The Turin Railway Link

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ABSTRACT

The Turin railway junction expansion project, which is at present in full swing and which should be finished in 2011, is the result of research and studies that were first started in the sixties and seventies and finished in the eighties.

A unique and unrepeatable occasion arose, during the general improvement works on the railway network, to design and plan the upgrading of the surrounding urban fabric and the area belonging to the railway. For this reason, the design foresaw that the new urban railway lines should be placed underground and that the already existing ones should be lowered and covered in order to create green tree lined areas, to improve traffic conditions and to reconnect the parts of the city that had been separated by the railway line, while valorising all the adjoining areas with a substantial redesigning of important portions of the city.

The Turin Town Planning Scheme, which was approved in 1995, intended making the Railway Link the midrib on which the so-called “Spina Centrale” was to be based, that is, the complex of areas existing around the axis of the railway line was to be opportunely redesigned through the transformation of old and by now deteriorated industrial areas into modern connection and urban development structures.

The conditions imposed by the city for the redesigning made the construction of the railway work very complicated, while the necessity of not interrupting the railway service and of reducing the disturbances to the city to a minimum proved to be a difficult challenge for the administrations involved, the designers and the work direction. The work, in short, represents, with the intrinsic potentialities, an opportunity for the improvement and integration of different city and metropolitan transport modalities.

1. INTRODUCTION

At the beginning of the eighties, the railway layout of the Turin junction was exactly the same as that of 1928 (fig. 1), the year the last part of the railway line and the railway structures were made.

The first stretch of the railway was built in 1848, between Turin and Moncalieri, with departures from the Turin Porta Nuova station, which was then called “wharf”. After this, the Dora station (1856) was built and this was followed by the Porta Susa station (1883), the Lingotto and Stura stations (1926), the Porta Susa –Susa line (1854), the Porta Susa-Valdoccio-Stura line (1856) and the Torino Porta Nuova-Torino Porta Susa line (1864). The last of these interventions, which was started in 1911 and completed in 1928, involved the lowering of the railway tracks in order to eliminate a series of railway crossings in the urban centre of Turin. In the eighties, a period of more than 50 years of inactivity as far as railway works in the city of Turin are concerned, had therefore to be dealt with.

In that period a series of hypotheses and studies were made with the purpose of expanding the railway system, which was beginning to show signs of limits in terms of traffic capacity and potentiality because of the crossings close to the various lines in the junction. However, as no further traffic
increases could be made, the railway system was proving to be an obstacle to the necessity of
development which was beginning to become evident.

One of the main concerns was connected to the problems on the Zappata crossing where four lines met
and branched off: one that went from Porta Nouva to Porta Susa and then to Milan, one from Porta
Nuova that went to Bardonecchia and Modane, one from Orbassano that went to Lingotto and
Moncalieri and one from Porta Susa that went towards Lingotto.
Other problems concerned the Crocetta junction, where the line for Porta Nuova and that for
Bardonecchia and Modane branched off just outside the Porta Susa station, while another drawback
was that of the layout of the Lingotto station which was then just a simple stop with just two lines
passing along the Porta Nuova line to Genoa and Savona.
At the beginning of the eighties, the new Torino Lingotto station started working with four tracks (the
two that already existed plus two new ones built in those years). This constituted the so-called Torino
Lingotto-Trofarello quadruplicating that allowed an opening on the southern side which improved the
junction traffic.
The guidelines for the whole project that is at present under construction were developed in those
years: after various proposals with other types of approaches, the final solution that was chosen
involved:
- the construction of a “link”, in other words a new connection between Torino Lingotto and
  Torino Porta Susa all of which was to be underground which made it possible to reach a
  theoretically already existing north-south line which was practically unusable because of the
  problems of traffic at the Zappata Crossing;
- a “quadruplicating” of the lines, in other words the addition of a couple of new lines between
  Torino Porta Susa and Torino Stura.
In this way a north-south corridor was created, from the infrastructural point of view, that crossed the
city from the first station on the southern side of the city (Lingotto) to the last station of the city on the
northern side (Stura). This infrastructural corridor suggested a service model that was defined as
“crossed consolidation”, that is, the possibility of carrying out a prevalently metropolitan and local a
train service which, coming from Lingotto (the Genoa and Savona line) could continue along the
route of the link directly to Porta Susa and then proceed towards the Torino Dora station and finally to
the Torino Stura station instead of going towards Porta Nuova (the head station from which it would
then need to exit with blockage and traffic problems).
In the same way, the trains coming from the Stura station (the Aosta and Milan line) instead of heading towards Porta Nuova, blocking and slowing down circulation, could directly continue from Porta Susa to the Lingotto station, creating consolidation in the station opposite to the direction of arrival and making it possible to have a metropolitan railway service within the city. The so-called General Town Planning Scheme of the Turin Junction was based on these ideas. This scheme included the works already carried out for the Lingotto-Trofarello quadrupling and the Orbassano railway goods yard, which was constructed at the end of the seventies to substitute the old and obsolete shunting goods yard situated in the Lingotto area.

