TIME SENSITIVE AND EFFECTIVE PAVEMENT CONSTRUCTION ON RUNWAY 08-26 AT WATERLOO AIRPORT

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ABSTRACT

Region of Waterloo International Airport in located in Waterloo Region in Southern Ontario. The airport serves an area with an approximate population of 750,000 and has scheduled flights to Canada, United States and the Dominican Republic. The airside pavements at the airport include two runways (Runway 14-32 and 08-26), a few taxiways and aprons.

This paper discusses the construction of the pavement on Runway 08-26 that was undertaken under very tight timelines and performance requirements. Runway 08-26 is the longer of the two runways at the airport and is required for the larger aircrafts. Due to its economic and functional significance to the airport and the surrounding community, minimal closure times were available to carry out necessary construction; however, reliable performance is required over its design life.

Although the paper presents a case study on the construction of a runway pavement, the lessons learned are equally applicable to roadway pavement construction and how to achieve a quality product while minimizing delays and inconvenience to the travelling public.

The runway pavement had three distinct pavement sections with varying pavement construction history and performance. The rehabilitation of the pavement undertaken in 2012 included reconstruction of approximately 400 m of the runway and major rehabilitation of about 1200 m of the runway pavement. In order to maximize the availability of the runway, the rehabilitation was carried out in three phases during which varying lengths of the runway were kept operational rather than obtaining complete closure. The following key steps were taken to ensure that the construction was executed in a timely and efficient manner:

- Consultations between pavement specialists, contract administrator and airport operators when developing the construction staging plan to minimize possibility of construction delays, maximize pavement performance and minimize number of scheduled flight cancellations;
- Detailed and customized specifications including contractor equipment requirements and redundancies to minimize construction delays due to equipment failure or plant breakdowns;
- Specifications included timelines for submissions prior to the start of paving that were enforced by the contract administrator and geotechnical/pavement consultant;
- Continuous cooperation and consultation between the owner, contract administrator, geotechnical/pavement consultant that allowed all issues and complications to be resolved in a time sensitive and technically sound manner;
- Good planning and execution of construction work including material delivery, mix production, hauling of mixes, preparation of existing layers and properly organized paving sequence; and
- Well organized quality control and quality assurance testing with timely decision making.

INTRODUCTION

Region of Waterloo International Airport (ROWIA) in located in Waterloo Region in Southern Ontario. The airport serves an area with an approximate population of 750,000 and has scheduled flights to Canada, United States and the Dominican Republic. The airside pavements at the airport include two runways (Runway 14-32 and 08-26), a few taxiways and aprons.

This paper discusses the construction of the pavement on Runway 08-26 that was undertaken under very tight timelines and performance requirements. Runway 08-26 is the longer of the two runways at the airport and is required for the larger aircrafts. Due to its economic and functional significance to the airport and the surrounding community, minimal closure times were available to carry out necessary rehabilitation and maintenance activities. In spite of the limited amount of closure time, it was essential that the pavement meets very high standards for both structural and functional performance through its design life. In general the performance requirements for airfield pavement tend to be significantly more stringent that for road pavements due to the greater public safety concern associated with the aviation industry.

The first steps in ensuring that the stringent performance requirements for the pavement were met were the pavement rehabilitation design and the construction specifications development. The pavement rehabilitation design methodology is detailed in this paper; it is the first and most critical step in ensuring the construction can be carried out in a timely manner while meeting all the necessary performance criteria.

Following the rehabilitation design, the next critical step is the construction specifications development. In order to ensure that the construction proceeds smoothly, without delay and delivers the quality product, it is essential that the specifications clearly outline the expectations and requirements. This was achieved on this project by means of customized specifications development that took in to consideration the unique requirements of this project.

Finally, the paper discusses all the steps that were put in to place during the construction phase in order to facilitate and ensure that the pavement rehabilitation was completed on time and safely while utilizing construction best practices and meeting the strict performance requirements.

BACKGROUND

Runway 08-26 is one of two runways located at ROWIA and was constructed in three distinct sections as listed below:

- Station 10+000 to 11+159 – originally constructed in the late 1940's and reconstructed in 1993;
- Station 11+159 to 11+555 – constructed in 1984; and
- Station 11+555 to 12+134 – constructed in 2002.

