4e Conférence spécialisée en génie des transports
de la Société canadienne de génie civil

*4th Transportation Specialty Conference
of the Canadian Society for Civil Engineering*

Montréal, Québec, Canada
5-8 juin 2002 / *June 5-8, 2002*

INVESTIGATION OF ASPHALT PAVEMENT RUTTING AT TWO CANADIAN AIRFIELDS

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ABSTRACT: Rutting is the permanent deformation of pavement layers which can accumulate over time. Highway rutting is common due to high channelization and higher repetition traffic. On airfield pavements, rutting is less prevalent because of the lower number of repetitions of aircraft traffic and less lane restrictions. Some of the common causes of airfield rutting are jet fuel spills, jet blast, high tire pressures, asphalt strength and flow characteristics, aircraft loading repetitions and environmental conditions. In the past five years, two Canadian air force bases, CFB Goosebay and Cold Lake, have experienced extensive rutting on some of the slower traffic areas, which have been in operation for over ten years. The affected areas are classified as taxiways, holding areas, touch-down areas, and run-up pads. The primary users of these pavement areas are fighter jet planes, for which potential ruts, sharp pavement edges and Foreign Object Debris (FOD) can cause substantial damage to aircraft tires, turbine engine and fuselage.

A site investigation was performed at each of the airfields to determine the cause of rutting and to recommend corrective measures. The investigation was to determine the composition of the pavement, the type of rutting, and its severity. The site investigation was comprised of surveying the cross-sections of the ruts and extracting cores and slabs from affected areas. The objective of this paper is to report on the site investigation and present the early findings of this study.

1.0 INTRODUCTION

CFB Cold Lake and CFB Goosebay are two Canadian air force bases located in Alberta and Labrador, respectively. These bases are home to fighter squadrons for the Canadian forces and Allied forces. The bases have been operational since the early 1950s. Their airfield pavements are composed of hot-mix asphalt concrete (HMAC), Portland cement concrete (PCC) and composite pavements.

Significant rutting distresses, developed recently at both bases, mainly in airside pavement sections that are subject to slow moving traffic. These areas include taxiways, holding bays, runways, and run-up pads. The rutting is occurring in areas where aircraft are required to slow for turning, slow for parking and braking after landing.

A recent study at the University of California, Berkeley, explored the issue of rutting occurring on taxiways subject to slow traffic movements and take-off operations at the San Francisco International Airport. The study was done to test the current FAA standards for mix design of asphalt using the SHRP-developed simple shear test. The repeated simple shear test at constant height was suggested as a method to replace the Marshall test as a mix evaluation procedure (Monismith C.L., et al. 2000).

This paper will describe the site investigation and present the data collected from each rutted pavement section. The data will be used to characterize the observed rutting behaviour and provide a basis for comparison in future analysis of volumetric properties and strength parameters of the pavements.

2.0 SITE INVESTIGATION

A detailed site investigation was carried out at each site to determine the extent of the rutting. Various methods were used to determine the location and depth of the ruts and to assess the surface distresses experienced by the pavement in the area. The on-site study included coring of the pavement, surveying detailed cross-sections, and measuring maximum rut depths with a straight edge. Photographs of the rutted areas were also obtained.

2.1 Coring

The affected areas were sampled by removing 100mm diameter cores, which extended to the full depth of the asphalt concrete. The cores were taken outside the wheel paths to ensure that unaffected asphalt concrete with original volumetric properties was obtained. Different tests are to be run on the cores including volumetrics, indirect tensile strength and resilient modulus. The cores will also be used to compare the actual thickness of the pavement structure, to the design structure. A minimum of nine cores were taken per site up to a maximum of 14 cores. This number should provide sufficient material for the destructive and non-destructive testing to be implemented. For certain sites, where there were no operational concerns, cores were also taken from the wheel paths, to provide cores that have undergone rutting for comparison of the changes undergone by the pavement.

2.2 Cross-Section Surveys

Detailed surveys of the affected areas give a visual representation of the progression, magnitude and location of the ruts. Survey shots were taken at 100mm intervals inside the affected areas and 500mm intervals outside the rutted areas. The measurements were taken to the nearest mm using a total station. The number of cross-sections and spacing between them depended on the length of the area under investigation, varying from 4 cross-sections up to 18 cross-sections for a section length over 100m. The maximum rut depth of each wheel path was measured using a 1.8m straightedge.

