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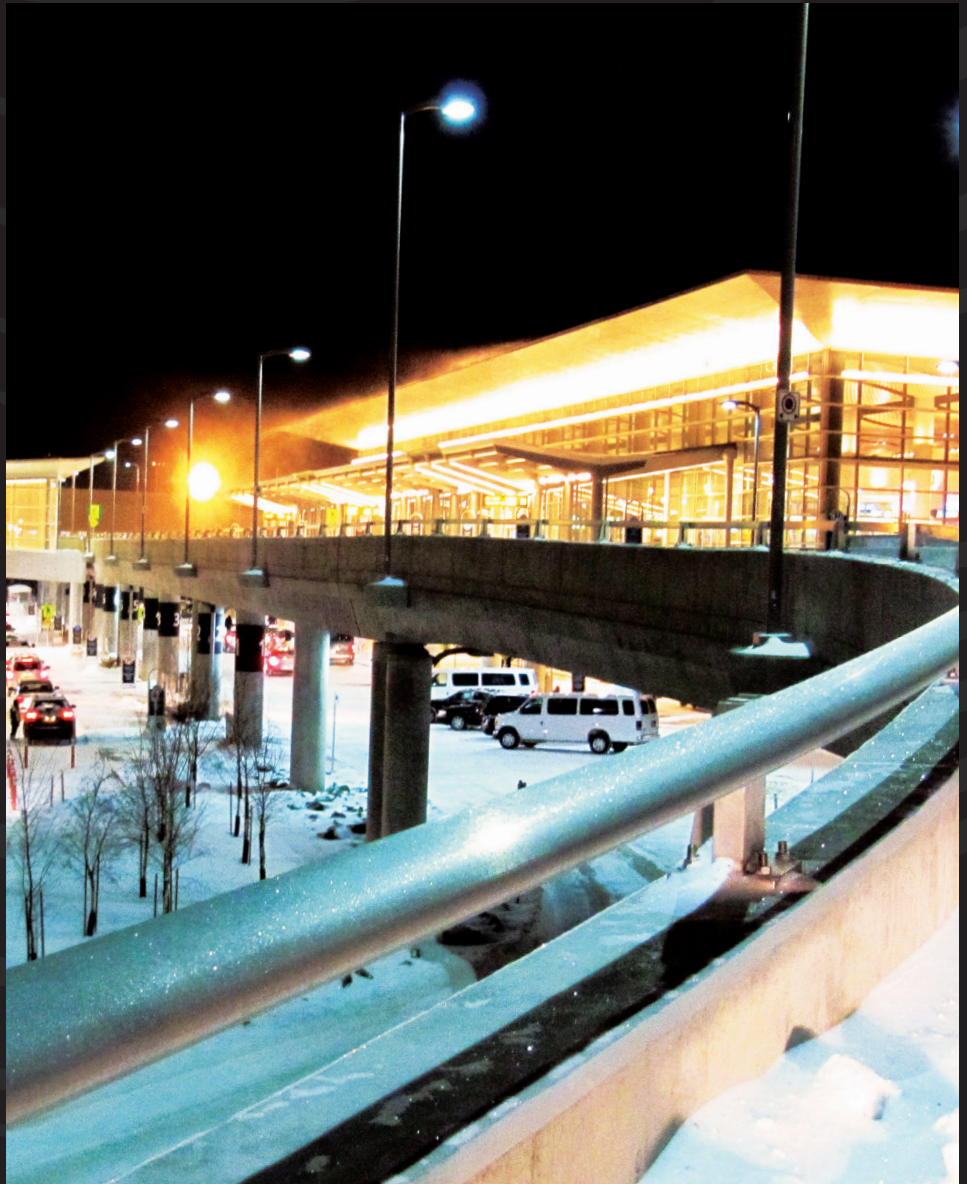
AECOM

JAMES A. RICHARDSON INTERNATIONAL AIRPORT, ELEVATED ROADWAY - DEPARTURES LEVEL BRIDGE



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WINNIPEG
AIRPORTS AUTHORITY



INTRODUCTION

Winnipeg continues to grow as a transportation hub and travel destination visited by travelers from around the world. As a result, its airport also needs to provide services and facilities appropriate to this changing environment. The Winnipeg James Armstrong Richardson International Airport is Manitoba's gateway to the world, it is the first place travelers see when they arrive by air, and it is Manitoba's first opportunity to create a favourable impression. As part of the complete Airport Site Redevelopment, on October 30, 2011 the Winnipeg Airports Authority (WAA) officially welcomed travellers through Canada's newest and greenest airport.

