Station M5 Lotto: une intégration entre deux lignes dans le métro de Milan

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G. Lunardi, *Rocksoil S.p.A., Milan, Italy*

L. Mancinelli, *Rocksoil S.p.A., Milan, Italy*

S. Viganò, *Metropolitana Milanese S.p.A., Milan, Italy*

Résumé

L'article décrit le projet et quelques élément constructifs de détail à propos de la nouvelle station M5 Lotto, à Milan (Italie). Cette station, la plus profonde de la ligne entière, a vu l'emploi de choix techniques particulières. L'attention est concentrée sur la conception des nouvelles structures, intégrées à celles existants, qui constituent ensemble un important noeud du transport public souterrain, qui met en communication la ligne 1 (existent) e la ligne 5 (nouvelle). En décriant les études qui regardent les fluxes des utilisateurs, base pour le renouvellement de la station Lotto, en considérant le nécessités constructives due à la présence de bâtiments, d'un important trafic local et aussi de spécifique aspects techniques et opératifs, l'article suit la construction des œuvres. Au même temps quelques procès particulier de travail sont illustrés.

Abstract

The paper describes design and construction details of the new Lotto metro 5 station, in Milan (Italy). This station, the deepest of the whole 5th line, required particular technical choices and construction stages. The contribution focuses in particular on the conception of the new structures that, linked to the existing ones, constitute an important public underground transport node connecting the existing line 1 and the new line 5. General construction steps are here described starting from people flux studies, basic elements that support the idea of the node of Lotto, and considering the restraints represented by the existing buildings, local traffic control, as well as the specific, technical and operative needs. At the same time, particular work procedures and their application are also shown.

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1 Introduction

In Milan, construction on the new Metropolitan Underground line M5 (lilac) is currently underway. Said work is split into two portions, the first of which was built between the Bignami station and the Garibaldi station and later integrated by an extension connecting the Garibaldi itself to Harar one. Overall, the line counts 19 stations, for a total length of 12.2 km, 5.8 km of which on the Bignami-Garibaldi track and 6.4 km on the Garibaldi-San Siro one. A very important phase of activity will consist in developing the Lotto station to accommodate integration of the new M5 line with the existing M1 one (red).

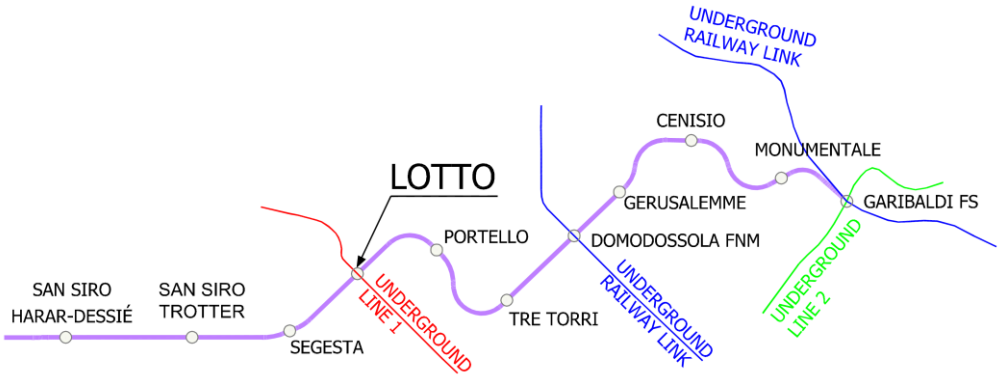

Figure 1. Chart of the M5 extension (second portion of the work) including intersections

Development of the Lotto node required building a new station for the M5 line with a volume of excavation, limited to the main shaft alone (greatest depth 32 m), of 52000 m^3.

Said construction is equipped with a few independent exits and is linked to the M1 station through an underground passage. This system necessarily required the existing structures to be adapted: new exits with fixed stairways, escalators, elevators. The original construction had been built during the '60s and therefore the project was based on the original documents, on specific inspections and evaluations, as well as on an assessment campaign focussing upon the reliability of the archived documents and upon the state of the structures.

Below you will find a summary of the studies that defined the new M1-M5 intersection, especially concerning the transit volume of users to the foreseen itineraries and to the overground exits. Finally, you will also find details on the operative necessities caused by the context of activity.