3.0 SITE DESCRIPTIONS

3.1 CFB Goosebay

CFB Goosebay is located in Labrador in north-eastern Canada. The airfield is used primarily as a training facility for the fighter squadrons of the allied forces, and as such, the pavements are subjected to high levels of jet traffic. The air temperatures experienced in this region reach an average maximum of 30.9°C and a minimum of -29.4°C, the pavement temperatures vary from a high of 42.9°C to a low -28.9°C as indicated in the weather station records stored in the LTPPBind software database (LTPPBind, 2000). The pavement sections affected at this base are Taxiway Alpha, the Last Chance Area, and the Run-Up Pad as shown in Figure 1.

3.1.1 Taxiway Alpha

Taxiway Alpha was initially constructed in 1943 as a PCC pavement; it was overlaid in both 1954 and 1987 with HMAC over an approximate area of 14,800m^2. The taxiway is used primarily by aircrafts travelling from the aprons to runway 08-26 or by recently landed aircrafts from runway 08-26 travelling to the aprons. The current pavement structure consists of 280mm of HMAC, 150mm of PCC and 100mm of granular base as shown in Table 1.

The rutting of the pavement is occurring primarily in the northbound lane of the taxiway over an approximate area of 4,600m^2, which encompasses the bend in the taxiway. In addition to rutting distresses, this area of the taxiway has a significant amount of rippling and patching in the rutted lane, but minimal surface cracking.