The approximately \$399 Million Airport Site Redevelopment program was completed under three major projects, the Terminal Building and Parkade, the Groundside Site Development (GSD) and the Airside Site Development. As part of the plan to provide a truly world-class facility, a fully integrated and versatile groundside system was required to connect the airport to its customers. In accordance with this vision, the new roadway system provides convenient and efficient connections between the new Air Terminal Building, new parkade, and reconfigured surface parking serving both the public and employees. As part of an attractive, modern and efficient facility, the new roadway system includes the Elevated Roadway / Departures Level Bridge, which provides direct curbside access to the Departures Level on the second floor of the Terminal Building, and direct curbside access to the

Arrivals Level on the main level of the Terminal Building.

The team for the Departures Level Bridge was led by AECOM (formerly Earth Tech). AECOM provided the traffic, roadway geometry, geotechnical, and municipal design for the GSD, and the structural engineering for the Departures Level Bridge. The Prime Architect team for the entire Airport Site Redevelopment consisted of Stantec Architecture Ltd. and Pelli Clarke Pelli Architects (formerly Cesar Pelli). The structural design of the up and down ramps to the Departures Level Bridge and the bridge lighting design for the entire Elevated Roadway was provided by Marshall Macklin Monaghan (MMM) in Toronto, as a subconsultant to AECOM. The landscape architecture for the Elevated Roadway was provided by Scatliff + Miller + Murray, also as a subconsultant to AECOM.