2 New concept of the Lotto node

Study of the flow of travellers between the new M5-Lotto station and the existing M1 was the basis on which the new structures were defined. In order to build an efficient link between the two structures it became necessary to not only consider the normal interexchange flow between the two underground stations when at their highest usage ("systematic" peaks), but also foreseeable traffic peaks in the following situations:

- ♣ the M1 branch where the Lotto station is situated leads to the trade-show structure of FieraMilano, the last station of which "Rho-Fiera" will furthermore be the site for Expo 2015 (the Lotto intersection and the M5 line itself are strategically pivotal for this event);
- ♣ the last station of the M5, "San Siro Stadio" is placed near the Meazza stadium, which hosts great sports and entertainment events.

The Milan Municipality, on the basis of these elements, commissioned the AMAT (*Agenzia Mobilità Ambiente e Territorio* – Environment and Territory Mobility Agency) to study the capacity of the designed structures in supporting the foreseeable flows in said specific situations.

The Lotto-M1 station was a Terminus for the original part of the first Urban Metropolitan line of Milan, opened in 1964. It was built by "cut & cover" method like all old M1 stations, (top of rail at about 9.5 m from the roadway) and it is made of two platforms and a concourse level.

The Lotto-M5 station is similar to the "typological" one used in various situations pertaining to the M5 Garibaldi FS-San Siro section and presents an island platform (in line with the presence of two single-track tunnels drilled by means of TBM - Tunnel Boring Machine). Unlike all other M5 cases - which usually present a top of rail (TOR) averagely at +108 m below sea level and a single intermediate floor ("technological floor") between the concourse and platform levels - the Lotto station is much deeper, with TOR at around +98.5 m bsl and three intermediate floors; said altimetry is due to the fact that in Lotto square the M5 tunnels underpass the M1 ones.

The two Lotto stations are connected by an underground passage with two overlapping corridors, which guarantee:

- ♣ transit between the concourse areas of the M5 and M1 stations set outside the turnstiles, called "no-pay" areas (higher corridor);
- ♣ passage between the M5 and M1 platforms and vice-versa, towards Rho Fiera and Sesto FS (lower corridor).

The intersection between the two lines is therefore in correspondence with the "paying" areas of the two stations, between the second underground level of the M5 station ("3rd technological floor") and the M1 platform leading to Rho Fiera. Passengers coming from the M5 towards the M1 leading to Sesto FS therefore have to move up to the concourse level and then down again towards the platform on the other side; this passage overlaps with the flow of travellers from the M1 station itself and travellers from the opposite direction, and is therefore the most critical situation.

The AMAT study has foreseen a flow of 2,260 travellers coming from the M1, Rho Fiera platform (Sesto FS direction) in the 7:00÷9:00 timeslot and directed towards the M5; it has also foreseen a flow of 2,160 travellers from the M5 to the M1 headed towards Sesto FS, for a total of around 4,400 travellers intersecting with the two lines and interfering with the flows of the M1.

During the events of the Meazza stadium, 15,000 people are expected to use the M5. In the 19:00÷20:00 timeslot the flow will overlap with the regular usage. In this case, the M1 and M5 intersection will manage 8,500 travellers.

