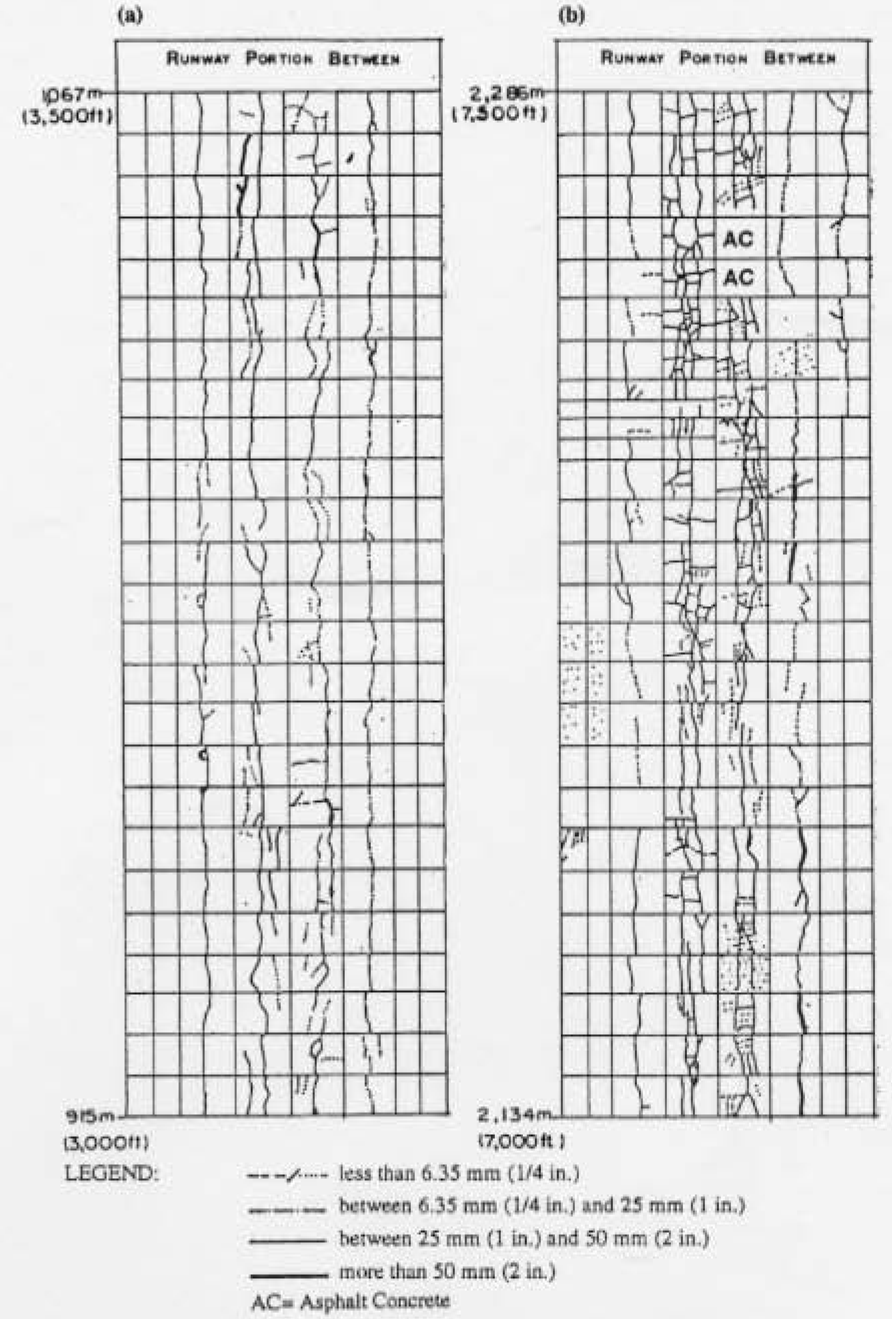


FIG. 4(a,b). Crack Pattern at Different Locations of Runway

supplemented by strength evaluation throughout the length of the runway by using Schmidt hammer tests.