Elevated Roadway - New Upper Departures Level



Beneath Elevated Roadway - New Lower Arrivals Level

PROJECT HIGHLIGHTS

PROJECT
HIGHLIGHTS



PROJECT HIGHLIGHTS

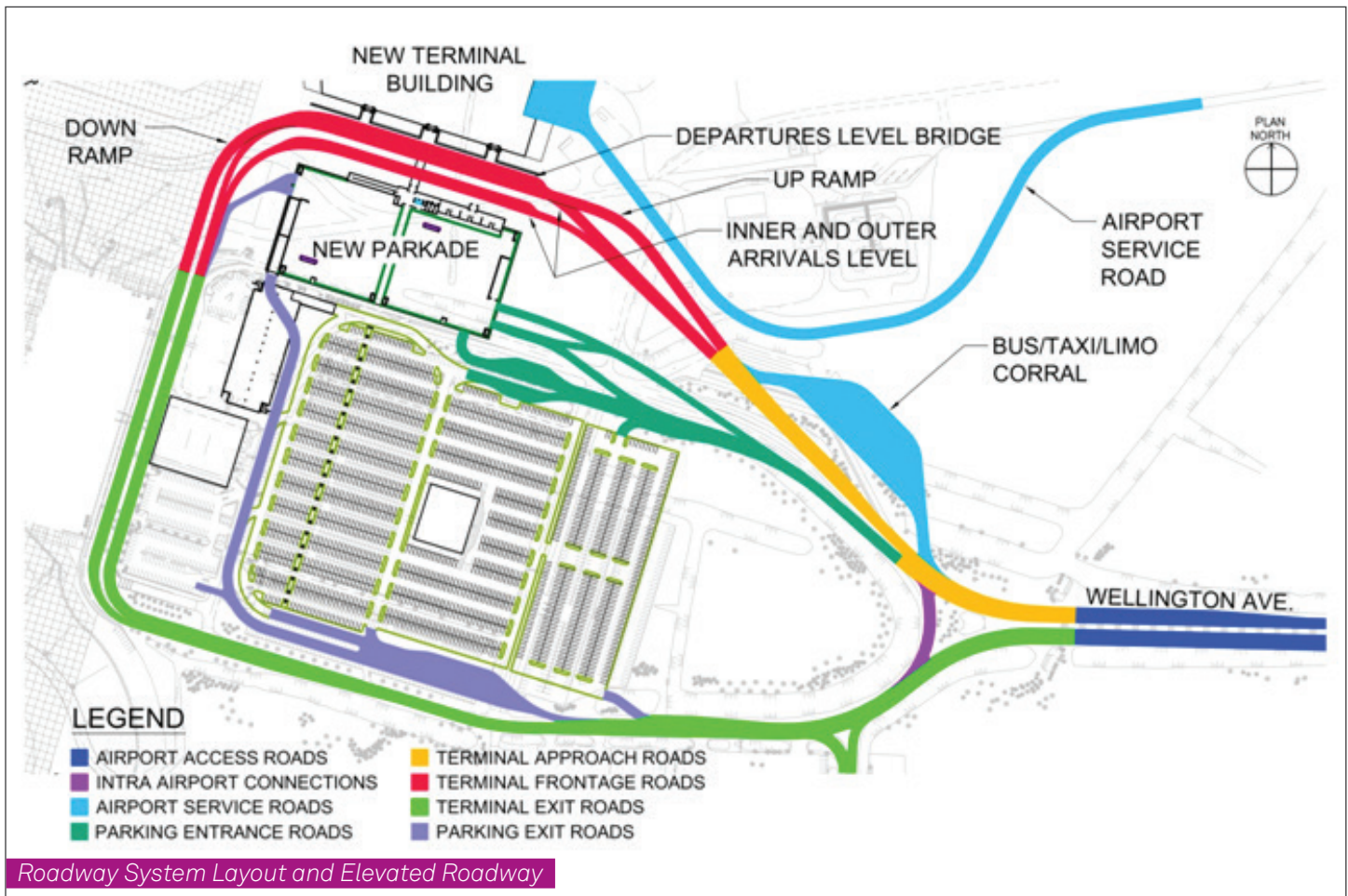
INNOVATION

WAA's vision for the Winnipeg Richardson International Airport is to lead transportation innovation and growth. The redevelopment of any major airport is inherently unique due to the site specific layout, volume of air traffic, roadway traffic requirements, existing infrastructure and projected development and growth. The Elevated Roadway / Departures Level Bridge is a key component and complements the new and innovative airport facility.

1.1 Traffic Planning and Roadway System Design

The terminal development project provides modern facilities to serve up to 3.5 million passengers by 2015 and 4.0 million passengers by 2020. This recognizes growth in the domestic and US/transborder traffic as well as an increase in direct international flights to other destinations. Terminal organization included: domestic operations at the west end; and transborder/international flights at the east end, which was important to ensure that wayfinding and passenger convenience was optimized in the roadway development.

Simulation of all groundside and terminal traffic was undertaken by a specialist subconsultant, Daniel, Mann, Johnson, Mandenhall (DMJM, now AECOM) during the Preliminary Design phase. The outputs from the simulation were used to confirm traffic volumes and lane requirements on all road segments in the terminal area. Level of service determinations were then undertaken for link capacity and weaving capacity. The simulation correlated vehicular and passenger demands based on flight schedules and confirmed roadway lane requirements and levels of service. The connectivity of roads, the Terminal Building, surface parking, and the parkade was fully defined for pedestrian circulation, ramp systems,



PROJECT HIGHLIGHTS CONT'D



Roadway Signage for Vehicle Wayfinding



Outer Arrivals Level Curb and Up Ramp to Departures Level Curb

wayfinding, parkade entry/exits, rental cars, and the roadway signage concepts.

A key element of the roadway system was the length of available curb at the terminal to accommodate arriving and departing passengers. Curb management, particularly during busy periods, was important to ensure that dwell times were controlled. Monitoring of operations and re-allocation of vehicles between curbs was also an effective way of making use of available curb length.

Fundamentally, it was essential to provide adequate curb length to accommodate the expected demands. Analysis undertaken during the Program Definition phase indicated minimum curb length requirements of 85 m for Arrivals and 175 m for

Departure Levels. The pre-design layout provided 350 m on the Arrivals Level (two curbs) and 220 m on the Departures Level. The curb length was reviewed upon completion of the simulation modeling. Mode split information was also utilized to determine appropriate terminal curbside allocation by vehicle type (private cars, taxis/limousines, rental cars, transit vehicles, and hotel shuttles).

The roadway system was developed to provide the following:

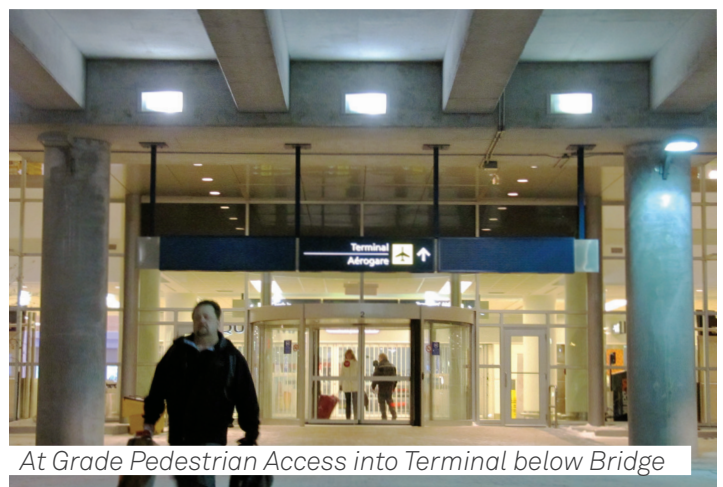
- Accommodation for various combinations of origins and destinations, including re-circulation movements.
- Adequate capacity to meet projected demands at acceptable Level of Service with minimal

congestion and delays, considering access roads, intersections, weave areas, parking ramps, and curb fronts.

