North Hollywood Station West Entrance—A Successful Connection of Metro Red Line Subway and Orange Bus Line

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ABSTRACT: The North Hollywood Station is currently the final stop of the Los Angeles Metro's Red Line Heavy Rail subway. Metro's Orange Line Bus Rapid Transit (BRT) Terminal is located on west side of Lankershim Boulevard across from the North Hollywood Station. Typically, there is a very high volume of patrons transferring from Orange Line Bus to Red Line Train going to Union Station in the mornings and vice versa in the afternoon. The heavy pedestrian traffic crossing Lankershim Boulevard to connect these two lines created a safety hazard for the patrons as well as traffic congestion for the vehicles in the north-south directions. The North Hollywood Station West Entrance was designed to address the above safety and congestion issues by providing a direct underground connection from the station concourse level to the ground surface via a stairway, single escalator, and two elevators. This new 150 feet long, 50 feet wide, and 40 feet deep underground entrance, constructed using cut-and-cover method, also houses ancillary equipment rooms to serve its operation. This paper will discuss in detail the design and construction challenges of this design-build project including: design optimization, deep excavation in a narrow footprint, tight budget and schedule, and connection to the existing structure and system.

INTRODUCTION

The North Hollywood Station is currently the final stop of the Los Angeles Metro's Red Line Heavy Rail subway. All patrons who wish to travel further north must cross Lankershim Boulevard to connect with the Orange Line Bus Transit Terminal. This resulted in about 50 to 100 people attempting to cross Lankershim Boulevard every 10 minutes or so, which posed an unsafe situation and contributed to traffic congestion. The connection time was also long and inconvenient due to the traffic signal timing at this busy intersection. To improve the pedestrian safety and vehicular traffic in this area, the Los Angeles County Metropolitan Transportation Authority (LA Metro) advertised the MRL/MOL North Hollywood Station West Entrance design-build project in 2013. The new entrance will also reduce connection time between the lines; hence improving capacity to accommodate the growing ridership. The contract was awarded to the Skanska-AECOM team in early 2014 as the lowest bidder. The design-builder team has overcome several design and construction challenges to complete the project in time. The new entrance was opened to the public on August 15, 2016. The project was well received by the community as it has greatly improved the pedestrian safety and traffic in the area.

DESIGN CHALLENGES

The main challenge of this project is to fit many components within a small footprint. These include the passageway, stairs, elevators, escalator, mechanical room, electrical room, elevator machine room, fresh air intake and exhaust ducts, and oil-water separator pit. The passageway connects to the existing North Hollywood station at the concourse level, which is located at approximately 40 feet below grade. The ground conditions at the site consist of interlayers of loose to medium dense silty sand and medium dense, fine to coarse, poorly graded sand. The underground

