Gall Zeidler Consultants
Geotechnics | Tunnel Design | Engineering

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Nasri A. Munfah, P.E.
Principal

Years of Experience
40

Education
Post-graduate Studies, University of Michigan, 1977-78; Various Management Courses
M.S., Structures and Geotechnical, Michigan State University, 1976
B.S., Civil Engineering, University of Aleppo, Syria, 1975

Professional Registrations
New York, 2002 (080267); Michigan, 1982 (28957)

Professional Associations
American Society of Civil Engineers (ASCE); International Tunneling Association: Chairman/Animateur for Working Group 19 - Conventional Tunnel and a former Member of Working Group on Immersed Tube Tunnels; The Moles Member; Transportation Research Board Committee AFF60 - Tunnels and Underground Structures; The American Underground Association (UCA of SME) Member and a former member of the Executive Committee.

Teaching Experience
Adjunct Professor, Graduate Level Courses on the Design and Construction of Tunnels and Underground Structures, Columbia University, New York, New York.
Lecturer at Colorado School of Mines
Lecturer in Breakthrough in Tunneling Short Course
Lecturer in the ITA-AITES - ITACET organization in various countries

Key Qualifications
Mr. Munfah has more than 40 years of experience in tunneling and underground engineering design and construction. He was responsible for the successful delivery of multi-billion-dollar projects from engineering through construction in the traditional design-bid-build and alternative delivery methods such as DB, CMGC, and P3. His experience encompasses TBM bored tunnels, SEM/NATM tunnels, Immersed Tube Tunnels (ITT), conventional tunneling, cut and cover, etc. for transportation and water conveyance and energy projects. Among his notable projects are: The Istanbul Strait Crossing, a 13.7 m (45ft) diameter tunnel; the Alaskan Way Tunnel in Seattle, a 17.45 m (57’-3”) diameter; the Central Subway in san Francisco, the $12B East Side Access Program in New York, and the $11B Gateway program in New York.

He is well recognized in the industry, held various leadership roles in professional organizations and has published numerous articles, and papers and he lectured in various universities and short courses on topics related to technical and management aspects of underground construction; and he received numerous awards. He led global tunneling practices in various engineering firms and he was an adjunct professor in

Columbia University's Civil Engineering Department, teaching graduate level courses on the design and construction of tunnels and underground structures. In addition, he was the principal investigator and one of the main authors of FHWA's *Technical Manual for Design and Construction of Road Tunnels,* the first tunnel design manual in the US.

Relevant past project experience includes:

Railroad/Transit

Infrastructure Ontario and Metrolinx - The Scarborough Subway Extension (SSE) Advance Tunnel Project, Toronto, Canada: Mr. Munfah was the Design Leader for the tender design of the Design-Build-Finance (DBF) of this project. The project includes tunneling of 7.8-km (9 mile) long, 10.7m (35ft) diameter subway extension from Kennedy Station to McCowan Road and Sheppard Avenue. The project also includes the design of launch and extraction shafts, bored tunnel, and headwalls for emergency exit buildings and stations; and activities necessary to build the tunnel, including utility relocation, impact on existing buildings and structures, support facilities, temporary power supply, ventilation, drainage, etc.

CSX Howard Street Tunnel, Baltimore, Maryland: Mr. Munfah led the technical team for a study of enlarging the existing tunnel using a state-of-the-art Tunnel Enlargement Machine in order to maintain the railroad operational during construction. The study evaluated the geotechnical issues, structural challenges, impact on adjoining facilities and utilities and the construction aspects including constructability, staging, schedule and cost.

Sepulveda Pass Transit Corridor, Los Angeles, California: Technical Leader and Principal for the preliminary engineering to connect San Fernando Valley to the Westside of Los Angeles and the Los Angeles Airport passing under the Santa Monica Mountains and connecting to several existing transit lines. The project includes 13.7 miles of twin tunnels and 13 stations along with the various associated facilities crossing the Santa Monica Mountains along the Sepulveda Pass.

VTA-BART San Jose Extension, Single Bore Study, San Jose, California: Serving as technical director of the project, Mr. Munfah led an in-depth study to the use of a large diameter TBM single bore tunnel with stations within the tunnel to extend the BART system to San Jose. In this scheme the tunnel construction will minimize excavation and impact on existing facilities and buildings. A 45 ft (13.7m) ID tunnel was determined. The $5B VTA-BART extension The BART Silicon Valley Phase II Extension project is a 6-mile extension from the current Phase I Berryessa Station terminus through Downtown San Jose to a new station and terminus in Santa Clara. This extension includes 4.8 miles of running tunnels through San Jose; four stations, of which three are underground. In his role, Mr. Munfah developed the initial concept and oversaw the development of the study and assured that all issues are addressed including risk assessment, constructability, construction planning and staging and construction sequencing and scheduling. Furthermore, he was a technical advisor in the PMC team for the implementation of the project.

Central Subway Project – Underground Stations, San Francisco Municipal Transportation Agency (SFMTA) San Francisco, California: Mr. Munfah was the project director and manager for the joint venture on this project, which consists of 1.8 miles (2.9 kilometers) of twin tunnels, 20 feet (6.1 meters) in diameter, and three underground stations at a cost of $1.58 billion. The project includes three stations: The Moscone Center Station is constructed using the top-down cut-and-cover method with slurry walls and secant piles. Union Square/Market Street Station is the deepest station, at about 110 feet (30 meters) deep and it is constructed using inclined tangent piles which were used as the final structure. Chinatown Station is constructed using sequential excavation method (SEM) or NATM in mixed-face ground conditions with a shallow cover, adjacent to sensitive utilities and buildings. At over 2000 sf (200 square meters) cross section, it is one of largest soft ground SEM construction in the US. The project is planned to be operational by 2022. Chinatown Station won the ITA project of the Year Under 500M€ Award in 2020 and Union Square/Market Street Station won the ITA Award for Innovation and Underground Space in 2020.

CDPQ Infra, Montreal REM (LRT), Tender Design, Montreal, Canada: Mr. Munfah was the technical director for the tender design of the tunnels and underground stations. The Project will allow for the deployment of a new high-frequency, LRT network in Montreal by building and transforming close to 67 km (41.5 miles) of double tracks, 24 stations, 9 bus terminals and 13 park-and-ride facilities at a cost of $5.5B. The project includes 5 km of new tunnels and 5 km of rehabilitation and enlargement of existing tunnel and three new underground stations. Two will be constructed using cut and cover and one will be constructed as a cavern 80 m (260ft) deep.

