Driven by a growing global middle-class, more efficient planes and lower airfare prices, current air travel is expected to double to 7.8 billion passengers per year by 2036. To handle the increasing demand, the aviation industry is investing heavily in expanding fleets and networks. According to Airbus, a leading aircraft manufacturer, rising global demand for aircraft will require an additional 34,900 planes by 2036.

Local governments are already competing to offer attractive global aviation hubs by updating and expanding airport infrastructure, resulting in a wave of new airport projects, as well as the expansion and rehabilitation of existing airports.

Very often, these airports are built in critical environments, exposing concrete substructures to high groundwater tables or contaminated soil. With many mission-critical utilities (communication systems, baggage handling and passenger transportation) often housed below-grade, protection from water penetration is crucial to ensure smooth operation and significantly reduced maintenance downtime and repair costs.

In addition, a durable concrete structure is key to optimizing investments on multi-million-dollar infrastructure projects. Preventing deterioration before a structure reaches its intended design life span allows for the complete utilization of the project over its full service life – maximizing return on investment.

In this edition of the PENETRON Newsletter, we present a number of international airport projects that have benefitted from our waterproofing and durability solutions.

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To meet the needs of increased air traffic, Changi Airport Terminal 3 opened for scheduled flight operations on January 9, 2008, after completion of a seven-year construction project. Terminal 3 was the fourth passenger terminal at Changi Airport, which extended the airport's capacity by 22 million passengers to a total of about 70 million passengers per year.

Designed by CPG Consultants, the 380,000 m² (4,180,000 square feet) terminal is a seven-story building that includes three basement levels and four above-ground levels. The basement levels contain parking facilities and the above-ground levels are dedicated to airport services, as well as a 20,000 m² (220,000 square feet) retail and F&B area. The total project cost was S$1.75 billion (US$1.3 billion).
Changi Airport Terminal 3 is built entirely on reclaimed land, exposing the three-level basement structure to high groundwater pressure. In order to protect the concrete from water penetration, the project engineers specified a crystalline admixture. Subsequently, PENETRON ADMIX was added to approximately 140,000 m³ (183,120 cubic yards) of concrete for the Terminal 3 retaining walls and base slabs. This not only ensured a completely impermeable concrete structure, but also significantly sped up construction time for the basement.

For the full CHANGI AIRPORT TERMINAL 3 case study, please [click here](#).

Chennai International Airport, India

Chennai International Airport (MAA) in Chennai, India (formerly Madras Airport), is the country's third-busiest airport after New Delhi and Mumbai. It is also the second-largest cargo hub in India.

In 2007-08, Chennai Airport handled over 10 million passengers per year, surpassing the airport's stated capacity of nine million. This made a modernization and expansion of the airport a priority.
Subsequently, the US$ 500 million upgrade and expansion project began in early 2007 under the supervision of the Airport Authority of India (AAI). The project included the expansion of the international terminal, construction of a new domestic passenger terminal, multi-level car parking facilities and a new runway across the adjacent Adar River.

The new terminal buildings, with an area of 140,000m² (1,540,000 square feet), feature 140 check-in counters and 60 immigration counters. A 1.2 km-long (0.8 mile) flyover and 36 travellators were installed to connect the domestic terminal with the international terminal.

At the time of completion in 2011, Chennai Airport was ready to handle 16 million passengers per year. It also became the greenest airport in India by incorporating green features, such as ecologically-sustainable gardens in both terminals, wing-shaped roofs for efficient rain water collection, natural lighting through expansive glass wall curtains, and a green roof parking garage.

The design of this project was the joint effort of four international companies: Hargreaves Associates (USA) designed the landscape; Frederic Schwartz (USA) created the building designs; and Gensler (USA) and the New Delhi-based Creative Group (India) were the local architects for the Chennai Airport Expansion. The construction was executed by a joint venture between M/s Herve Pomerieau Intl. and Consolidated Construction Consortium Ltd. (CCCL).