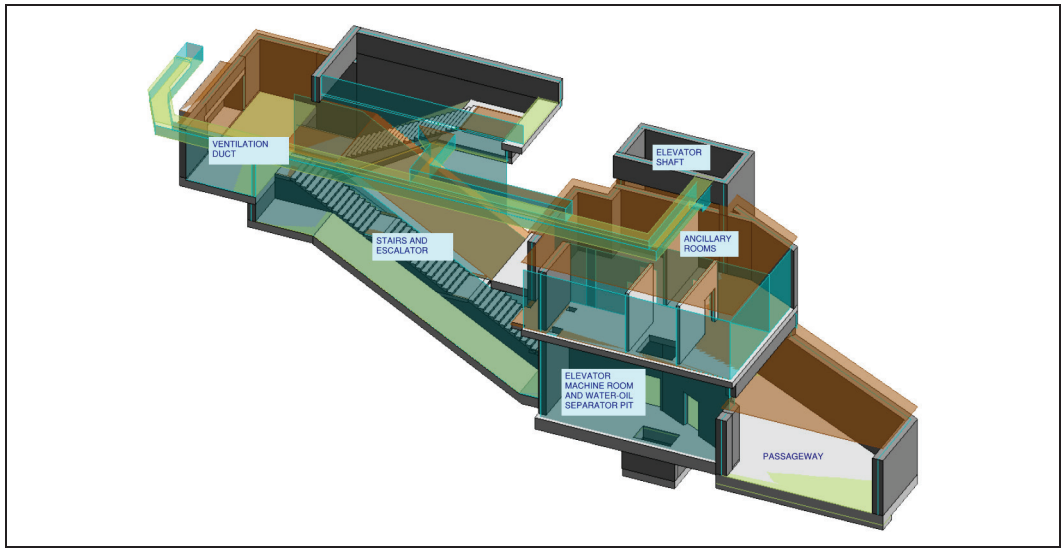

Figure 1. North Hollywood Station west entrance

structure is located above groundwater level. A 3D view of the underground entrance structure is shown in Figure 1.

In the request-for-proposal documents, the ancillary rooms were located underneath the stairs and escalator and at the same level as the passageway. This room arrangement would require the entire site to be excavated to 40 feet below grade to build these rooms and backfilled to the ground surface once they are constructed. During the bid proposal, major rearrangement and optimization of the room layout was done by the design team to make use of the available space and provide the contractor with competitive bidding costs to win the project.

First, the ancillary rooms were relocated to above the roof of the passageway with exception of the elevator room, which was kept at the passageway level as required by Metro's vertical transportation group. This allows the contractor save both excavation and backfill volumes. However, locating the ancillary rooms on the second floors required service stairs, which were difficult to accommodate within the very confined footprint. Fortunately, the existing emergency stairs No. 8, which were used for the North Hollywood station, were no longer needed after completion of the new entrance. These stairs were located within the site footprint and were to be demolished prior to the entrance construction. The design team reutilized a portion of this existing stairs that connects to the North Hollywood station to provide the access to the ancillary rooms on the second floor of the new entrance structure.

Second, the entrance structure was designed during preliminary engineering to be several feet away from the existing North Hollywood station structure to connect to the exit point at the surface. The design team reconfigured the entrance structure to build it against the existing station wall. This allowed the contractor not only to save costs by reutilizing the existing support of excavation system of the subway station, but also gaining additional space for the elevator machine room and oil-water separator pit.

Third, during the final design, a concern was raised by the community about a need for the increase of capacity when the Orange Bus Line is converted to a light rail line. As a result, knock-out-panels were introduced on the entrance walls to allow to expand the entrance structure to accommodate an additional escalator or stairs if the need for increased capacity exists. In addition, the design team also overcame other challenges such as fitting the location of the exhaust shaft to be 40 feet away from intake shaft and other entrance points, resolving conflicts of new traffic signal pole foundation with the existing station structures, etc. Details of structural analysis are discussed in the section below.

The main structures of the new entrance consist of the underground reinforced concrete structure and the elevator and escalator steel canopies above ground. The structures were designed in conformance with the Metro Rail Design Criteria (MRDC) and California Building Code. The steel canopies were analyzed using RISA 3D. Due to its variable shape, the underground structure was designed with SAP2000 3D using cell elements. The new underground entrance structure is connected to the existing station through the existing embedded couplers

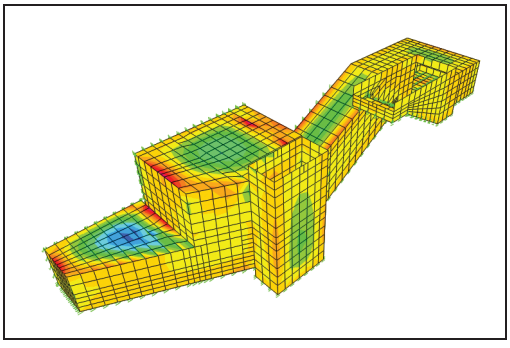

Figure 2. Results from SAP2000 3D model

and rebar dowels. The connection was modeled using link elements. The properties of these link elements were specified based on the structural capacity of the existing dowels and thickness of concrete elements at the connections. The ground support was modeled using compression-only soil springs at the base slab. Figure 2 shows an example of results from the SAP2000 3D model.