Amtrak Gateway Program, Preliminary Design, New York: As the Owner's Trusted Advisor, Mr. Munfah reviews the design team technical approaches, designs, and recommendations and constructability and construction sequencing and planning. The Gateway Program is a planned phased expansion and renovation of the Northeast Corridor (NEC) rail line between Newark, New Jersey, and New York City, New York. The proposed program would cost over US$20 billion. As part of the Gateway Program, two new tunnels would be built under the Hudson River, doubling the rail capacity. In addition, two tunnels will be built under the Palisades ridge in New Jersey and cut and cover boxes under the Hudson Yard Development. The tunnels will be 28 ft (8.5m) in diameter and will encounter mixed ground conditions and limited cover under the river. In addition, the tunnels will pass under historical structures, parkland, major roads and adjacent to sensitive facilities. Two construction and ventilation shafts 120 ft (36.5m) in diameter will be provided. Previously, he led the design of the project predecessors, the Access to the Region Core and the Trans Hudson Tunnel (THE) during the preliminary designs and the environmental clearance processes.

LA Metro – Crenshaw/LAX LRT Line, Los Angeles, California: Mr. Munfah was the design team leader, technical expert, and independent reviewer of the underground segment of this $2B program for the Design-Build JV. The project includes 3 miles of underground line structure and three underground stations constructed by the cut and cover method. The line structure includes two 22 ft EPB TBM tunnels and multiple sections of cut and cover structures. The project included all civil and system work.

California High Speed Rail – San Francisco-San Jose-Merced, California: Serving as Technical Director and Tunnel Subject Matter Expert (SME), Mr. Munfah oversees the preliminary design of this stretch of the CAHSR Program. This 84-miles corridor includes 15 miles of tunnels through the Pacheco Pass. Multiple tunnels ranging in length from 1.6 miles to 5.9 miles were originally envisioned; an alternative approach proposed by Mr. Munfah is to replace the numerous short tunnels with a long 13-miles tunnel and a short tunnel of 1.6 miles. The tunnels will be constructed using TBM and SEM (NATM) in very challenging grounds passing through shear zones and unstable grounds. In addition, the tunnels will be subjected to high seismic conditions. Mr. Munfah oversaw the development of the design, the construction planning and sequencing and identified critical risk issues and stability issues especially near the portal due to potential large slope failures.

DART D2 Alternative Analysis, Dallas, Texas: Mr. Munfah served as Senior Technical Advisor of the alternative study and the preliminary design. DART launched the D2 Study to identify and evaluate a range of transit improvements in the Central Business District (CBD). The D2 Study focused on identifying the second phase of major transit improvements in Downtown Dallas. The improvements will ensure high quality transit service as the DART system expands to meet growing needs. In addition, it is about improving mobility and circulation to, through and within the CBD, serving local and regional mobility needs, and enhancing the ability for the DART system to grow and thrive. Three alignments were considered, all of which are underground for a majority of their routes. The preferred alignment consists of about 1.5 miles twin tubes and three underground stations, one is to be constructed using NATM/SEM tunneling.

East Side Access Program, New York City, New York: Mr. Munfah served as Deputy Project Director, Design Manager and Chief Engineer for the design of this $12B multidisciplinary program to connect the Long Island Rail Road (LIRR) to Grand Central Terminal. The project will increase the railroad's overall system capacity, relieve passenger congestion in Penn Station, provide commuters improved access to their

final destination, and improve the overall New York Metropolitan area transportation system. This is the largest transportation program ever undertaken in New York City. The construction of the project requires significant tunneling and underground work utilizing a variety of construction techniques, including rock TBM, soft ground TBM, NATM/SEM, cut-and-cover, cavern construction, ground improvement, and surface structures and facilities. Mr. Munfah was responsible for all the technical aspects of the project and the daily management of the design team consisting of over 120 professionals. He managed the design aspects of all disciplines, led the decision process of major technical issues, and oversaw the production of the various construction contracts varying in size up to over $1B on time and within budget.

LA Metro – Regional Connector LRT Line, Los Angeles, California: As Technical leader and expert support for the Design Build contractor during the tender phase of the project, Mr. Munfah was instrumental in identification of over $80M of potential savings through Alternative Technical Concepts (ATC) in compliance to LA Metro design criteria and providing construability analyses and construction planning. The project includes 1.9-mile underground light-rail system, connecting the Metro Gold Line to the 7th Street/Metro Center Station and providing direct connection between Azusa and Long Beach and between East Los Angeles and Santa Monica; three new stations accommodating ventilation/service facilities-- 1st Street/Central Av, 2nd Street/Broadway, and 2nd Place/Hope; running tunnel, NATM, cut and cover and U-structures. In addition, during the preliminary design developments, Mr. Munfah acted as a technical expert and provided consultation and value engineering proposals.

AMTRAK - Baltimore and Potomac (B&P) Tunnel in Baltimore, Maryland: Mr. Munfah led the program management team providing technical oversight, peer review, constructability analyses, construction staging and planning and VE leader, for the preliminary design, and environmental assessment of the B&P Tunnel program. The project consists of four tubes 28 ft in diameter each to provide passenger and freight rail service. The goals of the program are to improve rail service reliability and address a longstanding bottleneck along Amtrak's busy Northeast Corridor (NEC) in the Baltimore area. The program was modified based on the VE study to limit it to 2 tunnels for passenger service only reducing the cost, the risk, of the project.

Evergreen Extension Line, Vancouver, Canada: As Tender Design lead for the DB contractor, Mr. Munfah was responsible for Technical Oversight of the design, constructability, and technical expertise with cost and risk reduction. The project consists of 10.9 km extension of the Millennium Line including six stations. The project includes a 2-km (1.25miles) 8.9 m (29ft) inside diameter tunnel with tunnel portals located in Port Moody and Coquitlam. The single tube tunnel houses both tracks was provided and it was divided by a center wall for fire-life safety requirements. A 10m (33ft) diameter EPB TBM was used to construct the tunnel using one pass segmental liner.