Two important projects were foreseen in this Town Planning Scheme: the real Porta Susa-Lingotto Railway Link and the Porta Susa-Stura quadruplicating.

The first project (two tracks entirely underground) was completed and inaugurated in September 1999. The remaining part that still has to be constructed is the so-called Porta Susa-Stura Quadruplicating in which two new stops called Rebaudengo and Zappata (below the crossing of the same name) were already foreseen back in the study of the eighties, with the purpose of integrating the number of stations of a metropolitan or local nature along the already mentioned Lingotto-Stura crossed consolidation, making the passage homogeneous.

Again in the eighties, the new layout of the junction was ratified and agreed upon by the Organisations involved, that is, the Regione Piemonte, the Turin Municipality and Satti (which is now known as GTT) the concessionary of the Turin-Ceres line. This line, which passes through Caselle, was planned, in the convention that was stipulated, to reach the Dora station and then continue to service the entire Turin metropolitan junction.

In the nineties, other agreements were reached with the Turin municipal administration which involved not only consolidating the previous idea of quadruplicating the Porta Susa-Stura line but also of thinking of this work as a continuation of the already constructed underground Lingotto-Porta Susa section, thus adding to the concept of the urban upgrading of the city of Turin, with the elimination of the railway trench and substituting it with a tunnel, to that of expanding the railway lines (the Quadrupling).

2. THE LINK AND THE “SPINA”

The Link can be defined as an axis that includes the new underground lines, part of which have already been constructed and part of which still has to be finished. These lines have made it possible to develop the urbanistic concept of transformation of the surface areas above this axis, a change that was acknowledged and rendered official by the Turin Town Planning Scheme (approved in 1995).
It is useful to recall that anything that concerns the railway along this infrastructure is called Link while whatever belongs to the surface improvements is known as “Spina” (fig. 2).

The city of Turin has carried out a real urban transformation along this axis (including, amongst others, the movement of the large factories outside the city): by lowering the tracks it has been possible to create a large tree lined avenue, the so-called “Spina”, on the same area freed of the tracks.

The General Town Planning Scheme has imagined four large transformation areas named Spina 1, Spina 2, Spina 3 and Spina 4. One of the most important of these is Spina 2 which embraces the area around Porta Susa where the railway lines will be completely lowered and a new station will be built completely underground.

There are some very important urban areas surrounding the Porta Susa station including the Justice Palace (already built), the ex O.G.R. (Large Repairs Workshop) railway areas which are being upgraded (still underway) and abandoned industrial poles (a real engineering workshop in the middle of the city). It is intended to set up of a kind of scientific-cultural pole in this area.

A new library will be built in the transformation area known as Spina 2 where the Politecnico di Torino will be doubled and some of the historical buildings belonging to the O.G.R will be reused, and so on.

The other transformation areas are Spina 3 and Spina 4 which are inserted around the Link alignment and complete the transformation of the city.

Spina 4 includes the new Rebaudengo station, which originally was only to be a stop along the line, but it was later decided to make it into a station because of the decision to construct a variant that will cross the Dora River.

The main element that cannot be eliminated is the concomitance between the construction of the work, which runs alongside the present tracks, and the existence of these tracks on which the circulation of the Turin-Milan railway line takes place, a line that is important both as far as the quantity of traffic and the number of trains is concerned.

The construction, the design and the studies all had to take into consideration that the construction works had to guarantee railway service without any limitation.

Another problem derives from the fact that the works have to be carried out in a town, in an urban centre, and it is therefore necessary to divert traffic thus causing problems for the inhabitants in the surrounding areas.

The basic concept of the construction is extremely simple: it is necessary to add two tracks to those that already exist and all four should be underground.

The project is divided into two stages: the so-called West Stage, that is, the construction of the complete tube for the two future tracks (those to be added) on the west side of the present line and running alongside it in order to not interfere with the circulation of the trains and to limit the specific interference to only some points.

Once the West Stage has been completed, the traffic at present using the surface tracks can be moved into the just completed tunnel (foreseen for 2009) and then the construction works on the East Stage can be started in the area freed from the tracks that were previously in service on the surface.

When the East Stage has been completed (foreseen for 2011), a second tube will be constructed in a tunnel, then the covering will be completed and the area above the underground tracks will be returned to the city. In this way there will be four tracks underground and these will make up the Turin Railway Link.