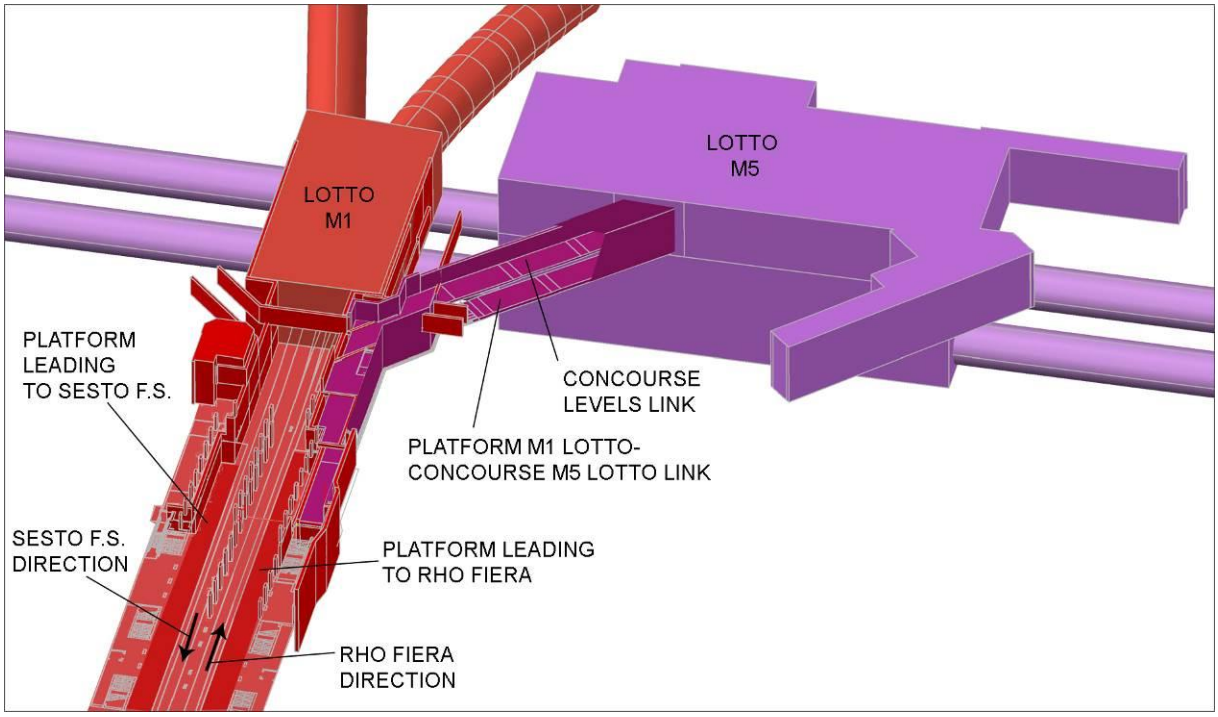

Figure 2. Chart of traveller flow

From a point of view of space management, the most critical situation was the connection of the lower corridor to the M1 station for the needs of travellers coming from the M5 towards the M1 platform and headed in the direction of Sesto FS. These travellers would have had to pass through a platform section before reaching the stairs for the concourse level, with serious risks of overcrowding.

The proposed solution was to widen the station structure and the M1 platform, as well as to invert the stairwell and the escalator (Figure 3 – operation n° 1) to make them directly accessible to passengers coming from the M5.

A new stairwell at the north-west corner of the station was designed to guarantee an adequate number of exits from the M1 concourse level (Figure 3 – operation n° 2). The new exit stairway was essential also in the stages of construction for the tunnel connecting the two lines; indeed this was made necessary during the temporary closing of the two existing exit stairs, which were set along the path of the tunnel itself.

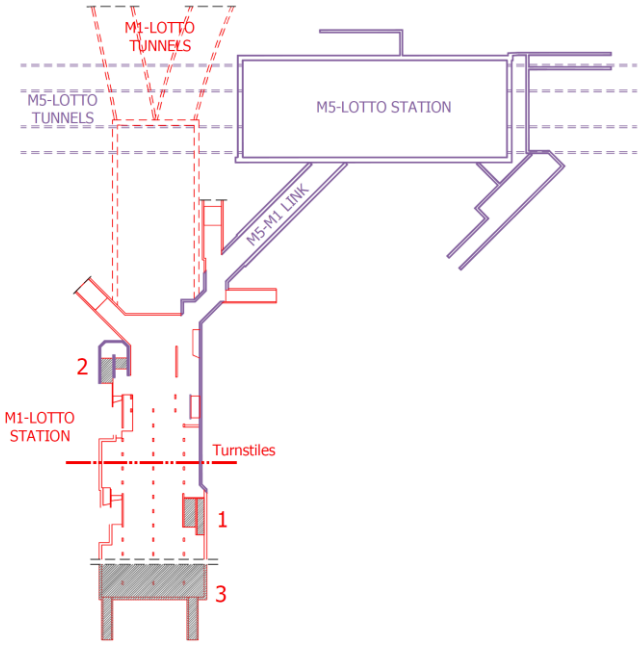

Figure 3. Planimetric overview of the Lotto station, indicating the existing and the new constructions

Redevelopment of the M1 concourse level was designed in order to contain the flow of travellers on the M1 interfering with those travellers intersecting with the M5 (Figure 3 – Operation n° 3). This concourse level has occupied the entire length of the station (about 110 m) since its construction, yet it was open to the public only in part and thus nullified two of the four staircases on each of the two platforms. The redevelopment has brought about a new face of turnstiles and the usage of two staircases between the concourse level and the roadway, which already existed and hadn't been used up to this point. Said operation also included three new elevator shafts for disabled passengers to access the M1 station.