The immediate proximity of the airport to the Bay of Bengal and the fluctuating ground water levels (-10m during summer and -3m during monsoon season) in Chennai demanded thorough protection for all concrete structures and concrete joints of the 10 m-deep (33 feet) basement at Chennai Airport. After benchmark tests at one of the world’s most advanced terminal structures at Changi Airport Terminal 3 in Singapore, Penetron Admix, Penebar SW and other components of the Penetron system were specified to effectively waterproof and protect the below-grade concrete structures of Chennai Airport.

**Kempegowda International Airport Terminal 1A, Bangalore, India**

To ready the airport for increased passenger traffic in the future, an expansion of the Kempegowda International Airport (formerly Bangalore International Airport) – already one of India’s busiest airports – was required.

This expansion project, carried out under the supervision of GVK Group, was divided into three phases: the construction of a lounge, retail and concession spaces; installation of new security checkpoints at arrival and departure gates (phase I); the full expansion of Terminal 1 (phase II); and construction of a new Terminal 2 (phase III).

Terminal 1A (T1A) was designed by HOK International Architects in conjunction with IMPaC. The structural, geotechnical, façade, electrical and baggage handling design services were done by Arup. To enlarge T1A's footprint to 1.5 million square feet (150,000 m²), the existing Terminal 1
was extended on two sides – the eastern and western piers. The US$ 217 million expansion lasted three years. Terminal 1A was officially inaugurated in December of 2013.

Today, a remarkable, smile-inspired, swooping roof structure forms a canopy over the main entrance to greet travelers. T1A’s design seamlessly blends with the ethos of Bangalore as a garden city by incorporating local plants and Karnataka art. Built with sustainability in mind, the structure is now a certified LEED (Gold) project.

T1A is equipped with 86 check-in counters, 26 boarding gates, 15 aero-bridges that can accommodate the giant A380 aircraft, 30 Common User Self-Service (CUSS) check-in desks and 24 emigration counters for each departure and arrival hall, as well as 13 baggage claim belts outfitted with Harman IDX Information Delivery Systems.

Passengers now have access to a range of services including 25 retail outlets, two new lounges, smoking rooms, baby care rooms, a prayer room, a day hotel, a bus lounge, a spa and 13 restaurants.

Waterproofing of the underground basement structures comprised a 30,000 m² (330,000 square foot) basement slab and a 6,000 m² (66,000 square foot) retaining wall. Work on the basement was completed in the record time of 4 months; the overall expansion project began in June 11 and was done in 18 months. The work involved a number of Penetron products including 105 tons of PENETRON ADMIX® and 20,000 m (over 12 miles) of PENEBAR SW-45 swellable waterstops.
Covering a total area of 7.6 km² (about 3 square miles), Chhatrapati Shivaji International Airport (CSIA) is India’s largest airport. To comply with international transportation standards and provide a world-class airport experience for business and leisure travelers, the modernization of CSIA (and Delhi airport) was approved by the Airport Authority of India (AAI) in 2003. In 2006, a 30-year operating concession for the airport was granted to a consortium comprised of GVK, Airports Company South Africa (ACSA) and Bidvest. In return, the consortium provided 74% of the funding required for the upgrade project.

Modernization of Mumbai airport was valued at US$ 1.26 billion and included a new integrated terminal for both domestic and international passengers, refurbishment of the previous domestic terminal, upgrade and development of the runway system, new access infrastructure for all terminals, and a new integrated cargo complex. Work started in 2008 and followed a master plan submitted by Netherlands Airports Consultants BV (NACO). This proscribed – among other works – the refurbishment and expansion of Terminal 1A, construction of a new domestic Terminal 1C, and the construction of a new Terminal 2 (T2).

The new, expanded Terminal 1 opened in April 2010, covers a total area of over 27,600 m² (297,200 square feet) and added six new passenger boarding gates/bridges to CSIA.

Designed by Skidmore, Owings and Merrill (SOM) and built by Larsen & Toubro, the new Terminal 2 was inaugurated in January 2013. This US$894.3 million project enlarges the Mumbai Airport by 208 check-in counters, 132 immigration counters for departures and arrivals, a 20,000 m² (220,000-square feet) commercial area and 5,200 additional parking spaces.