- Reserve capacity for operation during collisions, breakdowns, adverse weather, and other emergencies.
- Efficient interfaces with the surrounding City streets and accessibility for emergency vehicles.
- Provisions for future expansion in balance with the overall airport ultimate capacity.
- Roadway geometrics and other features that foster an efficient progression of speed reductions approaching the terminal, and speed increases leaving the terminal, that minimize trip times.



Inner and Outer Arrivals Level Curbs with Open Views to Terminal Building



At Grade Pedestrian Access into Terminal below Bridge

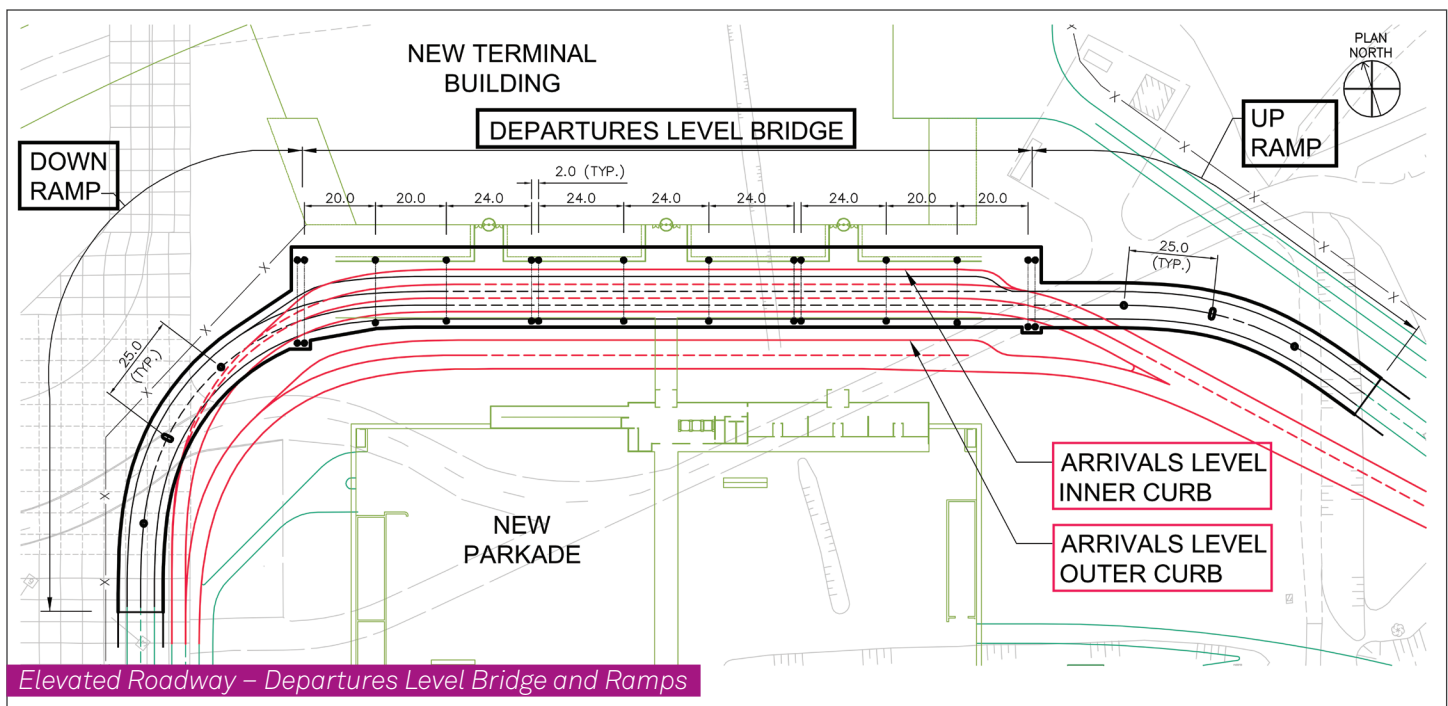
PROJECT HIGHLIGHTS CONT'D

- Directness of routing and ease of wayfinding, supported by signing with a simple sequence of decisions and adequate sight line distances to enable reading, comprehension, decision making, and lane changes.
- Compatibility with on-going airport operations during construction through proper phasing.
- Effective mitigation of potential pedestrian / vehicular conflicts.
- Identification and mitigation of potential environmental impacts.
- Accommodations for various types of commercial vehicles and their unique characteristics.
- Compatibility with utility requirements and relocations.
- Constructability and cost considerations.
- Provisions for effective snow and ice removal.