3 Construction solutions

Having defined the functional traits of the Lotto station, the following paragraphs describe the details regarding the main construction activities on the new M5-Lotto station and the adjustment of the existing M1-Lotto station.

The Lotto station is located in a heavily urbanized area of Milan, with many buildings, constructions and roadways. Furthermore, the presence of the Urban Metropolitan Line 1 and the geotechnical context itself – layers of gravel and sand – required a specific construction system.

Construction was mainly focussed on building the new M5 station, meaning the main shaft and its corresponding exits, from the tunnel transferring to the Line 1 as well as adapting the existing M1 station to the foreseen flow of people. All these activities required facing construction obstacles such as adjusting the existing structures with new stairwells, new elevators, etc.

3.1 The new M5 station

The new M5 station was developed using diaphragm walls, cut by hydromill machine, and completed by a system of cement injections (at the base of the shaft), thus creating a "waterproof box" necessary for the excavation to proceed. The support system made use of tie rods, metal struts and "top-down" slabs (Figure 4), assembled during the descent phase and directly linked to the perimetric diaphragms by specific connection keys, thus requiring construction of preventive pillars on the ground (Figure 5).

Figure 4. Construction stages: top-down slabs

Figure 5. Temporary steel pillars

Construction of the M5-Lotto station also presented challenges in allowing access to the two TBMs. These then proceeded to drill the tunnels to an internal diameter equal to 6.70 m and lined by a pre-fabricated ring in reinforced concrete (30 cm thick) made up of five segments plus key.

The side that the machine was projected to enter from (break-in) couldn't be adequately strengthened and protected from water (entry waterproofing) – actions that are necessary to avoid groundwater from entering the station –, so it was necessary to build two "false tunnels" (Figure 6). These temporary structures are built inside the station and necessary to defend the machine during the entry phase. Specifically, these waterproofed encasings in reinforced concrete help the machine to advance while resisting the head and backfilling pressures the hydraulic one. The length of these tunnels is such that all hydraulic communication between the inside and the outside of the station during the arrival of the TBMs is stopped, thus achieving the entry waterproofing mentioned before and is also used for the re-exit of the machines itself (break out).

The advantage of this solution is that activities can proceed independently from the works of the station, thus saving time.