Concrete core samples of 100 mm (4 in.) nominal diameter were collected to a depth of up to 300 mm (12 in.), covering the full depth of the PCC slab. Prior to compression testing, these cylinders were sized to give a height to diameter ratio of about 2.0. Results of compression tests on core samples are shown in Table 3. Six of these cores were taken from the runway and four from the taxiway. As it appears from Table 3, the cores from the runway showed an average compressive strength of 25.5 N/mm^2 (3,700 psi) against an average compressive strength of 28.3 N/mm^2 (4,100 psi) for the taxiway pavement.

Although the generalized correlations between the compressive strength and flexural strength of concrete are normally not very dependable, in the absence of appropriate flexural strength data, estimates of the flexural strength of the pavement concrete were obtained using the relationship of Walker and Boelm (1960). These estimates of flexural strength are included in Table 3. The average flexural strength of the runway was found to be 3.7 N/mm^2 (540 psi), with a standard deviation of 0.34 N/mm^2 (49 psi). The taxiway pavement slab, on the other hand, possessed a flexural strength of 4.0 N/mm^2 (575 psi), with a standard deviation of 0.2 N/mm^2 (31 psi).

The condition of the concrete in the runway pavement was also evaluated using Schmidt hammer tests on 50 different locations throughout the length of the runway. On each location, 15 readings were taken on a surface smoothened by carborundum stone. The average rebound numbers, when converted to equivalent cylinder strength using a calibrated relationship, indicated an average strength of 36.2 N/mm^2 (5,250 psi), with a standard deviation of 1.1 N/mm^2 (160 psi) in the runway pavement. The results of Schmidt hammer tests may not be representative in an absolute sense, but give an indiction that concrete strength was more or less uniform throughout the pavement. The strength evaluated from the concrete core samples, as shown in Table 3, indicates that the strength of the uncracked portion of the runway pavement was