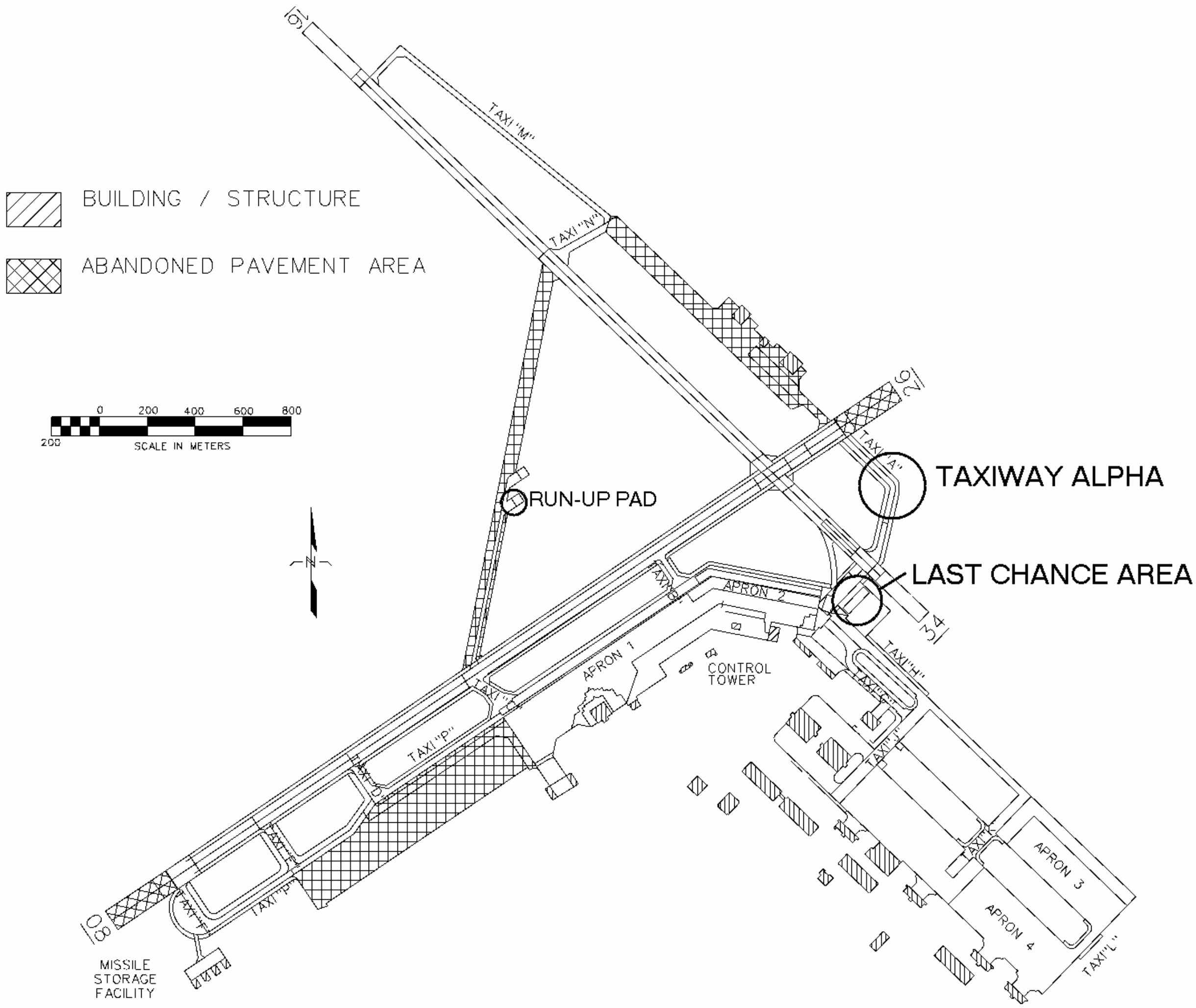


Figure 1: Locations of Rutted Pavement Sections at CFB Goosebay

3.1.2 Last Chance Area

The Last Chance Area was constructed in 1995 and consists of a 4000m^2 PCC pad surrounded by 25,500m^2 of HMAC. The current pavement structure is 130mm of HMAC and 300mm of granular base as shown in Table 1. It is located next to Button 34 and is the area used for final inspections of the aircraft prior to takeoff. The pavement area is divided into eight pads using pavement markings. Up to eight fighter jets can be positioned on this area at one time.

The rutting of this area is occurring mainly at the interface of the two pavement types on all eight of the pads, although, the pads located closer to the runway are experiencing a higher degree of rutting due to their more frequent use. The surface distresses observed are more severe on the northern portion of the HMAC slab, but the southern half is also experiencing significant cracking. Another significant distress is the loss of the joint sealant at the interface of the HMAC and PCC. Because of the rutting, the joint sealant is being pulled away by the separating joint permitting water infiltration and vegetation growth as seen in Figure 2.

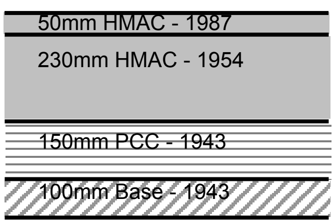
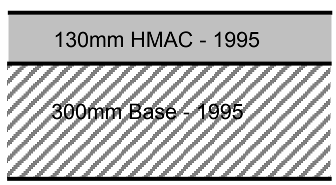
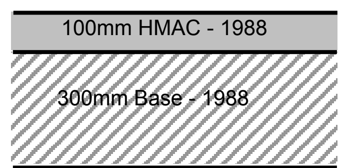
Figure 2: Vegetation Growth at the Interface

3.1.3 Run-up Pad

The run-up pad was constructed in 1988 and consists of 1,700m^2 of HMAC. The current pavement structure is 100mm of HMAC and 300mm of base as shown in Table 1. It is located north of runway 08-26 and is usually used once a day to test aircraft engines during regular maintenance. The area is equipped with a permanent storage area and a jet blast screen.

The rutting starts at the PCC and HMAC interface and extends over a length of 8m into the pad. Heavy steel plates are currently covering the most severe portions of the rutted pad. The surface of the pavement is covered with previous asphalt patches and minor fuel and oil spills. Like the Last Chance Area, the sealant between the asphalt and PCC area has detached and is showing signs of pulling out of the crack.

Table 1: Pavement Structures at CFB Goosebay

Taxiway Alpha	Last Chance Area	Run-Up Pad
		
		

3.2 CFB Cold Lake

CFB Cold Lake is located in the province of Alberta approximately 250km northeast of Edmonton. It serves as one of Canada's main CF-18 fighter training facilities and as such, the pavements are subjected to high amounts of jet traffic. The air temperatures experienced in this region reach an average maximum of 32.3°C and a minimum of -26.7°C, the pavement temperatures vary from a high of 43.6°C and to a low of -33.4°C C as indicated in the weather station records stored in the LTPPBind software database

(LTPPBind, 2000). As show in Figure 3, the affected pavements at this base include taxiways Delta and Echo and the touch-down area of Runway 13L-31R.