MTA, Second Avenue Subway, 96th Street Station, Design and Constructability Review, New York City, New York: As part of the Second Avenue Subway program and in association with the PM/CM services Mr. Munfah performed technical reviews, constructability analysis and risk assessment of the 96th Street station. The review covered all disciplines including civil, geotechnical, architectural, MEP, and fire/life safety aspects

San Francisco MTA – T Third LRT/Central Subway Phase 3, San Francisco, California: Mr. Munfah is project principal and technical expert for SFMTA feasibility study to expand the Central Subway LRT Program north, assess potential future rail transit expansion to serve northern San Francisco neighborhoods including North Beach and Fishermen's Wharf, and to analyze constructability issues related to the various alignments and the feasibility of potential transit alternatives.

Penn Station Capacity Enhancement, New York City, New York: Mr. Munfah was the project manager responsible for the design of this multidisciplinary extension of Tracks 1 through Track 4 eastward and westward to increase station capacity by allowing longer trains to access these tracks. The project involves significant underpinning, tunneling, maintenance of railroad operations, utility relocation, and new

entrances. The extension will be under two operating transit lines and within the basement of a major building on Seventh Avenue. Maintenance of Amtrak, NJ TRANSIT, and New York City Transit (NYCT) operations while constructing the extension, is one of the many challenges this project faces.

Rosslyn Station Access Improvement Project, Washington Metropolitan Area Transit Authority (WMATA), Washington, DC: As project manager, Mr.Munfah oversaw the design of the access shaft and the mezzanine cavern responsible for the preliminary and final design of the entrance. The shaft and the mezzanine are 80 feet (24 meters) deep and located within 20 feet (6 meters) of an operating transit line and connect into it. The project faces many technical and administrative challenges, including underpinning and connection to the existing operational station, excavating within limited distance to the existing station, and interfacing with WMATA, a private developer at the site, the county, and private and public agencies. State-of-the-art NATM/SEM with extensive instrumentation and monitoring program is implemented and an extensive construction planning and step by step staging were developed.

Weehawken Tunnel and Bergenline Avenue Station, Weehawken, New Jersey: Mr. Munfah was the project manager responsible for the preliminary and final design of this $250 million segment of the Hudson Bergen LRT, a P3 program. The segment consists of 4,100 liner feet (1,250 meters) of two track rock tunnel and the Bergenline Avenue cavern station, a multi-modal transportation station. The tunnel lies approximately 160 feet (48 meters) in the Palisades beneath Weehawken and is constructed using SEM/NATM. The access to the station was via a single large shaft accommodating access elevators and the ventilation system.

Southwest Light Rail Transit (SWLRT), Tunnel Value Engineering, Minneapolis, Minnesota: As part of this $1.85B program to provide a new route from downtown Minneapolis through the communities of St. Louis Park, Hopkins, Minnetonka, and Eden Prairie, two tunnels are required. Mr. Munfah provided VE recommendations and provided constructability and construction planning reviews of the underground segments including fire-life safety aspects.

63rd Street Line Connection, New York City, New York: Mr. Munfah served as the Engineering Manager responsible for the preliminary and the final design of the subway connection between the 63rd Street subway line and the Queens Boulevard line under Northern Boulevard in Queens NY. The $540 million project provided a great improvement to the operation and service of the Queens Boulevard Line. The project was divided into four different civil construction contracts, a system contract and a startup contract. A major underpinning program was implemented to protect the existing subway lines. A key work element was the construction staging in order to maintain existing rail operation and surface traffic. Detailed construction plans were developed and implemented. The project received several awards, including the ACEC Grand Conceptor Award in 2001.

Amtrak North Access Tunnel (Empire Line), New York City, New York: As the Project manager responsible for design, Mr. Munfah led the preliminary and the final designs and provided engineering services during construction for the tunnel on the west side of Manhattan. The tunnel alignment runs under the Eleventh Avenue viaduct and existing buildings. Underpinning of 56 columns was needed. The project received the NYACE First Prize Award in 1991.

Hiawatha Light Rail Transit System, Minneapolis, Minnesota: Mr. Munfah was the structural project engineer during the conceptual and preliminary engineering phase responsible for all civil and structural aspects of a 3-mile (4.8 kilometers) tunnel and five stations for this LRT system.

Mount Lebanon Tunnel, LRT System, Port Authority of Allegheny County, Pennsylvania: Mr. Munfah prepared the preliminary design of this approximately 3,000-foot (900-meter) double-bore rock, mixed-face tunnel that passes under Mount Lebanon near Pittsburgh. He also prepared the design criteria and the final design of the rock tunnel. The tunnel was constructed using SEM/NATM method; one of the early uses of NATM in the US.

Newark City Subway, Newark, New Jersey: Mr. Munfah was the project manager for a conceptual, feasibility analysis and preliminary design to add a subway station at University Heights.

Mount MacDonald Tunnel beneath Rogers Pass, British Columbia, Canada: Responsibilities Mr. Munfah undertook included the design and the development of the contract documents of the ventilation facility, mid-tunnel facilities, a 1,300-foot (396-meter) shaft, and the headhouse structure. This 9-mile (14.5-kilometer) rail tunnel through the Selkirk Mountains in British Columbia for the Canadian Pacific Railway is the continent's longest standard-gauge rail tunnel.

Charles River Tunnel, Boston, Massachusetts: Mr. Munfah evaluated the effect of a sunken barge on an existing subway tube for the Massachusetts Bay Transportation Authority (MBTA) and developed a removal procedure to avoid impacting the tunnel.

Moffat Tunnel Ventilation Improvement, Colorado: Mr. Munfah was responsible for the design of new air locks, equipment housing, ventilation shafts and buildings for the existing railroad tunnel in the Rocky Mountains.

Highway Tunnels

Federal Highway Administration (FHWA), Technical Manual for Design and Construction of Road Tunnels —Civil Elements, Nationwide: As principal investigator, Mr. Munfah was the main author of the first tunnel design manual in the United States. The manual addresses the design of all types of tunnels including cut-and-cover, soft ground tunnels, rock tunnels, immersed tunnels, tunneling in difficult ground conditions and mechanized excavation methods. The manual also addresses special topics such as seismic design of tunnels, construction aspects, risks, and tunnel rehabilitation. The manual provides the first documented guidelines in the US.