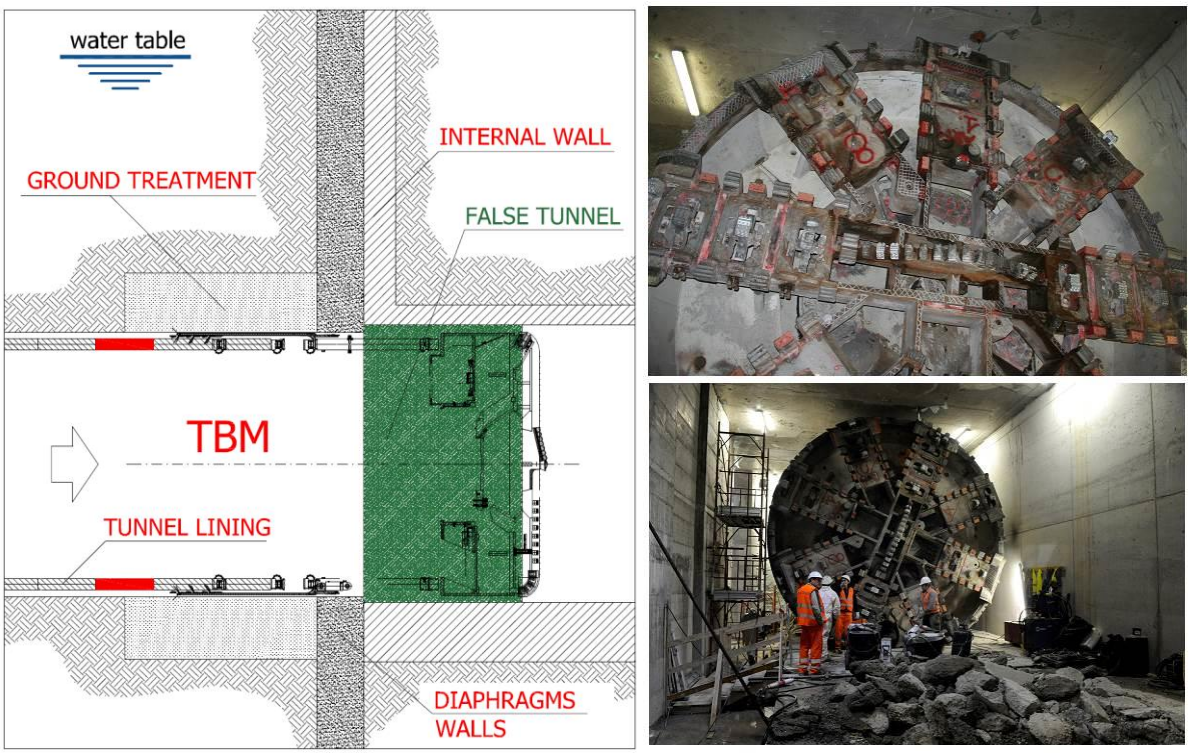

Figure 6. TBM break-in

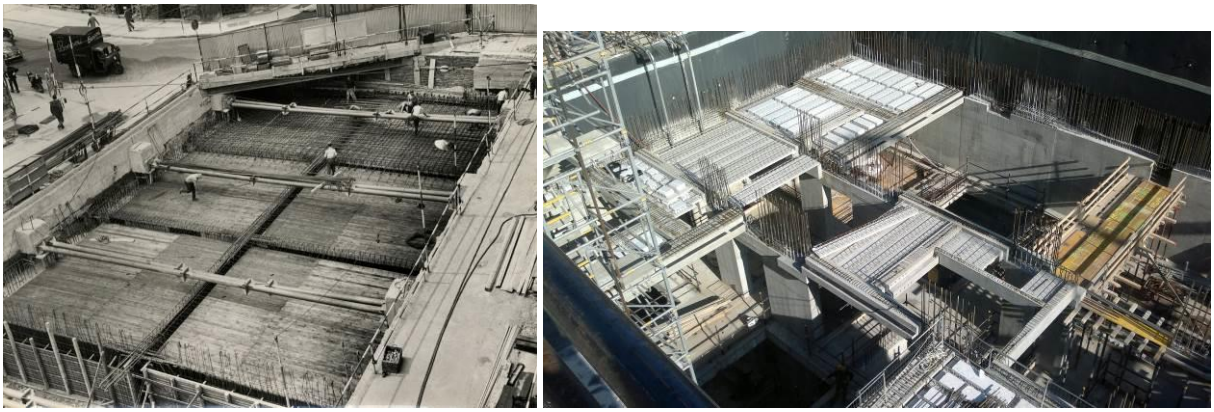

Figure 7. Construction of an underground station roof (Palestro-M1 '60's – Lotto- M5 2013)

3.2 Adapting the existing M1 station

At the level of the concourse floors, a tunnel connects the M5 station to the M1. Adapting the M1 station required upgrading the exits and widening the platform accessing the M5 (direction Rho Fiera). Initially, holes were made in the existing structures for the new elevators and stairwells alongside the required vertical and horizontal construction elements in reinforced concrete. Activity on the platform level also required delicate precautionary workmanship to guarantee the stability of the existing structures during the work phases.

Temporary and definitive works were both set up along with a detailed stage sequence. In order to reach the necessary volumes, the excavation used a system of steel piles walls, horizontal struts and anchors; these piles were also joined to the diaphragm walls of the existing station to guarantee vertical stability.

Construction of the new pillars at the widened area of the platform was carried out in stages and dividing the work into little portions (Figure 8) following these phases:

- creating openings in the existing wall;
- construction of new pillars connected to the foundation and the top slab;
- demolition of the pre-existing wall.

While these works were underway, the M1 line continued to function normally.