The terminal frontage roads consist of a combination of at grade roads and elevated structures. The inner and outer curbs on the Arrivals Level are at grade and consist of 3 and 2 lanes, respectively. On this level, private vehicles, taxis, limousines, shuttles, and buses are directed to the appropriate inner or outer curb. The Departure Level Road is on an elevated structure with 3 lanes. On this level the 3 lane configuration provides adequate capacity for drop off with provision for double-parking in Lane 2, if necessary. Pedestrian access to and from the parkade to both Departures and Arrivals Levels occupy a portion of the frontage road area with at grade crossings on the Arrivals Level and pedestrian bridges connecting the terminal and parkade to the Departures Level Bridge. Key constraints that influenced the relationships between the terminal, parkade, frontage roads, and pedestrian bridges interface were:

- Vertical clearances to pedestrian and vehicular bridges.
- Terminal elevations at Arrivals and Departures Levels.
- A horizontal offset between the Departures Level Bridge and Terminal Building to allow natural light to penetrate the Arrivals and Departures Levels both inside and outside of the Terminal Building.
- Parkade elevations at floors connecting to Arrivals and Departures Levels.
- Grades on roadways, sidewalks, and pedestrian bridges.
- Connection of pedestrian bridges to the terminal and parkade.
- Pedestrian/vehicular inter-visibility at the Arrivals Level.

These constraints had a direct impact on the design of the Elevated Roadway Structure discussed in the following section.



PROJECT HIGHLIGHTS CONT'D



Post-Tensioned Transverse Beams and Thickened Edge Beam to Meet Vertical Clearance Requirements, Improve Bridge Aesthetics, and Provide Open Column Spacing



1.2 Elevated Roadway Structure – Departures Level Bridge and Up / Down Ramps

The elevated frontage road structures include vehicular bridges serving to access the terminal curbside and consist of the Departures Level Up-Ramp, the Departures Level Bridge, and the Departures Level Down-Ramp. The geometry of the bridges was governed by the road alignment and cross-section. The flat section of the Departures Level Bridge is comprised of a series of bridges. Typical spans are 13.0 m to 15.5 m to provide an attractive layout, avoid a “forest of columns” and achieve a balance between an efficient structural system, reasonable structural depth, and aesthetics.

Bridge aesthetics were important to overall site development because of the visibility of the elevated roadways, accordingly every opportunity was used to provide attractive structures. The bridge aesthetics was developed in conjunction with the Prime Architect team. Pedestrian bridges (designed by others) provide a convenient link between the terminal and parkade at four locations, tying into both sides of the Departures Level Bridge.

The structural concept for the elevated frontage road was prepared while considering all the physical site constraints including: column configuration; staging areas; construction access limitations; emergency access; roadways; operating and maintenance requirements; tie-in requirements to the terminal building; aesthetic limitations; vertical and horizontal clearance envelopes above and below the structure; and drainage.

The general arrangement of bridges and ramps were further developed with due regard for utilities; electrical (lighting); foundation requirements; the landscape concept; and the terminal/parkade interfaces (canopies, railings, light fixtures, and column and soffit/beam shapes). Column locations were also placed with due consideration for sidewalk locations and vehicle/pedestrian inter-visibility.

1.3 Laterally Post-Tensioned Superstructure

Structural concepts were reviewed and feasible alternatives selected based on multi-disciplinary considerations: architectural, structural, and transportation/roadway. During the early stages of the preliminary design multi-disciplinary workshops were held with the Prime Architect team and Groundside design team to coordinate requirements, confirm layout and concepts, and obtain concurrence on the preferred general arrangement and aesthetics of the elevated frontage roads.