Republic of Turkey Ministry of Transport, Istanbul Strait Road Crossing (Eurasia) Tunnel, Istanbul, Turkey: Mr. Munfah was the principal-in-charge and project director for the preliminary and final design of this project, which consists of 5.4 kilometers (3.4 miles) of road tunnels, including a 3.3-kilometer (2-mile) underwater tunnel to accommodate a double deck for a 2x2 lane road for passenger vehicles and minibuses. The tunnel is 13.7m (45ft) external diameter and passes through various geological formations, including limestone and sandstone and soft alluvial channel deposits consisting of sand and silt. The tunnel is subject to 10.5 bars of water pressure and is located in a highly seismic zone. The project also includes the European and the Asian approach roads totaling 14 kilometers (10.5 miles) in length. In addition, Mr. Munfah acted as the Independent Design Verifier (IDV) and as Trusted Technical Advisor to the client in all aspects of the project during the design and construction. The Project is delivered in a BOT (P3) arrangement. This project received the Project of the Year Award by the International Tunneling Association in 2015 and selected by ENR as the Global Project of the Year for transportation in 2016 among numerous other awards.

Washington State DOT – Alaskan Way Viaduct Replacement, Seattle, Washington: Mr. Munfah was a leader of the design team of the design-builder and a member of expert review panel for this $1.4 Billion project. The project consists of 2.1 miles (3.4km) single bored tunnel that replaces the Alaskan Way Viaduct along Seattle waterfront. The tunnel was the world second largest 58-ft (17.5m) diameter and it was constructed beneath the city streets and encountered numerous difficult ground conditions. Mr. Munfah served in various roles and conducted design and construction planning reviews addressing technical issues such as the liner design, seismic assessment, ground loss, potential settlement, remedial measures, etc. He also was involved in the ventilation and fire life safety assessment.

Fort Lauderdale–Hollywood International Airport Tunnel, Ft. Lauderdale, Florida: Mr. Munfah was a Technical Advisor/Subject matter Expert for Tunnel Fire Durability Assessment for the D-B team. As part of this $830M expansion program, a multicell tunnel passes under the new runway and the taxiway was needed to accommodate highway traffic, rail traffic and local airport service vehicles. The tunnel was

designed to carry heavy aircraft loading of one million pounds (500 tons) with impact factor of 2. In addition, the tunnel was designed to accommodate fire loads from a potential jet fuel tanker fire within the tunnel. Safety provisions were provided to accommodate the challenging ground conditions and the extraordinary loading conditions.

Cooper Hospital Pedestrian Tunnel, Feasibility Study: Mr. Munfah was The Principal-in-charge and Technical Oversight. A study was conducted to connect the parking facilities of the Cooper Hospital to the main hospital building passing with very shallow cover under 8 lanes of I-676 and 3 railroad tracks in Camden New Jersey. The tunnel length is 600 ft with a cross section of 15 ft by 9ft. Four alternatives were evaluated including NATM/SEM, tunnel box jacking, interlocking pipe arch, and cut and cover. Construction planning and staging were developed to accommodate the construction while maintaining highway and rail traffic.

Caltrans' Devil Slide Tunnel (Tom Lantos Tunnel) - Pacifica/Motara California: Mr. Munfah was the Technical Expert for the design and construction oversight for this project. The Devil's Slide project is located along the California coast between Pacifica and Montara, west of the San Francisco Bay Area in a region with steep and unstable geological formations. State Highway 1 hugs the coastline for much of the distance between the two towns and has a long history of closure due to rockslides. Twin tunnels 9m (30 ft) wide x 6.8m (22.5ft) high and 1.3 km (4,300 ft) long were constructed using the New Austrian Tunneling Method (NATM). The two tunnels are connected by nine emergency pedestrian cross passages and an additional vehicular cross passage at mid-point for emergency vehicle access. At the northern end, two 300m long bridges span the valley at Shamrock Ranch, a very environmentally sensitive area. The project received numerous awards including the NCE Award for Project Management/owner's Advisor in 2012 and UCA's Project of the Year in 2013.

Presidio Parkway – Caltrans, San Francisco, California: Mr. Munfah acted as Principal Technical Advisor and Technical Lead in the DRB process for this $1.4B P3 program. Presidio Parkway is the first public-private partnership transportation project delivered in California replacing Doyle Drive, the aging approach to the Golden Gate Bridge used by more than 120,000 vehicles each day. The Presidio Parkway project improves seismic, structural and traffic safety, as well as integrates the roadway into the national park setting and creates additional recreation spaces. Mr. Munfah provided technical expertise in design and construction issues. The project includes the northbound Presidio Viaduct and Battery Tunnel, the Main Post Tunnels and the new Girard Road Interchange with a direct connection to the Presidio.

Windsor GreenLink, Windsor, Ontario, Canada: Mr. Munfah was the project manager and technical expert on this project and provided technical support and engineering services to the City of Windsor for conceptual and preliminary engineering, construction planning, and cost estimating for the extension of Highway 401 through the city as the approach road to the new Gordie Howe International Bridge between Detroit and Windsor. The developed concept consisted of six tunnels ranging in length from 240 to 1,220 meters (787 to 4,002 feet) and totaling about 3.5 kilometers (2 miles). A park-like setting over the tunnels was developed to enhance the corridor and to connect and protect adjacent communities and neighborhoods.

Cumberland Gap Tunnel, Kentucky/Tennessee: Mr. Munfah was the lead engineer responsible for the design of the cut-and-cover section of the tunnel.

Water/Wastewater Conveyance Tunnels

Narragansett Bay Commission, Pawtucket CSO Tunnel, Rhode Island: Mr. Munfah is the Technical Director of this design-Build (DB) project. The Pawtucket Tunnel Project is the first part of Phase 3 of the Bay's water management modernization program (Phase IIIA). The 2.2 miles (3.5 km) long 30 ft (9.14m) dia. main tunnel will be excavated along the Seekonk River using a pressurized face tunnel boring machine specially designed to accommodate the varied geology of the route. The project also involves the excavation of three main shafts, one of which will serve as a pumping station. Four drop shafts will also be built, as well as their connecting tunnels to the main tunnel. Carried out in the heart of an urban residential area,

measures were designed to protect the environment and minimize the impact on local residents.