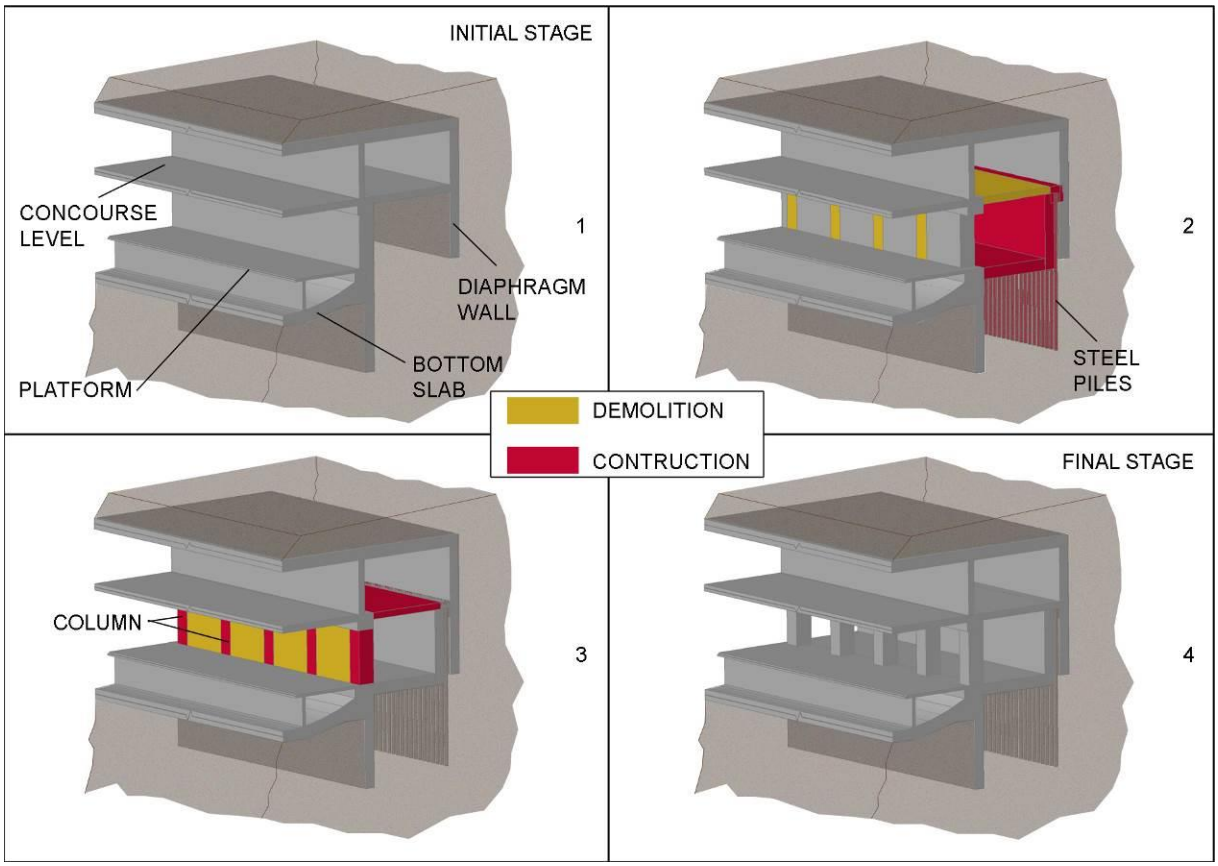

Figure 8. Summary of construction stages of the pillars for the widening of the M1 platform

The structural operations on the top slab (inserting new holes for the elevators or inverting stairwells) required a static configuration in line with the original one, without increasing action on the existing structures. When creating new holes near the station walls, placed against the ground, special care was taken efficiently contrasting the horizontal floor against the pressure of the ground and of water.

Construction of the tunnel connecting the two stations required open-air excavation with the protection of reinforced concrete walls or steel piles. Only a short section required use of the “top down” method for the underground services to remain functional.

The unique aspect of this operation was the interference of the tunnel’s path with two exit stairwells of the Lotto-M1 station. As said above, this required the temporary closure of said exits and the opening of a new stairwell onto Monte Rosa (to keep in use even after the work is completed).

Vicinity with buildings required a monitoring system for subsidence and its correspondence with design projections.

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