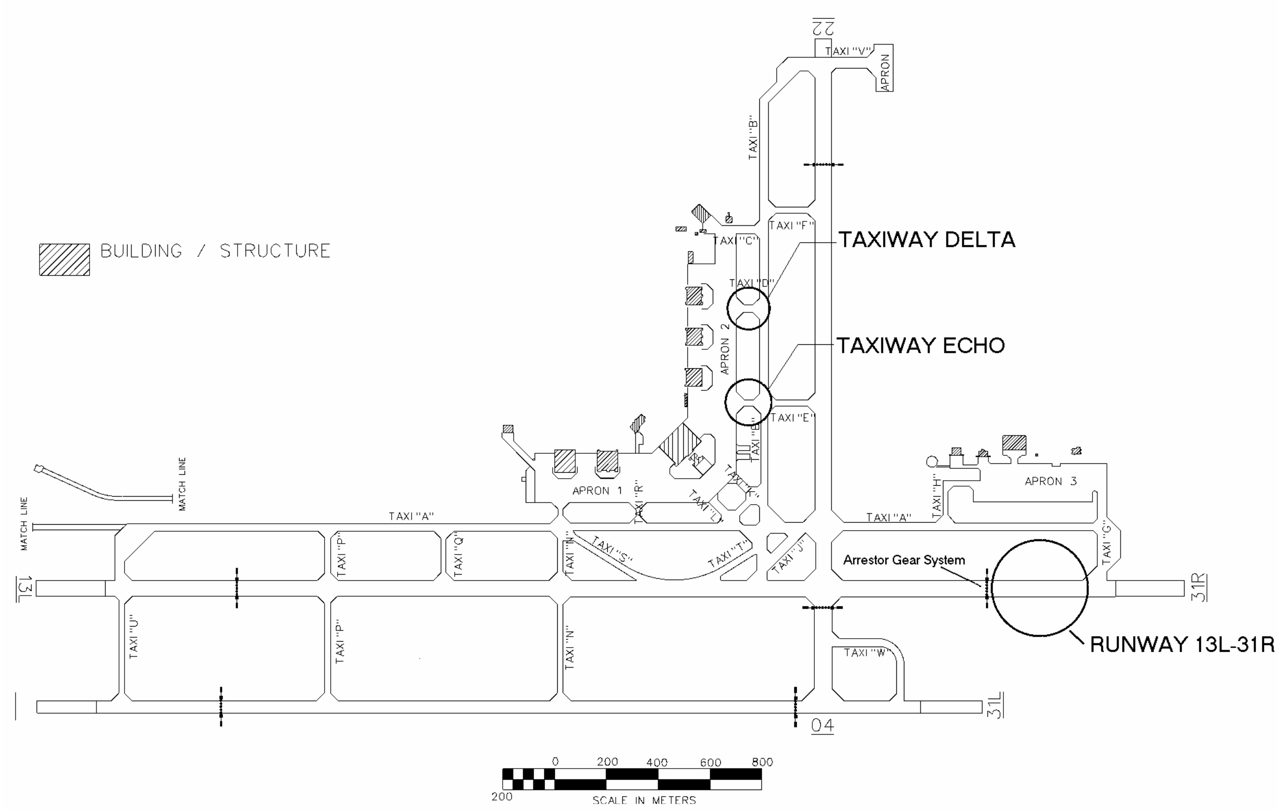


Figure 3: Locations of Rutted Pavement Sections at CFB Cold Lake

3.2.1 Taxiway Delta

Taxiway Delta was constructed in 1954 as a HMAC surface. The total surface area is 4,200 m^2. It was overlaid for the first time in 1963, and again in 1980 with 100mm of HMAC as shown in Table 2. The current pavement structure consists of 240mm of HMAC, 230mm granular base and 1220mm granular subbase. Taxiway Delta is primarily used by aircrafts travelling Apron 2 to runway 04-22 or 13L-31R via taxiway Bravo; it is also the highest used taxiway for this purpose.

The rutting of the HMAC is occurring on either side of the centreline generally closer to the middle of the taxiway. It has been observed by operations that aircrafts have a tendency to wait in the middle of the taxiway for clearance generally coming to a complete stop before heading to Taxiway Bravo or Apron 2. The rutted area of the taxiway was patched using cold mix in October 2000 which has caused a slight discoloration of the pavement. The repair has rutted again, but not to the same extent as previously. The rutted area is also experiencing significant cracking. Most of the cracks have broken through the sealant or have not yet been sealed.