I-75 Drainage Tunnel, Detroit, Michigan: Mr. Munfah is the Technical Advisor/Principal for the design and construction of this storage and drainage tunnel system consisting of 4-miles long, 14.5-foot diameter and 100 feet deep along I-75's northbound service drive between 8 Mile and 12 Mile Roads. The project also includes a mining shaft, an extraction shaft and a large pump station shaft in addition to 6 drop shafts. He also led a team of engineers to address issues developed during the construction requiring the addition of a 55 ft recovery shaft.

MDC - South Hartford Conveyance and Storage Tunnel (SHCST) Hartford, Connecticut – Mr. Munfah is a technical expert dealing with the Contractor's claims during construction. He led the design team in developing technical responses and presented the Owner's position to the Dispute Review Board (DRB) addressing the contractor's alleged different site conditions. The project consists of the construction of 4 mile (6.4km) of 18ft (5.5m) inside diameter a storage and conveyance combined sewer overflow (CSO) tunnel 200 ft (60m) underground in variable grounds. The project also includes multiple shafts including launch and retrieval shafts, a pump station shaft and drop shafts.

Sir Adam Beck Water Tunnel, Ontario, Canada: Mr. Munfah was the project design manager for the design/build contractor to construct a 48-foot (14-meter) diameter water tunnel to divert water from Niagara Falls for hydroelectric power generation. The work included the design of a single pass segmental, gasketed liner, groundwater control, and access facilities. The tunnel was constructed in squeezing and swelling rock. The design featured an innovative approach of providing a compressible grout to be injected behind the liner to address the squeezing and swelling rock.

West Branch Intercepting Sewer, Staten Island, New York: Project manager for the design and construction of this project. The project included the design a single-pass liner for an 8-foot (2.4-meter) ID, 4,000-foot-long (1,220-meter-long) interceptor sewer. This was the first use of a single-pass-liner system for sewer tunnels in New York and was done as an alternative design to the traditional two-pass system. A full-scale model was tested for its ultimate capacity to prove the viability of the tunnel liner system.

Tunnel Rehabilitation/Refurbishment/Repair

Amtrak, Structural Assessment of Four Underwater Tunnels and Rehabilitation, New York, New York: Mr. Munfah serves as Principal-in-Charge, technical expert, and court expert witness for the structural assessment and rehabilitation of four rail tunnels under the Hudson and the East Rivers in New York which were flooded during Super Storm Sandy in October 2012. The tunnels lengths are in the range of 10,000 to 12,000 ft with the flooded zones are in the range of 4000 to 4500 ft. The tunnels were constructed around the turn of the 20th Century and consist of cast iron liner with unreinforced cast in place concrete liner. The intent of the study is to identify visible and potentially latent defects and prepare repair measures. The investigation included the use of the state of the art three-channel scanner providing photogrammetric, laser and infrared scanning simultaneously in high resolution. He also served as technical expert witness in the claim and legal action between Amtrak and the insurance companies.

New York City Transit, Structural Assessment of Three Underwater Tunnels and Rehabilitation, New York City, New York: Mr. Munfah was the Principal and Technical expert for the structural assessment and rehabilitation of three subway tunnels under the East River in New York, which were flooded during Super Storm Sandy in October 2012. The tunnels are: Greenpoint, Rutgers, and Cranberry connecting Manhattan, Queens and Brooklyn. The tunnels range in length with the longest approximately 7000 ft long. The tunnels are constructed of cast iron liner with unreinforced cast in pace concrete liner. The investigation intended to identify visible and potentially latent defects and prepare repair measures. The investigation consisted of using state of the art three-channel scanner providing photogrammetric, laser and infrared scanning simultaneously in high resolution. The design of the rehabilitation measures included extensive construction planning and staging with detailed scheduling of activities to accommodate train operation.

Reconstruction of Amtrak East River Ventilation Shafts, New York City, New York: Mr. Munfah was the project manager for the $400M reconstruction of four ventilation facilities serving four railroad tunnels under the East River in New York City while the train operation uninterrupted. The tunnels serve three different railroads and over 250,000 daily commuters from Long Island. The ventilation shafts were completely reconstructed and equipped with ventilation fans to meet today's standards of fire/life safety in tunnels complying with NFPA 130 requirements with no impact on the rail operation. Extensive construction planning and staging were developed to maintain the rail operation and to avoid impact on adjoining facilities and structures. Complicating the project is the fact that two of the ventilation shafts are located within NYU Medical Center while the other two shafts are located in a future commercial development (Queens West).

Brooklyn Battery Tunnel Rehabilitation, New York City: Mr. Munfah was the project manager for this $100 million multidisciplinary tunnel rehabilitation project. The tunnel, the longest underwater vehicular tunnel in the U.S., was opened to traffic in 1950 and was never upgraded or renovated since its initial construction. The rehabilitation included a new ceiling; structural rehabilitation of spalls, leaks, and delaminations; new finishes; a new lighting system; balancing of the ventilation system; and a modern traffic control system. Detailed construction sequencing plans were developed and implemented to be able to operate the tunnels wile they are under construction. This project received the 1998 New York Association of Consulting Engineers (NYACE) Gold Award in the Transportation and Mega Projects Category.

Havestraw and Kingston Tunnels, New York: Mr. Munfah served as project engineer for the enlargement of two turn-of-the-20th century railroad tunnels. The work involved rock excavation in the tunnel roof, new lining, and new portal construction.

I-40 Sterling Mountain Tunnel, North Carolina: As lead structural engineer, Mr. Munfah was responsible for the investigation of the structural failure of the portal due to landslide and the reconstruction of the portal.

Immersed Tube Tunnels

Second Midtown Elizabeth River, Norfolk, Virginia: As Technical advisor of the Quality Control team of the Immersed Tube Tunnel, and a specialist to address structural cracking of the tunnel elements, Mr. Munfah provided technical oversight and recommendations for the repair measures of the cracked elements. The $2.1 billion P3 project entails four components: a new two-lane tunnel under the Elizabeth River, maintenance and safety improvements to the existing Midtown and Downtown tunnels, extension of the MLK Expressway from London Boulevard to Interstate 264, and Interchange modifications at Brambleton Avenue and Hampton Boulevard in Norfolk. The new two-lane 4,198-foot-long immersed-tube tunnel was constructed using 11 concrete elements. The tunnel is the first deep-water concrete immersed-tube tunnel in the US.