Column layout alternatives were reviewed in conjunction with the geometric design of the Arrivals Level. It was required to maintain a 2.0 m clearance from the face of curb to the face of any columns for pedestrian/vehicle intervisibility. Top of roadway elevations were determined based on the Departures Level elevation within the terminal, parkade elevations, slope requirements for the pedestrian bridges, curb heights, and roadway/boulevard grades. The need to maintain a minimum 5.0 m vertical clearance between the Arrivals Level inner curb and structure soffit while

PROJECT HIGHLIGHTS CONT'D

respecting the terminal frontage interface relationships, resulted in a 1.0 m maximum permissible structural depth. This presented the structural engineers with a very thin cross section for a structure of this size.

Column locations were established based on structural requirements, aesthetic considerations, Arrivals roadway alignment, Arrivals levels entrances/exits, pedestrian cross walks, roadway alignment consideration and permissible structural depth. The final column layout provided the maximum possible column spacing and large open areas below the structure.

Several options were investigated for the superstructure including precast prestressed concrete girders, a composite concrete slab on steel girders, a post-tensioned solid concrete slab, and cast-in-place concrete beams. The required structure depth could not be met with the prestressed concrete girders without compromising the optimum column layout. In addition, this would have strongly resembled an overpass or freeway structure in appearance. A steel girder superstructure would meet the span requirements;



Aluminum Railing on Concrete Traffic Barrier

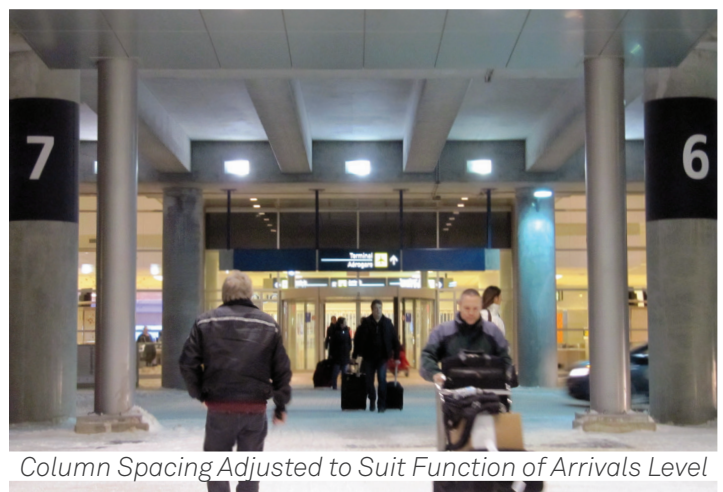
however, the appearance and long term maintenance of coatings were undesirable. In addition, the curved up and down ramps would have required expensive steel box girders to meet the torsional requirements for the horizontally curved geometry.

A post-tensioned concrete slab was a viable option to meet the structural depth and aesthetic requirements; however, the Prime Architect had a strong desire for a “coffered” layout from an aesthetic perspective. The selected structure for the Departures

Level Bridge included the cast-in-place “coffered” or transverse beam/ribbed structure, with lateral post-tensioning to reduce the beam sizes. It was determined that cast-in-place concrete would provide the following: allow for a variety of architectural features and shapes; was price competitive in the local market; the post-tensioning would increase long-term durability; and the additional use of high performance concrete would reduce the effects of chloride attack.



Column Size and Spacing Accommodated Open Structure



Column Spacing Adjusted to Suit Function of Arrivals Level

PROJECT HIGHLIGHTS CONT'D

For the curved ramp structures (Departures up-ramp and down-ramp), the selected alternative was a post-tensioned cast-in-place concrete slab superstructure supported on a concrete abutment and with circular pier columns, located to accommodate the merging Departures and Arrivals Level roadways.

Various column shapes were reviewed. Circular columns were selected to minimize the appearance of their size and provide the most efficient cross section. Heavily loaded columns were reinforced with two rings of vertical reinforcing steel to further minimize their diameter. All columns were supported by concrete pile caps on either steel H-piles or precast concrete piles depending on the suitability of the underlying soils and bedrock at various locations.

1.4 Other Design Elements

The coffered bridge structure with main beams running along the edge between columns, and laterally post-tensioned transverse beams to provide a shallow structure depth, is very unique for a bridge in any setting. This configuration was required in part because bridges rarely have roadways running parallel underneath them,

such as the Arrivals and Departures Level roadways. Where such elevated roadways do exist on top of each other, such as on major urban freeways, the architectural component of the work is not nearly as critical as it was for the Airport Redevelopment Project. This provided for a significant advancement of the Structural Engineer's art and skills, and provided an attractive blend of the Engineer's expertise with the Prime Architect's desired aesthetics.