The 1984 section of Runway 08-26 was originally constructed to a PLR of 7.0 and the 1991 and 2002 sections were originally constructed to PLR of 9.0. Table 1 shows the pavement designs for each of the above listed sections to achieve their respective PLR requirements as designed previously.

Due to the differing time periods of construction and the variable condition of the three pavement sections, separate rehabilitation strategies had to be developed for each section. Since the 2002 pavement section was only constructed 10 years prior and was designed to provide a life of approximately 20 years, no major rehabilitation was intended to be carried out on this section.

PAVEMENT REHABILITATION DESIGN

The following information was utilized to establish the existing condition of the pavement sections and for selecting proper parameters for the pavement design analysis.

- Data from previous investigations;
- Confirmatory limited geotechnical investigation; and
- Falling Weight Deflectometer (FWD) testing.

The geotechnical information from previous investigations was initially considered as the base for pavement rehabilitation designs; however, the designs were adjusted following confirmatory boreholes and laboratory testing.

FWD testing was utilized to confirm the existing structural capacity of the existing pavement and to accurately quantify the amount of structural improvement that would be required for the new pavement. The FWD testing was critical to increase the reliability of the designs and consequently decrease the somewhat necessary conservative assumptions if the structural capacity was unknown. Reduction in the amount of structural improvement required for the new pavement can significantly decrease the cost and the amount of time required for construction while still meeting all the necessary performance requirements.

Data from Previous Investigations

Information from two previous investigations of Runway 08-26 was reviewed. The first investigation was dated June 24, 1991 and included information regarding the pavement sections constructed in 1984. It also provided the designs for the pavement section that was subsequently reconstructed in 1993. The second investigation was dated November 23, 2010. It included pavement rehabilitation designs for the 1993 and 1984 sections.

During the 2010 investigation the majority of the boreholes were terminated at shallow depth due to apparent refusal on bedrock and therefore the granular layers thicknesses could not be accurately determined in either the 1984 or the 1993 sections. Additionally, the subgrade material was identified to be comprised of fine to medium sand with trace silt to some silt. In order to verify and supplement the subsurface information obtained from the previous investigations a limited confirmatory geotechnical investigation was carried out.

Confirmatory Geotechnical Investigation

A limited borehole investigation was completed to verify and supplement the information gained from previous investigations by others. A total of six boreholes were advanced through Runway 08-26 with one borehole in the 1993 section and four in the 1984 section. The last borehole was advanced through the transition between the 2002 and 1984 section. Soil and granular material samples were obtained during the borehole investigation for further testing in the laboratory.

The average asphalt thickness from the four boreholes in the 1984 section was 128 mm. For the 1984 section, the asphalt layer was underlain by a thin layer of granular material which ranged in thickness from 200 to 280 mm. The thickness of the asphalt layer in the 1993 section was 100 mm overlying 1350 mm thick layer of granular material. In the transition area borehole, the thickness of the asphalt layer was 150 mm and the thickness of the granular layer was 460 mm. Native subgrade soils were encountered in all the boreholes and were identified as fine to medium sands.

Laboratory testing included grain size analyses and water content testing. The granular materials in the 1984 section are of variable and poor to very poor quality with the gradation being consistently finer than the Transport Canada specified gradation envelope. The granular material from the 1993 section had a grain size distribution that generally fell within the Transport Canada specified gradation envelope.

Falling Weight Deflectometer

The FWD load/deflection testing was carried out on Runway 08-26 at 3 m and 7 m offset on either side of the runway centreline. The FWD results were analyzed to obtain the normalized deflection, pavement surface modulus and layer moduli.

Table 2 summarizes the normalized deflection and pavement surface modulus results for each of the tested offsets, for each pavement section (1993, 1984, and 2002). For the 3 m offset from the centreline the normalized deflections and pavement surface modulus for the 1993 and 1984 sections are similar. However, for the 7 m offset a significant difference can be observed between the testing results for the 1993 and 1984 pavement sections, with the 1984 pavement section showing higher normalized deflections and lower pavement surface modulus. Generally the structural capacity of the 1984 pavement section is lower than that of the 1993 section. The similarity of the FWD results for the 3 m offsets for the two sections can be explained by the fact that the asphalt pavement had been patched along this line for the entire length of the 1984 section.