The Marmaray Tunnel, Istanbul, Turkey: Mr. Munfah served as technical advisor for the immersed tube tunnel for the owner. The overall project is a 13.5 km long undersea railway tunnel beneath the Bosporus strait, linking the Asian side with the European side of Istanbul. The undersea section of the Marmaray tunnel is the deepest immersed tube tunnel in the world, with its deepest point being 60 m below sea level. This section of the tunnel is 1,400 m long and consists of 11 sections, The immersed tunnel was connected via bored tunnels on both sides. The project was delivered as turnkey DB.

Golden Horn Tunnel, Feasibility Analysis, Istanbul, Turkey: Mr. Munfah conducted a feasibility analysis to replace the existing Unkapani Bridge with an underwater tunnel consisting of three lanes in each direction. The crossing is 34 m deep with steep shorelines. Three options were evaluated including bored tunnel, immersed tube tunnel (ITT) and submerged floating tunnel (SFT). The recommended solution is the use of a hybrid of ITT and SFT in which the elements will be supported on underwater piles. A total of 9

elements each is in the range of 100m in length will be required.

Messina Straits Crossing, Italy: Mr. Munfah provided consultancy services during the conceptual and preliminary engineering of a fixed link crossing of Messina Straits between Sicily and mainland Italy. The crossing is about 7 kilometers (4.3 miles) long and consists of two vehicular tunnels and a railway tunnel. The crossing includes 5.9 kilometers (3.6 miles) of floating tunnel and 1 kilometer (0.6 miles) of landfall tunnel to be constructed by the immersed tube method. The maximum depth of the crossing is 350 meters (1,148 feet). As part of a task force, Mr. Munfah was in charge of developing the design of the landfall tunnel with focus on the constructability, construction procedures and staging, risk analysis, the design of joints between elements, the seismic aspects, and the land connection. Special seismic joints were designed to accommodate 1.5 meters (4.9 feet) of movement in each direction.

Great Belt Tunnel, Denmark: As part of a team of senior engineers, Mr. Munfah led the design for the immersed-tube tunnel and the preparation of the tender documents. The project consisted of 3.6-mile (5.7-kilometer) rail tunnel under the Great Belt Channel in Denmark.

Österleden Crossing, Saltsjön Tunnel, Sweden: Mr. Munfah prepared a feasibility study of a 400-meter-long (1,312-foot-long) immersed tunnel of the crossing, consisting of four elements. Two unique features were present: the elements were to be supported on piles and the land connection into to a rock tunnel.

Guadalquivir Tunnel, Spain: Mr. Munfah was the project manager and prepared a preliminary design of an 800 meters (2625 feet) long immersed tunnel, with a four-lane roadway for a design/build contract. The design focused on cost saving ideas, simplified construction planning, and innovative solutions.

Medway Tunnel, England, United Kingdom: Mr. Munfah was the project manager responsible for the preparation of the tender documents for a 600-meter (1,970-foot) immersed tunnel and the associated approaches. The tunnel consists of an immersed tube section and cut-and-cover sections. The project also involves ventilation, power, lighting, drainage, and fire protection.

Second Downtown Elizabeth River Tunnel, Norfolk, Virginia: As deputy project manager and project engineer, Mr. Munfah was responsible for the design and construction management of a 3,800-foot (1,160-meter) two-lane immersed tube tunnel in Norfolk Virginia. The tunnel consists of eight elements, two cut-and-cover sections, a ventilation building, two major depressed approach structures and associated interchanges.

High Energy Physics Underground Facilities

X-ray Lithography Source (XLS), Brookhaven National Laboratory, New York: Mr. Munfah was the project manager for the conceptual and preliminary design of 1 GeV underground linear accelerator and associated Klystron gallery, a conventional magnet X-ray storage ring building, a cryogenic magnet storage ring building and an office and laboratory building. The project involved clean room design of Class 10 for the exposure stations, Class 10 for laboratories, and Class 100 for working areas and associated gowning facilities.

Alternating Gradient Synchrotron (AGS) Accumulator-Booster, Brookhaven National Laboratory (BNL), New York: Mr. Munfah was Project manager of this multidisciplinary high energy physics project from the conceptual stage to final design and construction. The project consisted of an underground accumulator ring, which penetrates the existing AGS tunnel and an existing 200 MeV linear accelerator (Linac) tunnel, an underground experimental hall and a terminator room and connection structures. The contract documents were prepared to allow the construction of this facility while the AGS and the Linac are in operation.

Radiation Effects Facility (REF), Brookhaven National Laboratory, New York: Mr. Munfah was The project manager for this multidisciplinary high energy physics research project. It consisted of construction of a connection to an existing 200 MeV underground Linac by a transport tunnel to an underground

experimental hall, and an associated above ground control and staging building.

Neutral Beam Test Facility (NBTF), Brookhaven National Laboratory, New York: Mr. Munfah was the project manager for this multidisciplinary high energy physics research project. In conjunction with the REF, the NBTF was constructed by diverting a beam line via a transport tunnel to a 30-foot by 80-foot (9.1-meter by 24.4-meter) underground experimental hall, along with an associated control room and staging area.

Superconducting Super Collider (SSC) Reference Design Study: Mr. Munfah served as project engineer for conceptual design and feasibility and cost study for a 40-trillion-electron-volt particle accelerator, which would have been the world largest.

Other Facilities

Westway Project, New York City, New York: As part of this proposed major underground urban highway project, Mr. Munfah was responsible for providing the protection structures for the Holland and the PATH tunnels tunder the Hudson River.

Charleston Bus Annex, Staten Island, New York: Mr. Munfah was the project manager for the design and construction of a 200-bus maintenance and storage facility in Staten Island for NYCT. The project is a fast-track design/build and is designed in the LEED principles to meet the sustainability requirements.

Bowery Bay Bulkhead, New York City, New York: As project manager, Mr. Munfah provided an in-depth structural evaluation of a 500-foot-long (152-meter-long) steel sheet pile bulkhead protecting the fuel tanks in LaGuardia Airport. Alternative repair schemes were evaluated, and the recommended scheme was carried to final design. Mr. Munfah also provided construction planning, constructability analyses and construction staging and provided construction management services.