The structure utilized post-tensioned concrete beams, which are not common in Manitoba, and galvanized reinforcing in combination with a high performance concrete overlay to improve durability and reduce maintenance. The structure was very heavily reinforced to minimize the structural dimensions, and three-dimensional modelling was utilized to ensure that the reinforcing, post-tensioning, and various connection anchors could in fact be placed in the field.

Significant consideration was given to the traffic barriers along the edge of the Departures Level Bridge. Various traffic barrier configurations were researched, and traffic barriers were also investigated at many existing airports. The architect desired an

open structure that minimized any blockage of light into the terminal building; however, the barriers had to be safe for vehicles and pedestrians. It was determined that the barrier on the outer edge of the bridge would be a reinforced concrete barrier with an aluminum railing on top to provide adequate vehicle crash protection, meet bridge code requirements, yet lower the height and improve the aesthetics of the wall as much as possible.

The barrier on the inside edge of the bridge is at the back of the 5.8 m wide sidewalk. Significant discussion was held on whether this barrier required the same impact resistance as this condition is not addressed in the bridge codes. It was decided to have a reduced height concrete curb to prevent any errant but relatively slow moving vehicles or snow clearing equipment from going over the edge of the structure. On top of the curb a system of stainless steel posts, rails and mesh were installed to meet the building code for pedestrian railings, allow light penetration into the terminal building and arrivals level below, provide minimal maintenance, and increased safety from impact (in particular when compared to plexi-glass barriers in service at some modern airports).



Placing Cast-In-Place Concrete for Elevated Roadway – Departures Level Bridge

PROJECT HIGHLIGHTS CONT'D

This project required extensive input from the Prime Architect in order to achieve the objectives for the Elevated Roadway Departures Level Bridge. Coordination of the Structural Engineers and the Architect throughout the design process was critical to achieving this success.

COMPLEXITY

The new terminal location for the Groundside Site Development was selected to be in close proximity to the existing terminal in order to make the best use of the site, and existing infrastructure such as the existing parkade, hotel and parking areas. However, the location selection was also required to minimize impacts to the existing airport operations during construction. This presented many challenges, as the new road system was designed to serve the new 60,000 m² terminal complex and 1600 car parkade, yet still provide efficient operations and wayfinding for vehicular and pedestrian traffic during the various stages of construction.

The enormous redevelopment program included three major projects, the Terminal Building and Parkade, the Groundside Site Development, and the Airside Site Development. These three projects were also carried out by various consulting engineering and architecture firms and teams. The large number of active participants in the design and construction added significant complexity to the project.

The geographic layout of the site further increased this complexity, as the Roadway system wound through all components of the Groundside Site, Terminal Building and Parkade. The Elevated Roadway was located between the new Parkade and Terminal, and the new Terminal

was between the Groundside and Airside components of the site. All three projects were interdependent, and there were many critical links among them including roadways, bridges, tunnels, utilities, and other infrastructure.

The Elevated Roadway was a complicated structure to design due to all of the site constraints and architectural requirements. The sheer size of the bridge adds significantly to this complexity – at a total length of 506 m, this is the second longest bridge in Manitoba, and with a width of 20 m it is significantly wider than typical highway bridges. The requirements for post-tensioning in the Departures Level Bridge added significantly to the complexity, and the tight radii of the Up and Down Ramps created sharply curved structures requiring special considerations in design due to the significant torsion on the structures, and the significant expansion and contraction of these curved structures in multiple directions.

SOCIAL AND/OR ECONOMIC BENEFITS

The Airport Site Redevelopment Program was implemented following WAA's community-based strategic directions:

- Enhance customer service and value.
- Deliver and operate excellent facilities and services.
- Expand air service to and from Winnipeg.
- Be an effective community partner.
- Develop and realize employee potential.
- Develop new revenue streams.

There has been a significant enhancement in customer service and value for air travel through the new Terminal Building, Parkade, Groundside and Airside Facilities. This includes quick and efficient access for travelers using private, public or



Calgary – Perpetual Night Appearance, Large Columns Obstructing Views, and Low Clearance

PROJECT HIGHLIGHTS CONT'D

commercial transportation to and from the New Terminal Building via the Departures Level Bridge and Lower Arrivals Level. There is a measurable reduction in access time when compared to the single level arrivals/departures roadway of the Old Terminal Building. The configuration of the Departures Level Bridge combined with the open concept of the new Terminal Building allows travelers direct and clear access from the curbside to their check-in location.