The asphalt modulus for all the sections is within the typical range for asphalt in relatively good condition, between 2500 and 5000 MPa. The granular base/subbase modulus for the 7 m offset for the 1984 section is relatively low and below the granular base/subbase modulus for the 1993 section.

The FWD testing also identified that approximately 100 m of the 2002 section from station 11+600 to 11+700 had significantly lower structural capacity compared to the remainder of the 2002 section.

Pavement Design Recommendations

The pavement designs for the rehabilitation of the 1993 and 1984 sections were carried out in accordance with Transport Canada document ASG-19, entitled "Manual of Pavement Structural Design" [1]. The recommended pavement design for the 1993 and 1984 runway pavement sections are summarized in Table 3. Taking in to consideration the character of runway loading, separate design were developed for the runway pavement taking the majority of the aircraft loads (keel section) and the section only used sporadically in emergency situations (outside keel section).

CONSTRUCTION SPECIFICATIONS

The construction specifications that were developed for this project were customized to take into consideration the time constraints and performance requirements for this project. The majority of the customization was for the asphalt paving specifications. The main items that were customized in the asphalt paving specification for this project are as follows:

- Surface course and binder course asphalt aggregate gradations to provide adequate texture while still enabling the stringent smoothness and compaction requirements to be met;
- Increasing the minimum required asphalt cement content as compared to that specified for road paving mixtures to account for potential for increased oxidation in airfield pavements;
- Increased minimum stability requirements to ensure the supplied mix had adequate strength and durability;
- Tolerances of the mix properties and in particular the asphalt cement content were reduced to ensure a uniform product was delivered to site;
- Strict smoothness requirements were included in the specification to ensure that there were no significant distortions in the newly paved surface;
- Joint compaction requirements were included to ensure that adequate density was achieved at the joints as this is typically the weakest location in any pavement;
- Requirement for emergency paving equipment to be available on site at all times to ensure that equipment breakdowns do not result in significant delays to the schedule;
- Paving in echelon to minimize the number of cold joint;
- The use of infra-red heaters to heat cold longitudinal joints in order to be able to achieve the strict joint compaction requirements;
- Requirement to use a Shuttle Buggy® material transfer vehicle (MTV) to minimize potential for thermal of gradation segregation particularly taking in to account the time of year for which the paving was scheduled; and
- Payment reduction factors were included in the specification to allow for material that is found to be in the rejectable zone but still of reasonable quality to be accepted at a reduced payment rather than be removed and replaced. These payment reduction factors were primarily introduced taking in to consideration the very limited amount of time that was available for construction. The magnitude of the factors was to account for any additional maintenance that would be required over the pavement design life due to the lower quality material or paving product.

CONSTRUCTION

In order to minimize the number of flight cancellations and associated loss in revenue to the airport the construction and closure of the runway pavement was very carefully staged and additionally was undertaken during the spring months with work being carried out 24 hours a day. The construction staging was such that portions of the runway construction was carried out with the runway still being open to a limited number of flights, particularly for major commercial operations. The construction period was timed such as to occur before the summer travel period. It was recognized that the weather conditions and in particular the temperature and precipitation could have not been ideal for paving. The following precautions were put in place in order to ensure that a good quality pavement was placed even if adverse weather conditions occurred:

- Proper insulation and covering of the truck boxes was required and enforced to ensure that the Hot Mix Asphalt (HMA) did not cool significantly during hauling;
- An MTV was used to remix the material deposit from the trucks to prevent large temperature gradients immediately behind the screed;
- Trucks were not allowed to wait for long periods at the site before transferring their load to the MTV;
- Additional rollers were used as required to allow for timely compaction while the HMA was still hot; and
- Careful paving inspection including monitoring of weather forecasts and conditions and making sure that proper precautions were utilized when necessary.