3.2.2 Taxiway Echo

Taxiway Echo was constructed in 1954 as a HMAC surface, with a total area of 4,200m^2. Taxiway Echo is has the same pavement structure and construction history as Taxiway Delta. Like Delta, Echo is also primarily used by aircrafts travelling from the apron area to the runway, but is not as highly used by the aircrafts.

The rutting of the HMAC is occurring on either side of the centreline generally closer to the middle of the taxiway. It does not extend as far or as deep as the ruts on Taxiway Delta due to the less frequent use of the taxiway. The rutting is likely occurring due to the same reasons as previously mentioned with the aircrafts pausing in the middle of the taxiway for clearance or coming to a complete stop before heading to Taxiway Bravo or Apron 2. Like Delta, the rutted area on Echo was previously repaired using a cold patch in October 2000, which has caused a slight discoloration of the pavement. The repaired area is showing signs of rutting to a lesser extent than previously. The surface distresses are also significant on taxiway Echo. Most of the sealed cracks have reopened and there are newer cracks, which have not yet been sealed.

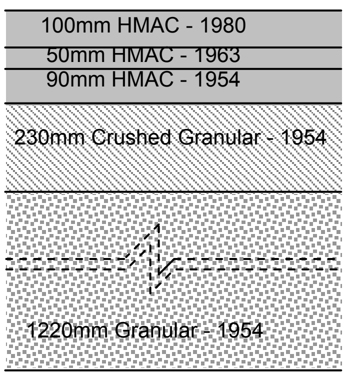
3.2.3 Runway 13L-31R

The touch-down portion of Runway 13L-31R was originally constructed in 1959 and is approximately 20,600m^2 in size. The section was overlaid in 1971 with 50 mm of HMAC and again in 1980 with 100mm of HMAC. The current pavement structure is 250mm of HMAC, 305mm base granular layer, and 1145mm granular subbase. The touch-down area experiences heavy impact loading as jet aircraft touch down during landing manoeuvres.

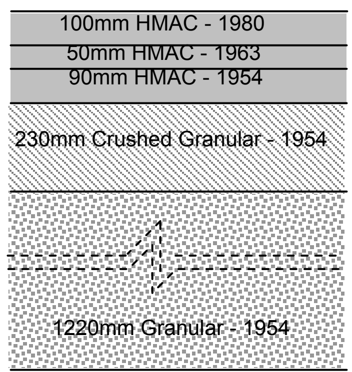
The rutting is occurring on either side of the centreline in the middle 10m of the runway. The ruts are more prevalent closer to Button 31R and dissipate towards the arrestor gear system. There are also numerous surface distresses in the section. The pavement has experienced significant ravelling and large thermal cracks occurring at regular intervals. There are also several areas severely affected by the heat of jet blast.

Table 2: Pavement Structures at CFB Cold Lake

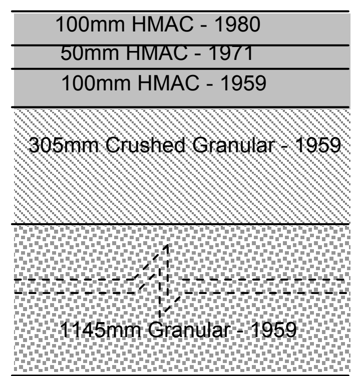
Taxiway Delta



Taxiway Echo



Runway 13L – 31R



4.0 DATA COLLECTION

4.1 CFB Goosebay

For the three sections of concern, a total of 29 cross-sections were surveyed and 57 core samples taken. Two sample rotated cross-sections are shown below in Figure 4; for taxiway alpha, showing both the first 4m on the left and right lanes of the centreline. The sample data shown are for the first and third cross-sections of the pavement area, which was labelled as "B" for the study. The rutting distresses appear to be more severe on the right side of the centreline. The cross-section data was analyzed to determine the rut depths using a 1.8m straight edge simulation and the extent of rutting is shown in Table 3.