3. THE PASSANTE AND THE TUNNELS

3.1 The axis Lingotto – C.so Vittorio Emanuele II

Looking along the axis of the infrastructure constructed from the Torino Lingotto station towards Corso Vittorio (fig.3), the alignment, which is entirely underground, presents typical sections side by side in different points along the section.
In the first stretch, at the Torino Lingotto station, the tracks of the , which are on the same level as the tracks of the station, are positioned on the ideal continuation of the Trofarello-Lingotto section of the Savona line, on the west side of the station, in correspondence to the 3rd and 4th tracks, as the tracks of the Historical lines are positioned on the continuation of the Genoa line, which runs along the 5th and 6th tracks of the Lingotto station.

Fig. 3. Section type along the axis of Passante Lingotto-Porta Susa.

Having passed the root side of Porta Nuova, the two tracks of the new plunge until they enter a tunnel, above which, on occasion of the recent Winter Olympics, the City of Turin opened the new street Via Zino Zini which leads to the centre of the Olympic Village.

Continuing along the alignment in the direction of Porta Susa, the Railway Link passes under the Corso Bramante railway overpass, an important street that passes over the railway yard in the vicinity of the Porta Nuova station and which is also an important means of communication between the centre of the city and the zone where the main hospitals in the city are located. Considering the great importance of this road, it was decided, during the design stage, to avoid closing it to road traffic and to pass under it on the inside of the first tube on the west, with a box structure in reinforced concrete which would act as a tunnel. This operation required important reinforcement works of the western abutment and of the pile together with works to improve the technical load-bearing characteristics of the surrounding ground.

After this, a section of about 350 m is encountered in a traditionally dead hole excavated tunnel. The construction of this stretch inside a tunnel made it possible to avoid interrupting a fundamental road artery of the city, Corso Turati, and to pass a stretch which is characterised by a strong asymmetrical thrust due to the surrounding morphology, passing under the Historical line in the end section close to the Zappata crossroads, with an overburden of just over 2 m between the tunnel extrados and the tracks in service, through the use of a pre-excavation drift to improve the characteristics of the soils and a refined automatic survey system of the levels of the platforms with continuous readings of the settlements/rises. A series of horizontal parallel micro-piles, solidarized at the two ends with a connecting beam in reinforced concrete to minimize the differential settlements and consequently the curving of the tracks during service conditions, were inserted in order to stiffen the tracks above in a transversal and longitudinal direction. The present tunnel was excavated utilizing traditional methods using the double umbrella technique with jet-grouting in advancement, underpinning with jet-grouting in the lining section on the crown, the subsequent completion of the excavation and construction of the reverse arch.(fig. 4).
The main principle used in the construction of the Turin Railway Link is that which is known as the “Milano” method. This method involves the construction of bulkhead diaphragms at the height of the ground level (the future walls of the railway tunnel); for this reason hydro-cutters were used. This construction method was “suggested” by the nature of the Turin soils which are basically made up of sandy gravel of an alluvial origin with the presence of lenses, without any distribution law, and of particularly cemented layers (pudding stones) which are difficult to attack when confined. The height of these layers varies over a few decimetres and rarely goes above 1-2 m, with an area extension that on average can be evaluated as about 5-10 m. The used methodology made it possible to obtain a greater construction velocity and more detailed dimensions of both the Kelly and the cable of the digging bucket. The adopted method, although requiring the almost total removal of the surface utilities, allowed the surface to be improved once the upper slab had been installed, the reopening of the town roads with a minimum impact on the environment (dust and noise) and also allowed work to be carried out at night when necessary. After the covering slab had been placed, the tunnel below was excavated till the height of the intermediate slab (when present), then this was cast and the excavation was continued until the bottom slab was placed.

The tunnel is almost completely made up of two side-by-side tunnels, the Historical line on the west and the Porta Nuova-Porta Susa Direct line on the east, with the Railway Link running along under the latter line for most of the stretch.
The tunnels divide into four sections close to the Crocetta junction (see fig. 5) with the mouth of the line to Modane on the west, the Historical line in the centre and the Direct line on the left of this with the Railway Link below. The Railway Link, which first passes under the Direct line, gradually moves west under the Historical line and then even further west and re-emerges at the station track level so that the three lines (Direct, Historical and Railway Link) arrive at the entrance to the Porta Susa station on the same level. The translation took place in stages with the railway remaining in service and being transferred from time to time into the tube that was free of work. A beam planking structure was constructed in subsequent stages with incorporated iron and it was then solidified. This allowed the railway service to continue above and the excavation of the Railway Link diagonally below.

One of the relevant problems that had to be faced during the construction stages of the new structures for the Turin Railway Link concerned the crossing of Corso Vittorio Emanuele II at the level of Corso Inghilterra and Corso Castelfidardo.