Pre Pave Meeting

To minimize the potential for unforeseen challenges arising during the asphalt production and paving operations, a pre-pave meeting was held in which all the parties involved in the project participated including the general contractor and all their associated sub-contractors, the Contract Administrator, the geotechnical subconsultant and the Owner. During the pre-pave meeting all potential issues that were anticipated to be encountered were discussed and measures were put in place to minimize any adverse impacts to the paving operation. The Contractor noted that in order to remain on schedule it was critical that if any geotechnical issues were identified during construction that the appropriate people that could make recommendations from the geotechnical consultant were reachable at all times. This was ensured by having personnel from the geotechnical personnel on site at all times and further by having senior pavement specialists on call 24 hours a day.

The requirement for a rapid turnaround for all materials testing results was understood and agreed upon to ensure that pavement quality was not compromised despite the tight timelines. Also during this meeting the submission deadlines for the HMA mix design, trial batch and test strip were brought to the attention of the Contractor and it was emphasized that the timelines would have to be strictly enforced in order to meet all the deadlines included in the specifications.

It was understood that although not all issues could be avoided, the timely resolution of any issues would require complete cooperation between all the parties that were involved. All health and safety requirements were discussed during the pre pave meeting and in particular the airport personnel emphasized the unique environment posed due to the fact that the construction site was within an active airfield.

HMA Approval

Although there was a very limited construction window, the specification called for a rigorous HMA approval process in order to ensure that the material being placed on the airfield provided the properties that were assumed during the design stage. Listed below are the three steps that were included in the asphalt mix approval process:

- Mix Design – Mix designs were required to be submitted for the surface course and binder course HMA and were to be compliant with the project specification. The mix design submission required detailed information to be submitted for the mix design process including graphs and calculation, the aggregate physical properties and the asphalt cement temperature viscosity chart. The mix design was subsequently reviewed by an experienced pavement and materials specialist to ensure compliance with the project specifications and design assumptions;
- Trial Batch – Following approval of the mix design, the Contractor was required to produce a trial batch of the approved mixes using the asphalt plant to make sure that the laboratory designed mixes could be produced in the plant within the specified tolerances. The produced mixes were sampled by the geotechnical consultant and tested for gradation, asphalt cement content and volumetrics. The results were again reviewed and approved by the pavement and materials specialist; and
- Test Strip – After approval of the trial batch, a test strip carried out, which was again sampled and tested by the geotechnical consultant to ensure that the Contactor could place the design HMA within the requirements of the project specifications. During the placement of the test strip the Contractor established the optimal rolling pattern that would produce the required mat and joint density and this rolling pattern would subsequently be used during the paving operation.

Although the rigorous asphalt mix approval process somewhat decreased the amount of time available for paving, it was considered to be essential for achieving a good quality final product. By ensuring that the specified timeline were strictly adhered to, the amount of paving time was maximized by reducing the time required for the approval.

Quality Assurance and Quality Control Testing

Significant amount of Quality Control (QC) and Quality Assurance (QA) testing was carried out during the project to ensure the quality of the final product. Due to the 24 hour construction operation, laboratory testing of the samples obtained in the field was also carried out 24 hours a day. Initial laboratory testing results for the asphalt sample was completed within four hours of obtaining the samples. These initial results provide a good indication regarding the quality of the asphalt mix such that paving could continue without any disruption. All remaining asphalt testing was completed and reported to all parties within 24 hours of obtaining the samples. The rapid turnaround on the asphalt laboratory testing allowed the material to be approved immediately or any necessary corrective actions taken and, therefore, subsequent lifts could be placed within 24 hours of the placement of the previous lift with the knowledge that the material being covered met all the required project specifications.

Pavement Inspection

As noted during the pre pave meeting, in order to ensure that the construction timelines were met it was crucial that all issues related to paving and geotechnical aspects of the project were resolved in a timely manner. An experienced pavement and material inspector was on site full time during pavement removal and placement operations. Listed below were the tasks that were undertaken by the full time construction inspector:

- Pavement removal inspection;

- Evaluation of condition and compaction of the subgrade (1984 Section) and granular materials (1993 and 1984 Sections);
- Proof rolling;
- Construction monitoring of the granular layers, HMA binder and surface courses;
- Inspection of the paving operation;
- Quality inspection for the HMA mat;
- Evaluation of joint construction; and
- Enforcement of the specification requirements.