A range of Penetron products was used to treat a large portion of the underground concrete structures at CSIA, including nineteen underground machine rooms, pump houses and luggage conveying equipment rooms. In addition, three major sewage treatment plants (two with 10 million liters per day (MLD) treatment capacity and one with a capacity of 6 MLD) and 6.5 km (4 miles) of underground service tunnels were all completely waterproofed with Penetron products, including PENETRON ADMIX, PENETRON topical material, PENECRETE MORTAR and PENEBAR SW-45 waterstops.

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São Paulo–Guarulhos Airport, Terminal 3, São Paulo, Brazil
For many years, the São Paulo–Guarulhos Airport (GRU), located 25 km (15.5 miles) from downtown São Paulo, was one of the busiest and most congested airports in Latin America. The construction of a third terminal to handle up to 12 million passengers per year had already been planned in 2001, but only took shape as part of the preparations for the 2014 FIFA World Cup. Construction of Terminal 3 (T3) started in 2011 to relieve the acute overcrowding of Terminals 1 and 2. To provide an interim solution until the completion of T3, Infraero, the former operator of GRU, decided in 2011 to renovate and convert a former cargo terminal into what became Terminal 4.

Terminal 3 comprises two building blocks covering a total area of 230,000 m², (2,530,000 square feet), larger than all other GRU terminals combined. The new design for Terminal 3 was developed by TYPSA/Engecorps Group, who took over responsibilities from MAG consortium, (PJJ Malucelli, Biselli+Katchborian Arquitetos and Andrade Rezende Engenharia), who had initially won the contract. The construction of the new five and two-story buildings was undertaken by OAS. The terminal opened in May 2014.

Terminal 3 added 20 boarding gates/bridges, 90 check-in desks, and seven carousels in the baggage claim area. Inspired by European and Asian airports, Terminal 3 expanded the commercial area of GRU by approximately 100 shops, bars, cafes, restaurants and general services.

PENETRON ADMIX provided waterproofing and durability for the 25,000 m³ (32,700 cubic yards) concrete basement slab in Terminal 3. All construction joints were sealed using PENEBAR SW-55 waterstops.
Beijing Capital International Airport Control Tower 3, Beijing, China
In preparation for the 2008 Olympics, a new Terminal 3, complete with a new control tower, was added to the Beijing International Airport (PEK). Over 98 m (320 feet) in height, the Control Tower 3 is one of the tallest control towers in the world.

The Penetron System had already been used to waterproof PEK’s Control Tower 2; PENETRON was used to waterproof 2,500 m² (27,500 square feet) of concrete in Control Tower 3, including the entire basement structure and emergency water tank.
The New Orleans Aviation Board (NOAB) undertook the latest expansion of the Louis Armstrong International Airport in early 2016. The completed project added five gates to the new North Terminal, approximately 76,000m² (820,000 square-foot) with 35 gates, two new concourses, a 2,200-car parking garage, a central utility plant and a ground transportation hub. The $110 million construction project was carried out by a joint venture of Hunt Construction, Gibbs Construction, Boh Brothers and Metro Service Group.

The airport expects an estimated 6.23 million passengers in 2019, an 18% increase over the airport’s initial forecast. A five-gate extension was necessary to handle continued growth.

Located between the Mississippi River and Lake Pontchartrain, the construction site demanded a robust solution for the high-water table. A membrane/surface-applied coating was initially specified for the project when construction began in January 2016, but soon proved to be too complex and costly to install.

Ultimately, PENETRON ADMIX was chosen as a waterproofing solution for the North Terminal project. Landrieu Concrete & Cement Industries supplied over 500 cubic yards (380 m³) of concrete treated with PENETRON ADMIX for the below grade elevator pits and footings in the airport’s new North Terminal.
Tancredo Neves International Airport, Belo Horizonte, Brazil

The second expansion stage of the Tancredo Neves International Airport in Belo Horizonte began as part of the preparations for the Rio 2016 Olympic Games. The project included enlarging the existing passenger terminal, construction of a new international passenger terminal with 14 boarding gates, and expansion of the aircraft apron. This brought much-needed space to the international hub, increasing capacity to 22 million passengers per year.