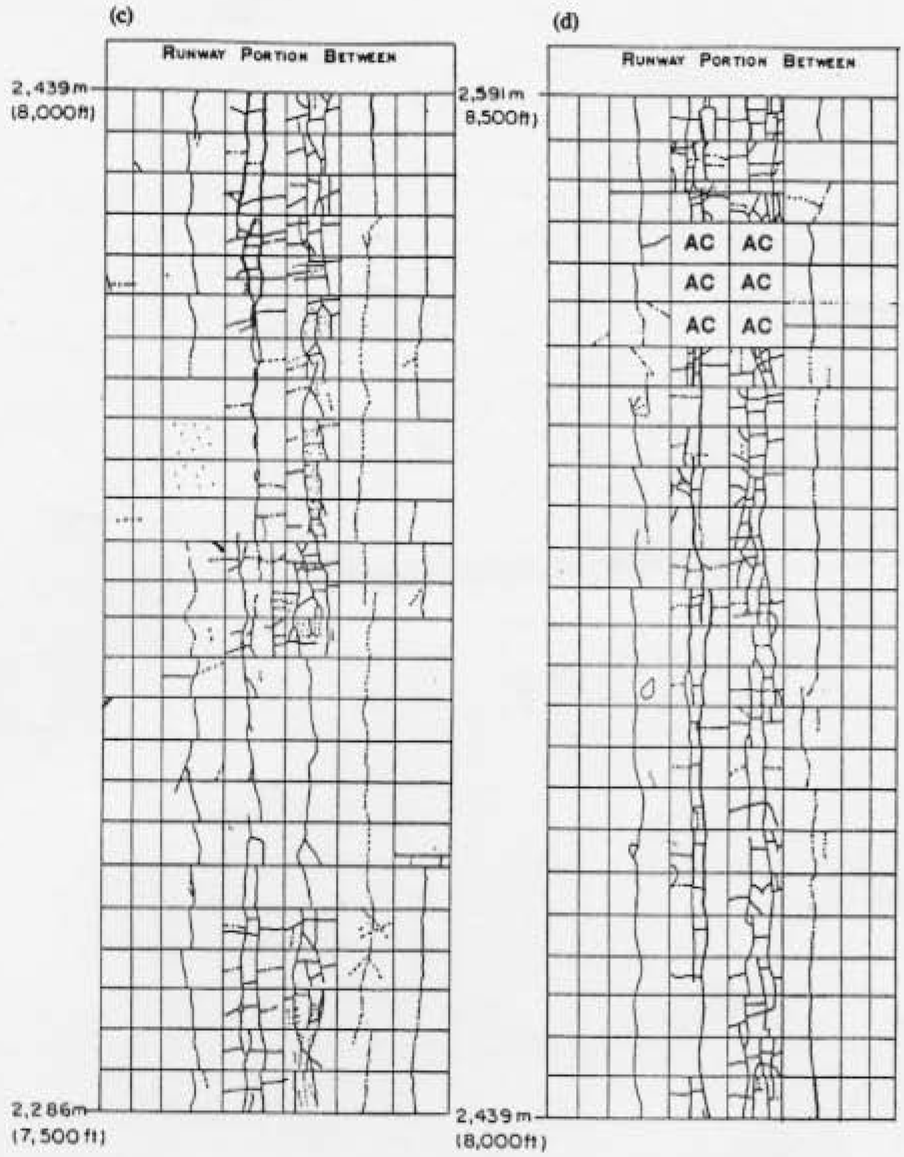


FIG. 4(c,d). Crack Pattern at Different Locations of Runway

TABLE 2. Degree of Cracking at Different Locations of Runway

Chainage location m(ft) (1)	Degree of cracking* cm/m² (2)	Remarks (3)
914–1,067 (3,000–3,500)	18.7	Portion of runway experiencing load from landed aircraft
2,134–2,286 (7,000–7,500)	29.9	Takeoff/touchdown zone
2,286–2,438 (7,500–8,000)	31.2	Takeoff/touchdown zone
2,896–3,048 (9,500–10,000)	24.8	Portion of runway experiencing load from aircraft to depart

*Length of crack/relevant area of central 30.5 m (100 ft) of runway.

generally low for airport pavement use. The strength of the pavement concrete as observed from the core test results compares reasonably well with results obtained 12 years earlier, in 1981, by Nippon Koei Co. Ltd. Engineering Consultants ("Technical" 1986), who reported that the pavement concrete near the edge of the runway possessed a compressive strength of 23.79 N/mm² (3,450 psi). The portion of the runway from which cores were taken is located close to the runway edge and, as such, is unlikely to have experienced any heavy live load. This means that this portion of the runway had not been