The results from the SAP2000 3D model were used to design the structural elements of the entrance structure for the static loads. For the seismic design, some typical sections of the entrance structure were analyzed for the seismic racking that is typically required per MRDC for cut and cover structure. The racking deformations that were previously developed for the design of the existing North Hollywood station for the maximum design earthquake and operating design earthquake were used for this new entrance structure. Even though the entrance structure is located above the permanent groundwater level, a hydrocarbon resistant (HCR) membrane was also designed to cover the entire underground structure to prevent water and gas leaks into the structure.

As discussed above, two knock-out-panels were designed on the walls to allow the future expansion of the entrance to include an additional escalator or staircase. A knock-out-panel (KOP) is typically a predefined opening on the walls of the structure where the boundary elements around the opening are designed to allow safe removal of the KOP without impact on the remaining structure. Rebar arrangement and construction joints are designed to facilitate removal of KOPs in the future. In addition, the anchored water barrier strips are embedded in the concrete wall around the KOP to allow the future removal of the HCR membrane at the KOP without compromising the remaining water/gas proofing system. The KOPs have been designed for several existing subway stations in Los Angeles where an increase in future ridership is anticipated. New entrances will be built and connected to the existing stations through these KOPs to accommodate the growing demand.

CONSTRUCTION CHALLENGES

The construction experienced several major challenges. The project site is very small and located between busy streets. Figure 3 shows the approximate the worksite footprint and the laydown area. Due to the confined worksite and the fact that the project was being constructed between two active subway and bus lines, the entire project was built from only one access point. Material was transported by forklift to and from the laydown yard crossing Chandler Blvd. The construction team had to carefully choreograph all construction activities to overcome this logistical constraint while maintaining production efficiency in order to stay on schedule.

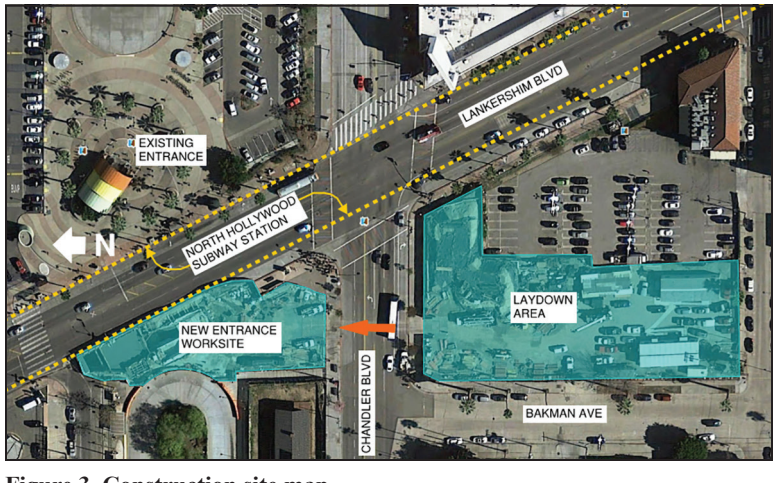

Figure 3. Construction site map

Figure 4. Extended existing soldier piles for reutilization

Figure 5. Small size excavator for low headroom excavation

This condition existed the entire time of construction, from the very beginning of the soldier pile installation to the final placement of the street level architectural colored concrete at the plaza.

The entrance was designed to allow the use of existing soldier piles of the North Hollywood station. This provided a big time and cost savings to the overall project. In all, there were twenty (20) soldier piles that were reused. However, the challenge was that these piles were cut off to a depth of 6 feet below grade when the North Hollywood station was completed. In order to fully utilize these existing piles, they needed to be extend to the existing street surface level before start of excavation. A great amount of effort was spent on locating these piles, trenching, and welding to extend them to the street level. Figure 4 shows an example of some soldier piles after they were extended. The reutilization of the existing soldier piles proved to be faster and cheaper than installing new twenty-four inch by fifty plus foot piles.

The next challenge with the support-of-excavation was installing a temporary roadway deck at the very north end of the excavation. The original excavation layout called for a 100% open cut excavation; however, because the turning radius at the north end of the excavation and the adjacent roadway was not wide enough to accommodate large trucks, the City of Los Angeles Department of Transportation (LADOT) required a temporary steel deck to support the roadway allowing for a 26-foot radius turn versus 14-foot. The addition of the steel deck resulted in an excavation that was now only 90% open cut. To make up for the production impact caused by the steel deck, the construction team utilized smaller excavation equipment: a mini-excavator and a skid-steer as shown in Figure 5. Their smaller pieces of equipment were able to work below the steel deck and maintain our production and thus schedule time.