The new terminal now covers an area of 53,950 m² (593,450 square feet) and is equipped with 42 check-in counters. The concrete for the foundation slabs of the terminals and the aircraft aprons was treated with PENETRON ADMIX to reduce permeability. The drinking water tank was waterproofed with PENETRON ADMIX and PENEBAR SW-55.

Cape Town International Airport, Cape Town, South Africa

Extensively expanded and renovated to accommodate the 2010 FIFA World Cup, the Cape Town International Airport added a central terminal building to link the domestic and international terminals and provide a common check-in area.

Initially, a self-adhesive membrane was specified for the new airport ramps. However, there was concern that the membrane would soften, allowing movement of the premix finish cover. Ultimately, PENETRON was chosen as an integral waterproofing solution – and also brought about significant cost-savings.
Originally dating from the early 1950s, the Chelyabinsk Balandino Airport was expanded to better accommodate the larger passenger jets that increasingly fly to the Chelyabinsk region. The enlarged and upgraded infrastructure helped expand airport capacity to over 1.2 million passengers annually.

Penetron Russia was asked to help ensure water impermeability and enhanced durability for the airport project. PENETRON ADMIX was used for the floor slabs; PENETRON topical material and PENECRETE MORTAR were applied on the walls and tie beams (binding joists).
The expansion project for the Astana International Airport included a new terminal and a two-level parking garage. The new terminal increased the airport’s annual passenger capacity to approximately seven million passengers.

Temperatures in Astana during the cold winter months can drop as low as 6°F (-14°C). Because of such temperature extremes, PENETRON crystalline materials were specified to waterproof the airport’s concrete runway aprons. PENETRON’s crystalline technology reduces the permeability of concrete and enhances resistance to damage from extended freeze-thaw cycles common to this part of Central Asia.

**Galeão International Airport, Rio de Janeiro, Brazil**

The recent transformation of the Galeão International Airport is immediately visible. The project covered four major expansions that included more boarding gates/bridges and two new courtyards enlarging the parking areas. It was critical to carry out the expansion project without interfering with the ongoing operation of the airport.

During the airport expansion work, 7,000 kg of PENETRON ADMIX were added to the concrete for the below-grade structures to ensure permanent concrete protection and meet the project’s technical requirements.
To increase annual capacity of the airport by 6.5 million passengers, construction of a new Terminal 2 (T2) began in 2004. The project was executed by a consortium of Ferrovial Agroman, Budimex and Estudio Lamela, who were responsible for the design and architecture, as well as the construction of the terminal.

Inaugurated in March 2008, T2 added over 94,000m² (1,034,000 square feet) of floor space, 70 check-in desks and 44 gates to Frederic Chopin Airport. Over 30,000 m³ (of concrete for the foundation slab were waterproofed with PENETRON ADMIX and 5,000 m² (55,000 square feet) of wall area were treated topically with PENETRON. The total waterproofed area was approximately 60,000 m² (660,000 square feet).
The 5.2 m-high and 46 m-long underpass under the feeder road to Runway no. 2, was built in the 1970's and showed severe signs of concrete deterioration, especially in the external tunnel wall sections in direct contact with the soil. Groundwater filtration into the concrete walls and joints and exposure to the elements led to carbonation of the concrete and corrosion of the reinforcement steel, which had pushed away the overlying concrete cover in some parts of the underpass.

The only way to repair the underpass without interrupting busy air traffic at Italy’s largest airport was only possible by non-destructive means, applying treatment to the concrete structures from the negative side.

Penetron products were used in the repair and restoration of the underpass below the feeder road. This involved repairing cracks, construction joints and faulty concrete parts with PENECRETE MORTAR. PENETRON ADMIX was used in the grout and concrete to repair and restore the surface of the tunnel walls. Afterwards, the entire surface was treated with PENETRON on the negative side with a spray application.