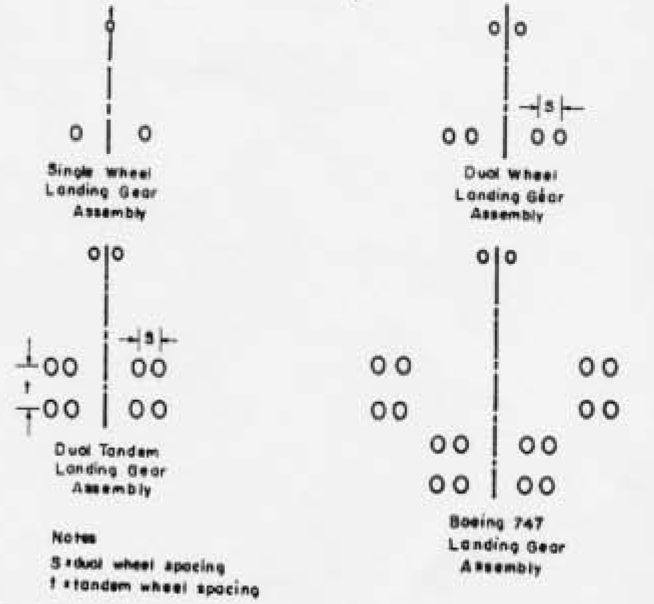


FIG. 5. Landing Gear Arrangement for Different Aircraft Gear Configurations

TABLE 3. Test on Concrete Cores from PCC Slab

Sample location (1)	Size of test sample (mm × mm) (2)	Height-diameter ratio (3)	Compressive strength (N/mm²) (4)	Average compressive strength (N/mm²) (5)	Flexural strength (N/mm²) (6)	Average flexural strength (N/mm²) (7)
RW	99 × 204.7	2.07	23.92	25.52	3.52	3.72
	99 × 192.3	1.94	28.48		4.0	
	99 × 204.5	2.06	28.48		4.0	
	99 × 201.4	2.03	21.30		3.38	
	99 × 204.0	2.06	20.68		3.28	
	99 × 204.7	2.06	30.41		4.14	
TW	99 × 204.2	2.06	29.72	28.28	4.07	3.96
	99 × 204.2	2.06	32.34		4.24	
	99 × 206.2	2.08	23.92		3.65	
	99 × 194.6	1.96	27.17		2.52	

Note. RW = runway; TW = taxiway.

TABLE 4. Number of Aircraft Operating Weekly at ZIA (between January 1986 and February 1990)

Aircraft type (1)	January 1986 (2)	February 1990 (3)
EA-30	6	1
F-27	54	64
F-28	96	28
TU-54	2	1
B-707	44	1
B-737	18	16
A-300	—	7
A-301	—	5
B-727	20	4
B-747	10	5
DC-10	31	22
L-1011	12	4

subjected to fatigue effects. It has been estimated that the number of takeoffs and landings between 1981 and 1993 was equivalent to 13,500 takeoffs and landings of DC-10 aircraft.

Aircraft Loading

As mentioned earlier, although the runway pavement at ZIA was not designed for wide body aircraft, the operation of such aircraft was allowed. Table 4 shows the statistics of different types of aircraft operating weekly at ZIA between 1986 and 1990.

The runway pavement design, as per the Federal Aviation Administration (FAA) (*Advisory* 1978), is based on the gross weight of the aircraft. The maximum takeoff weight of the aircraft is considered for design, assuming 95% of the gross weight is carried by the main landing gear and 5% is carried by the nose gear. The aircraft landing gear type and configuration dictate how the aircraft weight is distributed to the pavement, which, in turn, determines the pavement response to aircraft loadings. Aircraft landing gear may consist of the following types (Fig. 5):

- Single gear aircraft
- Dual gear aircraft
- Dual-tandem gear aircraft

Wide body aircraft (i.e, B-747, DC-10, and L-1011) represent a radical departure from the geometry of those described before, and the design load would certainly be different in terms of gross weight, tire contact area, and tire pressure.

Runway pavement designs are normally based on static load analysis as per the FAA (*Advisory* 1978). Wide body aircraft are assumed to have a landing gear arrangement of a dual-tandem gear. Fatigue effects are taken into consideration by converting traffic to coverages.

TABLE 5. Maximum Joint Spacing for Different Thicknesses of Unreinforced Runway Pavement (*Advisory* 1978)

Slab thickness, mm (in.) (1)	Maximum Joint Spacing m (ft) Transverse (2)	Longitudinal (3)
Less than 225 (9)	7.6 (25)	3.8 (12.5)
225 (9)–300 (12)	6 (20)	6 (20)
Greater than 300 (12)	7.6 (25)	7.6 (25)

Pavement Jointing System

Unreinforced pavement slabs usually have joints in both the longitudinal and the transverse directions to reduce the detrimental effects of the stresses due to temperature and volume change. The amount of stress that can be resisted by a given thickness of the slab dictates the spacing of the joints. The FAA (*Advisory* 1978) recommends the maximum joint spacing as shown in Table 5. For most parts of the runway at ZIA, pavement thickness is less than 300 mm (12 in.), requiring, as per the FAA, a maximum joint spacing of 6 m (20 ft) in both the longitudinal and the transverse directions. However, the longitudinal joints of the runway at ZIA are spaced at 7.6 m (25 ft).