Seagirt Containment Facility, Baltimore, Maryland: A containment structure for dredge spoil disposal, constructed of a cellular cofferdam, was to be converted to a 3,500-foot-long (1,070-meter-long) marine terminal. During initial loading, most of the cells underwent displacement up to 4.5 feet (1.3 meters). Mr. Munfah assessed the cofferdam condition and evaluated strengthening alternatives for the final loading and for the marginal wharf schemes and provide constructability analyses and construction staging.

Awards

Chinatown Station in San Francisco received the ITA Project of the Year Award for project under 500M€ in 2020; Union Square/Market Street Station in San Francisco received Innovative and Underground Space Award from the ITA in 2020; The Istanbul Strait Crossing (Eurasia) Tunnel received the International Tunneling Association Major Project of the Year Award in 2015, and ENR Global project of the year, 2016; The Devil Slide Tunnel (Tom Lantos) received the Underground Construction Association Project of the Year and the American Public Works Association's Public Works Projects of the Year, in 2014 in addition to NCE award for Program Manager/Owner Advisor in 2012; The East River Ventilation Shafts Project, 2011 received NYACEC, Gold award for Engineering Excellence; The 63rd Street Connection Project received several awards, including the ACEC Grand Conceptor Award, 2001; The Rehabilitation of the Brooklyn Battery Tunnel received NYACE Gold Award for Engineering Excellence in the Transportation and Mega Projects Category in 1998; the Amtrak North Access Tunnel Project received the NYACE First Prize Award for Engineering Excellence in 1991; His paper, "The Fabrication of an Immersed Tube Tunnel: Case History," received a 1984 award from the James F. Lincoln Arc Welding Foundation.

Technical Papers and Publications

Numerous technical articles and Thought Leadership publications in Tunnel Talk, Tunnel Business Magazine, Tunnel and Underground Construction Journal, and other publications

Numerous presentations, panelist, and session chair in various tunneling and underground engineering conferences.

Technical Publications:

DESIGN AND CONSTRUCTION CHALLENGES OF SEM CONSTRUCTION IN URBAN AREA: CHINATOWN STATION, SAN FRANCISCO, Tunneling Association of Canada (TAC) Conference Proceedings, Toronto, 2021

CONTROLLING RISK OF TUNNELING PROJECTS IMPLEMENTED BY ALTERNATIVE DELIVERY METHOD, Rapid Excavation and Tunneling Conference (RETC) Proceedings, Chicago, Illinois, June 2019

CONVENTIONAL TUNNELING IN URBAN AREAS, Co-Author, ITA's World Tunneling Congress (WTC) Proceedings, Naples, Italy, May 2019

MANAGING CONSTRUCTION RISKS OF LARGE DIAMETER SOFT GROUND TBM TUNNELS, Keynote Speaker, 16th Danube Tunnel Conference, Skopje, Macedonia, June 2018

MANAGING UNDERGROUND RISKS OF CONVENTIONAL TUNNELLING PROJECTS, Co-Author, ITA's World Tunneling Congress (WTC) Proceedings, Dubai, April 2018

CONVENTIONAL TUNNELING IN DIFFICULT GROUND CONDITIONS, Co-Author, ITA's World Tunneling Congress Proceedings, Bergen, Norway, June 2017

RECENT TRENDS IN CONVENTIONAL TUNNELING (SEM/NATM) IN THE US, Co-Author, ITA's World Tunneling Congress Proceedings, San Francisco, California, April 2016

ISTANBUL STRAIT ROAD TUBE CROSSING: CHALLENGES, RISKS AND MITIGATION STRATEGIES, Co-Author, ITA's World Tunneling Congress Proceedings, San Francisco, California, April 2016

APPLYING SCANNING TECHNOLOGY TO TUNNEL INSPECTIONS, Co-Author, Geostrata Magazine, June 2015

CONTROLLING RISKS IN ALTERNATE DELIVERY METHODS OF TUNNELS AND UNDERGROUND PROJECTS, Co-author, Rapid Excavation and Tunneling Conference (RETC) proceedings, June 2015

ISTANBUL STRAIT ROAD TUBE CROSSING PROJECT USES GOOD PRACTICES TO MANAGE RISKS, Co-Author, ITA's World Tunneling Congress Proceedings, May 2015

RISK RELATED TO PPP TUNNELING PROJECTS FOR DESIGN PROFESSIONALS, Co-author, Tunnel and Underground Construction Journal, June 2014

LESSONS LEARNED FROM THE FIRST NATM TUNNEL IN CALIFORNIA, THE DEVIL'S SLIDE TUNNEL, Co-author, ITA's World Tunneling Congress Proceedings, Iguassu Falls, Brazil, May 2014

REDUCING RISK ON ALTERNATE DELIVERY OF TUNNEL PROJECTS, Transportation-Point Extra Journal, May 2014

ISTANBUL STRAIT TUNNEL OVERCOME UNIQUE SETS OF RISKS, Co-author, Roads and Bridges Journal, September 2013

CHALLENGES OF THE LARGEST DIAMETER TBM TUNNEL IN THE WORLD - THE ALASKAN WAY TUNNEL IN SEATTLE, USA, Co-author, ITA's World Tunneling Congress Proceedings, Geneva, Switzerland, June 2013

TUNNELING IS AN INCREASINGLY ATTRACTIVE AND COST-EFFECTIVE APPROACH TO MEETING INFRASTRUCTURE DEMANDS FOR RAPIDLY GROWING CITIES, ACROSS THE COUNTRY AND AROUND THE WORLD, SOLVE Journal, June 2013

MINIMIZING THE ELEMENT OF SURPRISE IN TUNNEL CONSTRUCTION – RISK MANAGEMENT DELIVERS TUNNEL PROJECTS SAFELY, ON TIME, AND WITHIN BUDGET, Viewpoint Journal, May 2013

LESSONS FROM INTERNATIONAL MEGA-TUNNELING PROJECTS: THE ALASKAN WAY TUNNEL, SEATTLE, Qatar Transport Conference, May 2013

CONTRACTUAL CHALLENGES OF CONVENTIONAL TUNNELING IN THE US, Co-author, ITA's World Tunneling Congress Proceedings, Bangkok, Thailand, May 2012