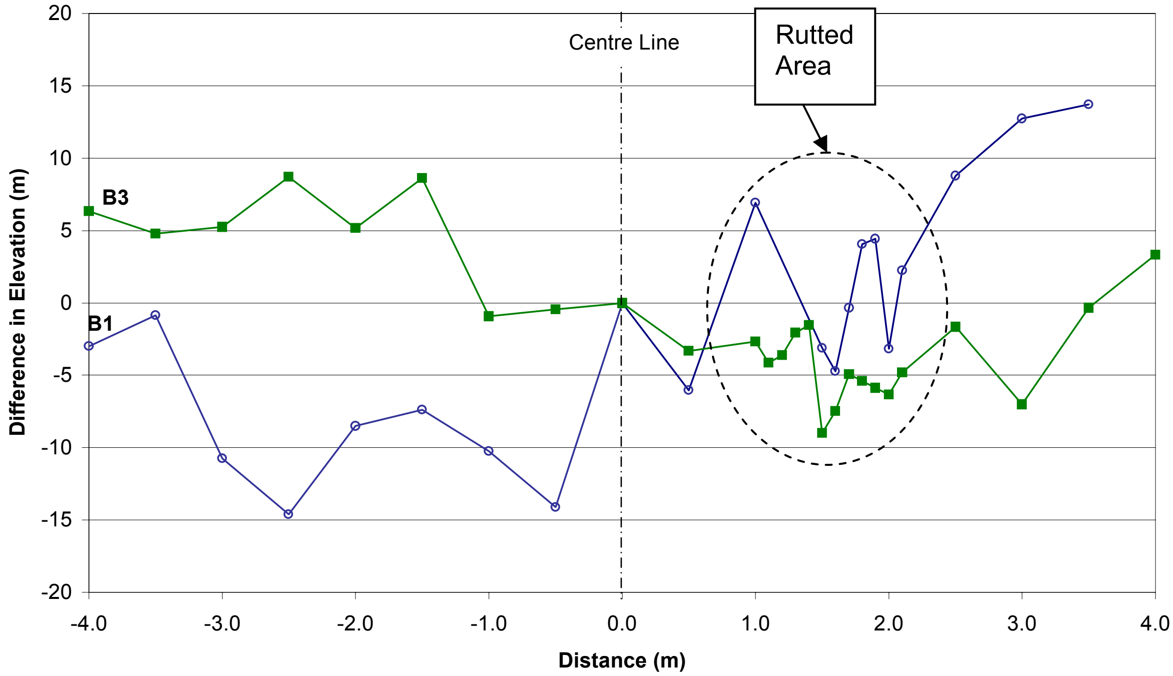


Figure 4: Sample Cross-Sections for Taxiway Alpha

Table 3: Summary of Rut Depths for CFB Goose Bay

LOCATION	**RUT DEPTH (mm)**		
	Minimum	Average	Maximum
Taxiway Alpha	4	8	17
Last Chance Area	2	12	28
Run-up Pad	5	8	19

4.2 CFB Cold Lake

For the three affected areas, a total of 24 cross-sections were surveyed and 40 core samples taken. Two sample rotated cross-sections from the base are shown in Figure 5; for runway 13L-31R, showing 4m to the left and right of centre. The sample data shown is for the third and fourth cross-sections of the pavement area which was labelled "F" for the study. As can be seen in the figure there appears to be rutting distresses on both the left and right side of centre. The rut depths found for each section through analysis of the collected cross-section data are shown in Table 4.