Referring to the analysis suggested by the ACI Committee 207 on Mass Concrete ("Effect" 1990), the tensile strength at which cracking will start at the base of the slab is given by

$$f_t' = 0.75\frac{WL^2}{h} \qquad (1)$$

where W = unit weight of slab; L = length of slab; and h = thickness of slab. Assuming 2,300 kg/m³ (145 lb/ft³) concrete unit weight, L = 7.6 m (25 ft), and h = 0.305 m (12 in.), the critical tensile strength for cracking at the slab center becomes 3.25 N/mm² (472 psi). This stress value is marginally safe against the flexural strength estimate shown in Table 3. With the application of traffic load, this stress is likely to be much higher, as will be shown in the section that follows.

Interaction between Slabs/Transfer of Loads at Dowel Joint

At joints, 16 mm (5/8 in.) dowel bars have been used to transfer loads. Physical inspection of the dowels confirmed that they were intact and no crack was evident at or near the dowel joint. This obviates any further investigation to be carried out related to dowel (keyed) joints.

Stress Analyses in Runway Pavement

Analysis of the stress condition in the runway pavement was expected to provide valuable insight as to the causes of cracks in the runway pavement at the ZIA. The stress analysis by finite element method was conducted using SAP90 of Computers & Structures, Inc. ("SAP90" 1990). The analysis was based on the following assumptions:

1. The pavement slab panel [7.6 m × 6 m (25 ft × 20 ft)] was modeled as a series of eight-noded solid elements. A fine mesh comprising 100 elements was used for analyzing the slab. The adequacy of this mesh was verified by a mesh sensitivity analysis.
2. The aircraft tire pressure was considered as static pressure on the pavement.
3. The pavement foundation was modeled as an elastic

spring having a stiffness based on the modulus of subgrade reaction of 0.05 N/mm^3 (200 pci), as suggested by the Boeing Corp. "Summary" (1989).

The following loading conditions were considered:

- Temperature differential across the depth of the slab panel
- Aircraft load applied as pressure at locations of the pavement slab panels

Local climatic conditions could cause an ambient temperature as high as 48.9°C (120°F) during the summer. The resulting pavement surface temperature of the order of 65.5°C (150°F) can be expected. At the backdrop of this, a temperature differential of 27.5°C (50°F) was considered, with the ground surface being at 38°C (100°F) and the top surface at 65.5°C (150°F). For stress analysis, the wheel load for the wide body aircraft was taken, as per the FAA (Advisory 1978), as the wheel load for a 1,334 kN (300,000 lb) dual-tandem gear aircraft. Considering this to be the design aircraft, dual spacing of 750 mm (30 in.) and tandem spacing of 1,200 mm (48 in), with a tire pressure of 1.25 N/mm^2 (180 psi), were assumed for the present case. Four positions of wheels were considered, as shown in Fig. 6.

The stress (σ_x) contour at the top surface caused solely by the temperature differential of 27.5°C (50°F) is shown in Fig. 7. The corresponding stress (σ_y) contour is shown in Fig. 8. On a hot summer day, temperature may produce a transverse tensile stress up to 3.5 N/mm^2 (510 psi) on the top surface. The deflected shape of the slab for a temperature differential of 27.5°C (50°F) is shown in Fig. 9. The maximum stress