Figure 6. Cutting 4-foot thick reinforced concrete KOP

One of the biggest challenges was demolition and removing the existing KOP in order to make the connection of the new entrance structure with the existing North Hollywood Station. To reduce the risk of potentially causing any damage to the existing station structure and utilities, the construction team decided to use a diamond wire-saw versus the conventional method of using a 2600 lbs hydraulic jackhammer ram at the end of an excavator arm. The diamond wire-saw method was carefully planned to precisely cut the station wall to avoid damages to the existing structure as well as to avoid additional concrete to be removed with handheld tools. The end result was a big success. The demolition did not cause damage to the existing structure and the exact size of the KOP was removed. Figure 6 shows how the 4-foot thick KOP was cut and removed.

In addition, due to incompleteness of the as-built documents of the existing station, the construction team could not locate the existing tie-in electrical

Figure 7. Installing escalators

conduits and the existing rebar couplers (or formsavers) to make connection with the new entrance structure. The team spent 20 days locating the electrical conduits with the use of specialized camera equipment. It was discovered that the existing conduits were located outside of the tie-in point. This resulted in beginning the construction work from the opposite end and finishing at the tie-in point. And in order to maintain schedule and reduce the 20 days impact, the construction team built the exterior concrete walls simultaneously. On the 30-degree sloped area, the exterior walls of the stairs and escalator were braced against each other, which meant that both walls were placed simultaneously enabling the formwork to support itself from both sides.

The next challenge was figuring out how to install the new escalator in the very tight space while coordinating with the other concrete work. The new entrance consisted of two new escalators, one 60-foot long and the other 40-foot long. The longer 60-foot escalator was at the bottom of the entrance and needed to be installed prior to the construction of the new entrance roof. This was a significant challenge for several reasons. First, timing of the delivery of the escalator as to not impede the schedule was critical. Second, lowering the escalator into place and avoid hitting the support-of-excavation struts and roof rebar was difficult. Last, it was critical to ensure the onsite crane had the capacity to pick and set the escalator into place. To overcome these challenges, the escalator arrived on site two months early and the roof rebar was shortened by installing 90-degree rebar with couplers at the ends in order to add on the required rebar splice length later. Last, the escalator was fabricated in four sections each within the cranes lifting capacity. Figure 7 shows how the escalators were installed.

In conclusion, the construction of the North Hollywood Station West Entrance was challenging due to various constraints and a very tight footprint. The linear construction activities made up 90% of the time due to these constraints. However, due to proper planning and good project team work, the construction was successfully completed on time and budget. Figure 8 shows the entrance at its completion.

Figure 8. North Hollywood Station west entrance completed

Figure 9. Patrons crossing Lankershim Boulevard prior to North Hollywood west entrance open

Figure 10. No patrons crossing Lankershim Boulevard after entrance open

SUCCESS OF THE PROJECT

The MRL/MOL North Hollywood Station West Entrance project was designed and constructed to ensure safety for the patrons commuting between Metro Orange Line and Metro Red Line. The new underground entrance was engineered to utilize a narrow strip of Metro owned property and connect to the North Hollywood station through the existing knock out panel. The design-builder has overcome numerous challenges and accomplished the objective of the project. The new entrance has not only created safe transfers between two different modes of transportation for the patrons, but it has also reduced their transferring time. It has helped reduce the traffic back-up for the vehicular traffic. The project provides the patrons with conveniences with the operation of new escalators, elevators, and ticket vending machines. The design complies with ADA requirements for the patrons.

The construction was completed on time without causing any significant inconveniences to the patrons. It was opened to public on August 15, 2016 and has been well accepted by the community. Figures 9 and 10 illustrate the pedestrian traffic improvements due to this new entrance structure. Due to its success and contribution to the community, the project was awarded the Outstanding Active Transportation Project of the Year by the Metropolitan Los Angeles Branch of the American Society of Civil Engineers in July 2017.

ACKNOWLEDGMENT

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