Given the importance of the Corso Vittorio road in the road system of the city, it would not have been possible to adopt a tunnel design solutions that would have been generally accepted along the alignment. It was therefore decided to proceed with the construction of two 12 x 12 x 15 m monoliths in reinforced concrete on either side of the Corso which were later scissor pushed down using oil-pressure jacks, one to house the Railway Link, on the left of the railway line in service and the other placed on the right of the Torino Porto Nuova – Torino Porta Susa Direct line.

3.2 The axis C.so Vittorio Emanuele II – C.so Grosseto

The section that goes from Corso Vittorio Emanuele to Corso Grosseto was inserted into the second Lot of the works concerning the Turin Railway Link. Again in this section the design choice, strengthened by the experience of the first lot, was focused on the use of the “Milano” method. Two thirds of the future Porta Nuova station had already been constructed at this stage; the station foresees six tracks at about ten metres below the Corso Inghilterra road surface and part of the west tunnel, the site of the real quadruplicating.

At this stage of the work, a fundamental preparatory procedure, without which it would not have been possible to have the areas ready to carry out the work, that is, the movement of the utilities, deserved particular attention. Piazza Statuto proved to be one of the most critical nodes: more than a hundred utilities of different kinds (light, gas, telephone, optic fibres, etc…) ran under this square. It was necessary to move these, in different stages, while maintaining service, in order to be able to prepare the areas for the continuation of the excavation and construction operations.

It was also necessary to move and complete the largest sewage collector of - water in the city of Turin (Ø 2500 mm); it was necessary to carry out this work while the previous collector continued to work but also trying not to interfere too much with the urban road traffic.

The portal structures were also constructed in Piazza Statuto at the crossroads with Corso Francia, and these had the purpose of allowing the city Underground system that was being built at that time to pass underneath line 1, as there were three tunnels one above the other at this point. At the same time that the square was being passed under, quadruplicating the lines with two separate tubes, the Turin Municipality requested that this square be changed, at a level above that of the railway, to a vehicle underpass and that the other higher tube should be arranged as an underground car park. It should be noted that, during the construction of the Railway Link, the opportunity arose of creating spaces that were not occupied by the railway line and these spaces were utilized to create five underground car parks able to house a total of more than 1000 cars.

As far as the construction of the new Corso Regina Margherita railway underpass is concerned (today the railway line passes over it), a prefabrication technique was adopted and an innovative multiple hinge arch was constructed with a span of more than 20 m which made it possible to save more than six months, compared to traditional technologies, during the construction works. Construction took place during the summer period in order to reduce the impact on the urban traffic.
3.3 The Variant of the Dora River underpass

During the nineties, a project was drawn up in the general railway planning programme of the City of Turin to pass under the Dora River using a metallic girder structure at the same height as the railway tracks in the present Dora station and to directly join the Torino-Ceres GTT joint line with the RFI (Italian Regional Railway) at the Torino Dora station. The alignment should have then re-emerged on the surface after Corso Grosseto.

At the beginning of 2000s, after a careful examination by the City of Turin, it was decided to put the entire line underground with a consequent underpass on the Riparia River thus allowing the total rejoining of the last portion of urban texture still divided by surface railway lines in an ex-industrial zone, which has been evaluated as being more than 6 million square metres and which is at present undergoing an important housing expansion with the possibility of conversion into service structures. This involved a re-examination of the project “The Dora Riparia River underpass” which had been designed according to a feasibility study that had been drawn up by Prof. Sebastiano Pelizza of the Politecnico di Torino in 2002 on behalf of the City of Turin. The new version involved placing the line underground at about 20 m from the Dora station tracks thus making it very difficult to maintain the present connection of the GTT tracks with the State Railway. This meant it was necessary to invert the functions between the Dora station, which would become a stop, and the Rebaudegno stop, which would become a station. It was also necessary for the GTT lines to enter the latter station and therefore to add three new lines, side by side, to the already foreseen four Italian Regional Railway lines for the parking of the GTT trains and connection to the State Railway network. The idea of going underground was formalised in the 2002-2003 period and the present works were granted in the middle of 2005 with an integrated contract.

The construction of the second lot was also designed according to the “Milano” method. The construction was aided along most of the section by an abundant bottom layer in jet-grouting in order to prevent siphoning of the excavation bottom as a great part of the alignment falls within the ground water table.

Fig. 6. Construction of railway between Corso Vittorio Emanuele II and the Dora river.
At the end of the Rebaudegno station, the tracks, which pass under the present Corso Grosseto railway overpass, emerge and join up with a quadruplicated section, which was built back in the eighties, that goes from Corso Grosseto to the Torino Stura station and includes a double viaduct next to the Stura di Lanzo River in substitution of the already existing metallic girder structure which needed substantial reinforcement work. The entire work, carried out in functional stages, foresees the western part being finished in the first half of 2009 and the eastern part, below the present tracks, being completed in 2011.

The cost of the entire work is about 1.5 milliard euros.

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