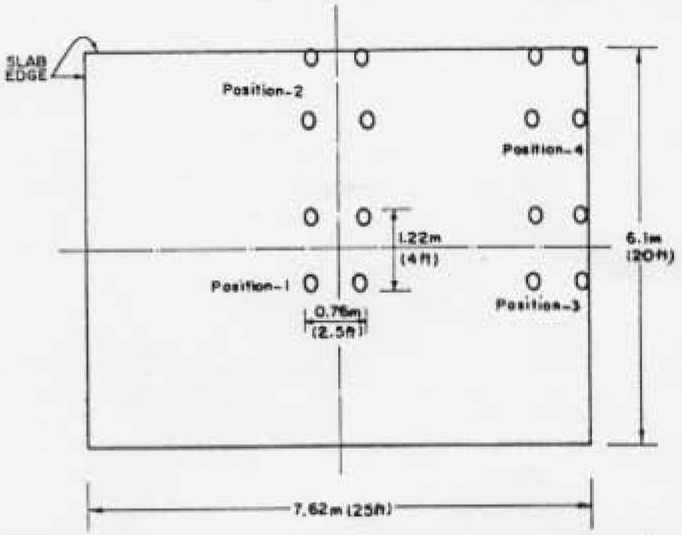


FIG. 6. Positions of Dual Tandem Gear Wheel Configuration Considered for Pavement Analysis

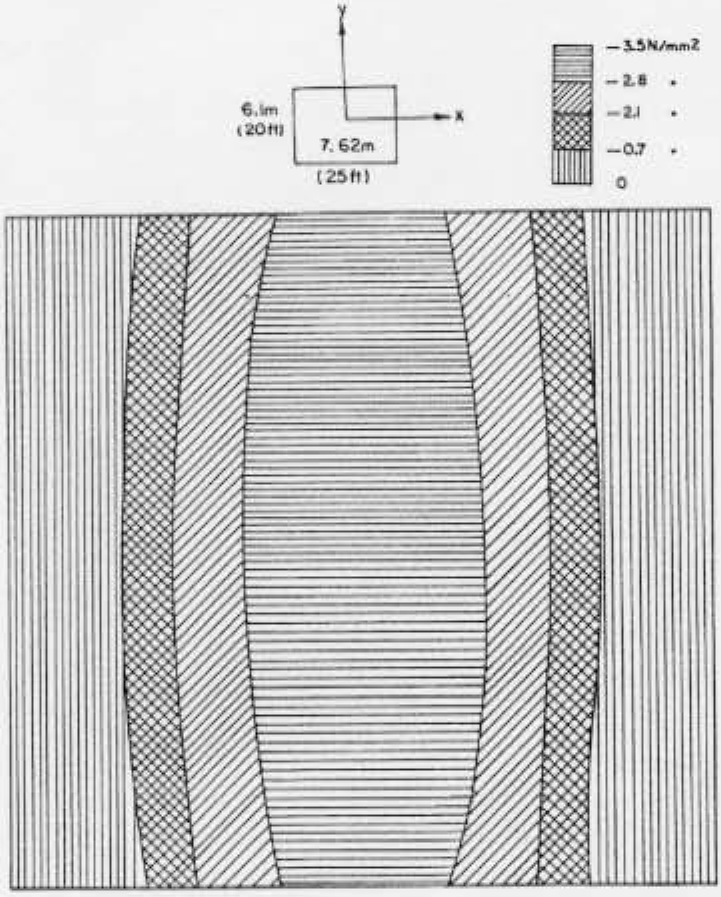


FIG. 7. Top Surface σ_x Stress Contour for Temperature Difference of 27.5°C (50°F)