ABOVE OR BELOW GROUND? FACTORS THAT HELP DETERMINE WHERE TO PLACE A NEW TRANSIT SYSTEM, In-Transit Journal, Fall 2012

FIRST COMPREHENSIVE TUNNEL DESIGN MANUAL IN THE UNITED STATES, Co-author, North American Tunneling Conference Proceedings, Portland, Oregon, June 2010

DESIGN GUIDELINES OF SEQUENTIAL EXCAVATIONS METHOD (SEM) PRACTICES IN THE UNITED STATES, Co-author, North American Tunneling Conference Proceedings, Portland, Oregon, June 2010

THE FIRST TUNNEL DESIGN MANUAL IN THE US, ASCE Met Section Conference "Tunnels of the World - Planning, Design, and Construction," March 2010

UNCONVENTIONAL USES OF UNDERGROUND SPACE, Co-Author, ITA's World Tunneling Congress Proceedings, Vancouver, Canada, May 2010

GREENLINK: A SUSTAINABLE ROAD ALTERNATIVE, Co-Author, 2nd World Road Conference Proceedings, Singapore, October 2009

SAFETY AND SECURITY OF TUNNELS AND UNDERGROUND TRANSPORTATION FACILITIES, ITA's World Tunneling Congress Proceedings, Budapest, Hungary, May 2009

TUNNELS CONNECT AND PROTECT COMMUNITIES- WINDSOR GREENLINK, Co-Author, ITA's World Tunneling Congress Proceedings, Budapest, Hungary, May 2009

INTRODUCTION TO FHWA ROAD TUNNEL DESIGN AND CONSTRUCTION MANUAL, Workshop sponsored by the Transportation Research Board, Washington, DC, January 2009

THE EAST SIDE ACCESS PROGRAM: FROM CONCEPT TO REALITY, Presentation at ASCE Conference, Baltimore, Maryland, November 2008

THE TRANS HUDSON EXPRESS (THE) TUNNEL, ITA's World Tunneling Congress Proceedings, Prague, Czech Republic, 2007

CONTRACTING ISSUES FOR CONVENTIONAL TUNNELING, ITA's World Tunneling Congress Proceedings, Prague, Czech Republic, 2007

TUNNELING IN CONTAMINATED GROUND, ITA's World Tunneling Congress Proceedings, Seoul, South Korea, 2006

CONTRACTING METHODS FOR UNDERGROUND CONSTRUCTION, North America Tunneling Conference Proceedings, Chicago, Illinois, 2006

CONTROL OF CONTAMINATED GROUND WATER DURING TUNNEL CONSTRUCTION, Fifth International Symposium TC 28 Geotechnical Aspects of Underground Construction in Soft Ground Conference Proceedings, Amsterdam, Netherlands, 2005

APPLICATION OF THE DISPUTE RESOLUTION BOARD (DRB) TO THE EAST SIDE ACCESS PROJECT, Presentation in the Rapid Excavation and Tunneling Conference Proceedings, New Orleans, Louisiana, 2003

CONNECTING A COMMUTER RAILROAD TO A HISTORIC TERMINAL IN MANHATTAN, ITA's, World Tunneling Congress Proceedings, Prague, Czech Republic, 2003

CONTRACTING PRACTICES FOR UNDERGROUND CONSTRUCTION, Underground Construction Conference Proceedings, London, United Kingdom, 2003

CONTRACTING PRACTICES FOR UNDERGROUND CONSTRUCTION, International Tunneling Association (ITA), World Tunneling Congress Proceedings, Amsterdam, Netherlands, 2003

CONNECTING LONG ISLAND RAILROAD TO GRAND CENTRAL TERMINAL IN MIDTOWN MANHATTAN, Rapid Excavation and Tunneling Conference Proceedings, San Diego, California, 2001

THE MANHATTAN CONNECTION, Tunnels and Tunneling Magazine, 2001

THE GRAND CENTRAL CONNECTION PROJECT IN MANHATTAN, 16th Congress of the IABSE Proceedings, Lucerne, Switzerland, September 2000

MODERN USE OF AN OLD TUNNEL TO MEET PUBLIC NEEDS, Co-Author, International Congress of Underground Construction in Modern Infrastructure Proceedings, Stockholm, Sweden, 1998

MINIMIZING RISKS IN UNDERGROUND CONSTRUCTION USING THE DBOM APPROACH: A CASE STUDY, Co-Author, International Congress of Underground Construction in Modern Infrastructure Proceedings, Stockholm, Sweden, 1998

DESIGN CONSIDERATIONS OF A TURNKEY CONTRACT FOR AN UNDERGROUND LRT SYSTEM, Co-Author, ITA World Tunneling Congress Tunnels and Metropolises Proceedings, Sao Paulo, Brazil, 1998

REHABILITATION OF THE BROOKLYN BATTERY TUNNEL UNDER TRAFFIC, International Conference on North American Tunneling Proceedings, April 1996

A NEW LIFE UNDER THE EAST RIVER, ASCE Seminar "New Life for Old Structures" Proceedings, Spring 1994

FULL SCALE TESTING OF TUNNEL LINER, Co-Author, ITA's International Congress on Progress and Innovation in Tunneling Proceedings, Acapulco, Mexico, 1992

UNDERPINNING OF VIADUCT AND BUILDING COLUMNS FOR AMTRAK RAIL TUNNELS IN MANHATTAN, Co-Author, Tunnels and Underground Construction Seminar Proceedings, ASCE Metropolitan Section, 1991

EFFECT OF SETTLEMENT ON TUNNEL LINER, International Congress on Progress and Innovation in Tunneling Proceedings, Toronto, Canada, September 1989

THE DESIGN AND CONSTRUCTION OF STEEL IMMERSED TUBE TUNNELS: AN AMERICAN TECHNOLOGY, Co-Author, Immersed Tunnel Technique Conference Proceedings, Manchester, England, April 1989

NONLINEAR ANALYSIS OF TUNNEL LINERS UNDER LONGITUDINAL BENDING, Co-Author, The William Barclay Parsons Fellowship Publication, 1987

WATERPROOFING OF TUNNELS, The William Barclay Parsons Fellowship Publication, 1986.

THE FIRST HORSESHOE IMMERSED TUBE TUNNEL—CONCEPT AND DESIGN CONSIDERATIONS, 25th Annual Structures, Structural Dynamics and Material Conference (SDM) Proceedings, May 1984