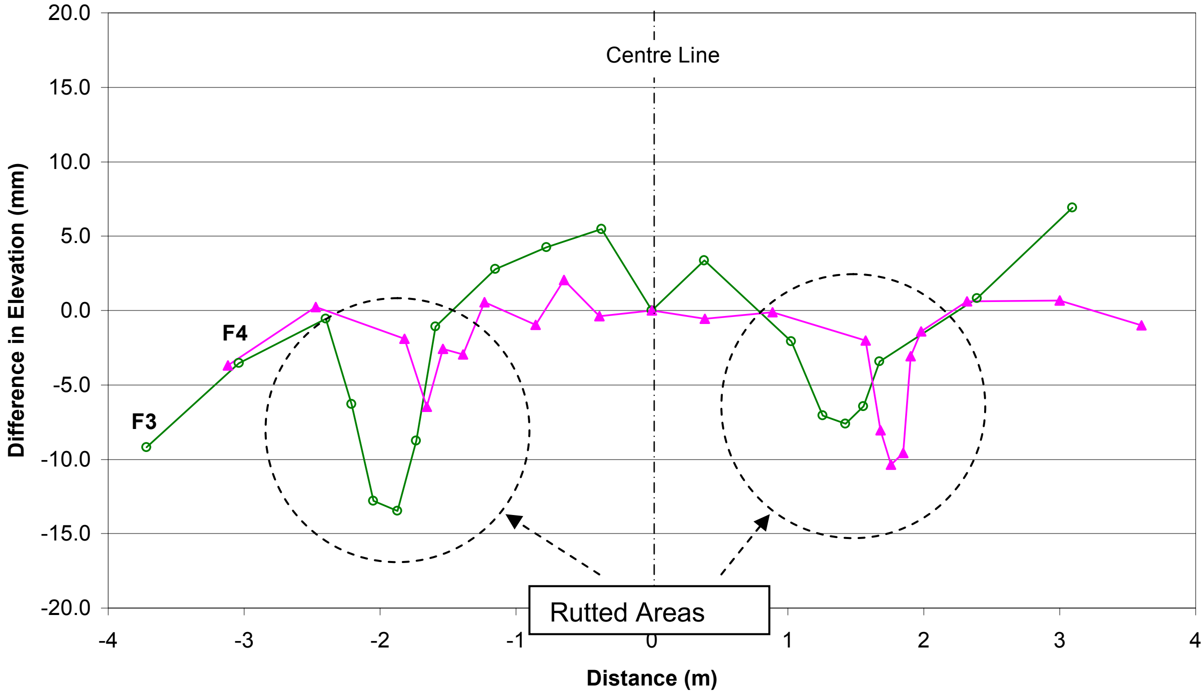


Figure 5: Sample Cross-Sections for Runway 13L-31R

Table 4: Summary of Rut Depths for CFB Cold Lake

LOCATION	RUT DEPTH (mm)		
	Minimum	**Average**	Maximum
Taxiway Delta	2	9	19
Taxiway Echo	3	5	12
Runway 13L-31R	3	6	14

5.0 GENERAL FINDINGS

5.1 Goose Bay

Two of the three affected areas, Last Chance Area and Run-up Pad, are located at an interface of concrete and asphalt pavements with wheel loads travelling across the joint. The edge loading conditions are the main cause of rutting in these areas. It is reasonable to assume that this rutting is caused by lack of structural support to the pavement. The maximum tire pressure experienced by these pavements is from the Tornado jet fighters, with a 2.07 MPa pressure.

Taxiway Alpha is experiencing mix instability which is causing shoving to occur along the curve in the taxiway. Slow-moving aircraft, stop-and-go movements and sharp turns have caused rippling and rutting on the asphalt pavement surfaces on the taxiway. The maximum tire pressure experienced by the taxiway is from the Tornado jets with a 2.07 MPa pressure.

5.2 Cold Lake

The two taxiways are experiencing rutting problems caused by the slow to stationary movements of the aircrafts using the facilities. The rutting occurring in the centre of the taxiway indicates that the asphalt material is unable to support the stationary loads imposed by the aircrafts due to a deficiency in the mix design. From site observations there does not appear to be an issue with the HMAC/PCC interface indicating adequate stability for the pavement with moving loads. The taxiways experience the highest tire pressures from F-18 jets, which have a pressure of 1.38 MPa.

The touchdown zone of Runway 13L-31R experiences high impact loads and exposure to jet blasts, which are contributing to the observed rutting patterns. The pavement is subjected to dynamic loads from the aircraft landing as well as intense heat from aircraft jets causing the softening of the asphalt mix. The highest tire pressure on this runway is from F-18 fighter jets at 1.38 MPa.

6.0 LABORATORY TESTING AND ANALYSIS

The data presented thus far represents the first phase of this study, which is aimed at determining the extent of the rutting. The following phases will analyze the asphalt paving mixes and construction details, and provide recommendations to improve the rutting resistance of new asphalt pavements. The pavement design will be analysed using volumetrics, which will be compared to the mix designs used for the construction of the pavement sections. The structural adequacy of the pavements will be determined by analyzing the aircraft traffic, as given by base operations, and determining if the pavement can withstand the tire pressures and loads.

The deformation properties of the pavement are also a critical factor in determining its potential for rutting. Currently the University of Manitoba is developing a modified indirect tensile test, which subjects the pavement cores to compression loads applied diametrically. The test has been found to correlate rutting to the deformation ratios obtained from the test (Thiessen et al. 2001). The final step in the study is an analysis of the creep potential and the resilient modulus of the asphalt mixes. This will be accomplished by subjecting the pavement samples to a sustained load for creep and to a dynamic indirect tensile load for resilient modulus.

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