New Railway Connection below Brussels Airport

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Summary

Reaching Brussels Airport by car or by train from the Northern part of Belgium has become difficult. For this reason, a new railway connection is being built below this airport. The new link will connect the existing train station to a new 24 km long railway section from Brussels to Mechelen, located in the central reservation of the motorway between these two cities. The most important part of the connection is a 1084 m long twin tube bored tunnel, passing below the runway and taxiways. Because of this, an adequate design load for aircraft actions had to be chosen, which complies to modern aircraft characteristics. Particular attention is given to the boring of tunnels below an aircraft maintenance hangar with pile foundations. Although passive protective measures are taken to prevent damage to the building, an accidental loading case of concentrated pile loads on the tunnel lining must be considered. In addition, concrete cracking of lateral diaphragm walls of the cut and cover sections of the new railway tunnels is being considered.

Keywords: bored tunnel, aircraft design load, concrete cracking in tunnelling, tunnel boring below pile foundation.

Abstract

The main objective of the new railway connection to Brussels Airport consists of establishing a direct link between the existing underground station and a new line between Brussels and Mechelen, located at the central reservation of the motorway between these cities. Because of the general plan view of these connections, resembling to the toy called likewise, the project has been given the name Diabolo. The part below the airport itself, crossing 2 of the 3 aircraft runways and several piers and maintenance buildings, has now been fully developed and the work has started at the beginning of November 2007.

A bored tunnel section of 1084 m length will cross below the air side. It consists of two bored circular sections of 7.3 m inner diameter, the thickness of the ring segments being 0.35 m. The TBM is of the mixshield type and has a diameter of 8.2 m and allows boring of curved tunnels. The ground water level is about 2 m higher than the tube crown and slightly raises towards the station. Initially, the tunnel boring would start from the North side and arrive at the airport building. The TBM would then have been turned and the second tunnel would have been bored from this location towards the North side. This procedure was adopted, since no high-rise cranes or equipment can be allowed in the air side, and turning of the TBM does not require that type of equipment. However, the contractor has negociated special terms to allow extraction of the TBM at the air side and subsequent transportation to the North side. Hence, the second boring will be in an identical direction as the first one, and the soil and materials installations can be kept operational at the same location.

Concerning the design loads due to aircraft, there are no specific references or standards. Data have been obtained during former projects on the Brussels Airport, although the background for the data are unknown. The adopted scheme consists of a total mass of 640 tons, divided among 16 wheels of

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a possible landing gear of aircraft. Referring to modern aircraft, such as the Airbus A 380, when loaded, the total mass equals 562 tons but the landing gear has 40 wheels. Consequently, the knife loads are more distributed than in the adopted loading scheme. While landing, aircraft approach the runway in a sharp angle and thus can produce low impact loads only. In addition, calamities such as blasts and shock wave can but produce low downward loads, since the air is free to move in all directions.

An important obstacle near to the departure location of the bored tunnels is the hangar number 117, used by Brussels Airlines for maintenance of smaller aircraft. As this buildings is just 60 m away from the starting point of the tunnel boring, and the first section generally is used for fine tuning the boring parameters, the crossing may become critical. Already during the preliminary design and discussions with the client and his consultants for fund raising, the passage below hangar 117 was considered to be a critical phase. The building consists of a steel truss roof, the truss being simply supported and thus some moderate settlement should be acceptable. However, the aircraft enter through large doors, which are partly suspended tot the roof structure and are partly supported by beams. The building has a foundation of precast concrete piles. As at some locations, the tunnel crown is at 2 m distance from the pile base, there is a risk that, while boring the tunnels, and subsequent destabilization of the surrounding soil mass, the piles would suddenly collapse. The initial idea was to provide a reinforcement of the pile bases by fraction grouting. Obviously, the vertical pressure can not be active during the passing of the TBM. As an alternative, the contractor proposed to reinforce the piles by passive jet grouting, which can be sufficiently effective for the doors below the beams. However, this requires considering an accidental situation of patch loading on the tunnel lining by the pile forces.

An important design issue for underground structures is concrete crack width in slabs and walls. Severe cracking in underground structures may be harmful to the durability and the waterproofing of tunnels. Hence, crack widths have to be calculated and limited to small values, since generally a characteristic value of 0.2 mm is recommended. Normal concrete members used in civil engineering have minimum concrete covers of 35 to 40 mm. However, due to the construction method and tolerances in placing the reinforcements, the normal concrete cover of diaphragm walls is close to 75 mm, with a minimum value of 50 mm. It may be argued that the concrete, in excess of normal cover of 35 mm can be disregarded since it just adds to the durability of the element. However, this does not take into account that the actual crack width at the concrete surface is larger than 0.2 mm and the penetration of water or chlorides will be larger. Once penetration has started, it may continue more rapidly and there is no evidence that excessive concrete cover adds durability. From literature was found that limitation of the crack width to 0.2 mm is confirmed and considering a value of 50 mm for the concrete cover is recommended. Obviously, steel sections will increase beyond the minimum values necessary for ultimate limit state resistance. In addition it is recommended to verify the crack width at each construction phase.

Conclusions

A new railway connection is presently under construction below Brussels airport. The largest part of this connection consists of a twin bored tunnel. In spite of strict regulations inside the airport, the TBM can be taken out from the arrival location and transported again to the departure shaft before boring the second tunnel. The design loads for structures carrying aircraft have been chosen adequately and appear to be less important than provisions for later building above the tunnels.

Several alternatives have been considered for boring of tunnels below a hangar for aircraft maintenance, with pile foundations. The final option, including jet grouting below the piles necessitates verifying the case of concentrated loads at the pile base on the tunnel lining.

The cut and cover section of the link has revealed the relation of concrete cover and crack width, in view of the durability of underground structures. A balanced method, based on previous experience with this type of structures has been adopted.