The presence of the construction inspector allowed the identification of any areas of weak subgrade then verified by proof rolling, which were brought to the attention of the Contractor and addressed immediately. The construction inspector also identified the locations without adequate joint compaction while the mat was still relatively hot and these locations could be reheated by the Contractor using an infrared heater and then additional compactive effort was applied. This timely inspection of the mat and joint compaction allowed the adequate density to be achieved for all the paving carried out on the project.

CONCLUSIONS AND LESSONS LEARNED

Although the paper presents a case study on the construction of a runway pavement, the lessons learned are equally applicable to roadway pavements construction and how to achieve a quality product while minimizing delays and inconvenience to the travelling public.

Listed below are the key lessons that were learned during this project that can be applied to all road and airport paving projects to allow a high quality pavement to be placed in a safe and time sensitive manner.

- Cooperation between contractor, pavement specialists, contract administrator and airport operators is essential when developing the construction staging plan to minimize possibility of construction delays, maximize pavement performance and minimize number of scheduled flight cancellations.
- Detailed and customized specifications including contractor equipment requirements and required emergency equipment will minimize construction delays due to equipment failure or plant breakdowns.
- Specifications should include timelines for submissions prior to the start of paving that should be enforced by the contract administrator and geotechnical/pavement consultant and should be adhered to by the Contractor.
- Any potential issues and complications shall be resolved in a time sensitive and technically sound manner by the owner, contract administrator, geotechnical/pavement consultant and contractor before they become problems.
- Good planning and execution of construction work including material delivery, mix production, hauling of mixes, preparation of existing layers and properly organized paving operation will result in a smooth construction operation.
- Well organized quality control and quality assurance testing with timely decision making will ensure that no delays are incurred due to material testing and acceptance.

REFERENCES

1. Public Works and Government Services, July 1992. *Manual of Pavement Structural Design*, ASG-19 (AK-68-12).

Table 1: Existing Pavement Structures on Runway 08-26

Section	Asphalt Thickness (mm)	Granular Base Thickness (mm)	Granular Subbase Thickness (mm)
1993	100	300	340
1984	90	225	150
2002	100	300	340

Table 2: Summary of Normalized Deflections and Pavement Surface Modulus

Offset from Centreline	Pavement Section	Normalized Deflection (mm)		Pavement Surface Modulus (MPa)	
		Mean	Standard Deviation	Mean	Standard Deviation
3 m Left	1993	0.34	0.05	448	68
	1984	0.34	0.01	435	18
	2002	0.22	0.14	885	445
3 m Right	1993	0.33	0.04	453	53
	1984	0.36	0.04	413	45
	2002	0.18	0.10	945	342
7 m Left	1993	0.30	0.05	494	77
	1984	0.48	0.07	308	47
	2002	0.21	0.12	900	567
7 m Right	1993	0.29	0.03	504	42
	1984	0.50	0.04	297	21
	2002	0.20	0.07	794	294

Table 3: Pavement Rehabilitation Design Recommendations for Runway 08-26

<table>
<tr><th colspan="2">1993 Section</th><th colspan="2">1984 Section</th></tr>
<tr><td>Keel</td><td>Outside Keel</td><td>Keel</td><td>Outside Keel</td></tr>
<tr>
<td>Remove 200 mm of the existing pavement structure;
Place 150 mm of binder course HMA in two (2) lifts; and
Place 50 mm of surface course HMA.</td>
<td>Mill 100 mm of the existing pavement structure;
Place 50 mm of binder course HMA; and
Place 50 mm of surface course HMA.</td>
<td>Remove material to a depth of 750 mm below the existing grade;
Place and compact 550 mm of granular base;
Place 150 mm of binder course HMA in two (2) lifts; and
Place 50 mm of surface course HMA.</td>
<td>Remove material to a depth of 750 mm below the existing grade;
Place and compact 650 mm of granular base;
Place 50 mm of binder course HMA; and
Place 50 mm of surface course HMA.</td>
</tr>
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