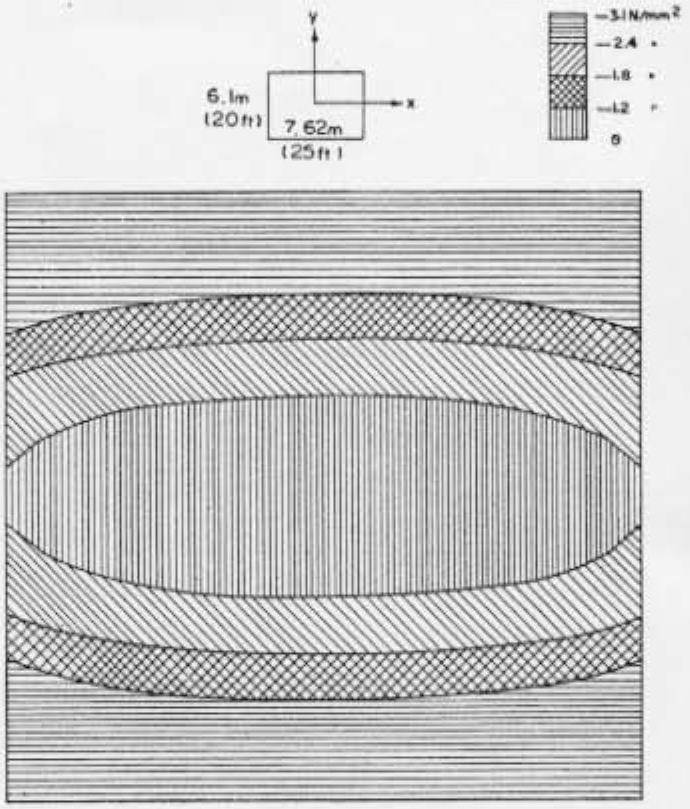


FIG. 8. Top Surface σ_y Stress Contour for Temperature Difference of 27.5°C (50°F)

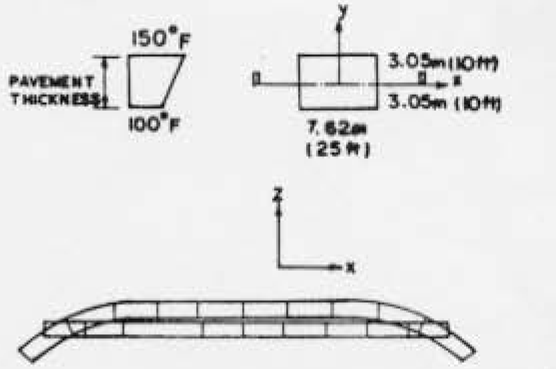


FIG. 9. Deflected Shape of Pavement Slab for Temperature Gradient Shown

TABLE 6. Maximum Stresses for Different Positions of Wheel Loads

Position of wheel (see Fig. 6) (1)	Maximum tensile stress N/mm² (psi) (2)	Maximum compressive stress N/mm² (psi) (3)
1	6.1 (880)	6.3 (910)
2	7.8 (1,125)	6.8 (993)
3	3.5 (514)	3.0 (430)
4	3.7 (530)	7.2 (1,040)

occurring in the transverse direction is close to the estimated flexural strength of the pavement concrete (see Table 3).

Recognizing the inherent limitation of the compressive strength to flexural strength conversion, it is suggested that the actual flexural strength available could be much less than that estimated. This suggests that thermal stresses were the primary cause behind the formation of longitudinal cracks prior to the application of the air traffic.

Table 6 presents the results of the stress analysis due to the application of the wheel loads. Tensile stresses up to 7.8 N/mm^2 (1,125 psi) were observed for wheels in position 2. For other locations of the wheel, the tensile stresses ranging from 3.5 N/mm^2 to 6.1 N/mm^2 were observed. The lowest value of maximum tensile stresses of 3.5 N/mm^2 occurring for wheel position 3 is in excess of the estimated flexural strength values.

CONCLUSIONS

The plain cement concrete runway pavement at ZIA suffered widespread cracking, requiring frequent repair, sealing of the crack openings, and an eventual resurfacing of the pavement. The present study reveals that use of low strength concrete, large slab sizes, occurrence of high temperature induced stresses, and operation of aircraft of sizes larger than those considered in the design have all contributed to the poor performance of the pavement slab. Large slab panel dimensions were responsible for initial cracking, as was observed prior to the application of any traffic loading. Temperature stresses as obtained from a finite element analysis have, in most cases, resulted in stresses likely to cause longitudinal cracking of the pavement top surface. The 254 mm (10 in.) slab thickness coupled with the poor strength of the slab concrete was found to be inadequate for the slab size provided; as a consequence, cracking in the pavement was triggered.

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