Despite a global economic downturn air passenger travel through Winnipeg increased 5% from 2010 to 2012. Recent announcements also include expanded air service to and from Winnipeg.

A variety of community benefits have been realized through the redevelopment program including: improved safety and reliability; cost efficiency; adaptability for future industry needs; and ongoing support of local economic development. The new facility is also a very positive project for the City of Winnipeg, and one that residents of the City are proud of.

ENVIRONMENTAL BENEFITS

As Canada's greenest airport, and the first to seek LEED Silver Certification, the Airport Site Redevelopment is an environmentally sustainable project. LEED certification distinguishes building projects that have demonstrated a commitment to sustainability by meeting higher performance standards in environmental responsibility and energy efficiency. One of the contributing performance categories is Sustainable Sites, which minimizes environmental impacts related to construction and operational activities. With respect to the Departures Level Bridge and associated roadway system, this includes a land drainage sewer system equipped with an oil/grit separator. The separator is capable of removing 80% of suspended solids and oil and grease from collected stormwater runoff.

With respect to transportation, employees, passengers and building occupants have access to two regularly scheduled local bus routes accessing the Terminal Building via the Arrivals Level.

In the Energy and Atmosphere performance category the Terminal Building takes full advantage of daylight harvesting. The design and offset of the Departures Level Bridge from the Terminal Building maximizes the amount of light which can enter both the Arrivals and Departures Levels of the Terminal Building, which is unique for most major airports in Canada.

In the Materials and Resources performance category the structure was constructed using durable high quality materials which have a longer life span and require less maintenance. For the Elevated Roadway this included galvanized reinforcing, a high performance concrete overlay, and a post-tensioned superstructure which will minimize cracking, chloride ingress and subsequent deterioration.



MEETING CLIENTS NEEDS

The owner and AECOM's client, Winnipeg Airports Authority, operates, manages, maintains, and invests in the Winnipeg Richardson International Airport. The Groundside Site Development project recognized the overall program objectives related to enhanced customer services and value; delivery and operation of excellent facilities and services; expanded air services; development of new revenue streams; and effective community relations. The new road system was designed to serve the new terminal complex and

Edmonton – Dark and Highly Congested Appearance, Low Vertical Clearance

PROJECT HIGHLIGHTS CONT'D

parkade by providing convenient and efficient wayfinding for vehicular and pedestrian traffic. The roadway system and Departures Level Bridge provide a modern and direct approach to the terminal complex.

The new terminal building is designed to be a very open structure, with minimally obstructed sight lines throughout. It has an emphasis on views outwards from the terminal, and views from one portion of the terminal to the next (i.e. from the arrivals/departures curbs through glass façades into the building). This open concept allows for ample natural light, an aesthetically pleasing structure, and most importantly a highly functional facility where visitors can actually see where they are going next. The Elevated Roadway and Departures Level Bridge design complements this concept. This resulted in the requirement for a high vertical clearance, a structure that would allow natural daylight in during the day, be well lit at night, and not have the appearance of a bridge or freeway. The adjacent photos demonstrate how these objectives are not met by the other airports in Canada.

The Elevated Roadway Departures Level Bridge was completed ahead of the schedule required to meet the overall schedule for the Airport Site Redevelopment. The Departures Level Bridge was also completed on budget relative to WAA's revised budgets adjusted for the market values at the time of construction. The selected structure for the Departures Level Bridge provided an economical structure given the tight vertical constraints and architectural requirements set for the project. Design elements were also optimized to provide increased durability, thus reducing long term maintenance costs.



Ottawa – High Vertical Clearance and Open Concept but with Appearance of Freeway



Winnipeg – High Vertical Clearance, Open Views, Well Lit, Arrivals Curb is Extension of Terminal

AECOM's Quality Management program includes independent design reviews within AECOM. Timely design inputs, internal and external, were critical to the overall success of the project and for adherence to the schedule. Coordination and cooperation between all parties was a significant factor in the success of the project.

At the outset of the project AECOM completed a detailed risk analysis and mitigation measures were developed for the various design, schedule, and budget risks. This was of particular importance on this project due to the three main design contracts, large number of consultants, multiple construction contracts, and the significant impact of errors or delays on the remainder of the Groundside Redevelopment Project and associated liability.

The AECOM logo is centered on a dark gray background. It features the word "AECOM" in a bold, white, sans-serif typeface. The letter "E" is stylized with three horizontal bars. The background is decorated with several thin, dark gray, wavy lines that flow horizontally across the page, creating a sense of movement and depth.

AECOM