Annex

THE GREATER CAIRO METRO NETWORK

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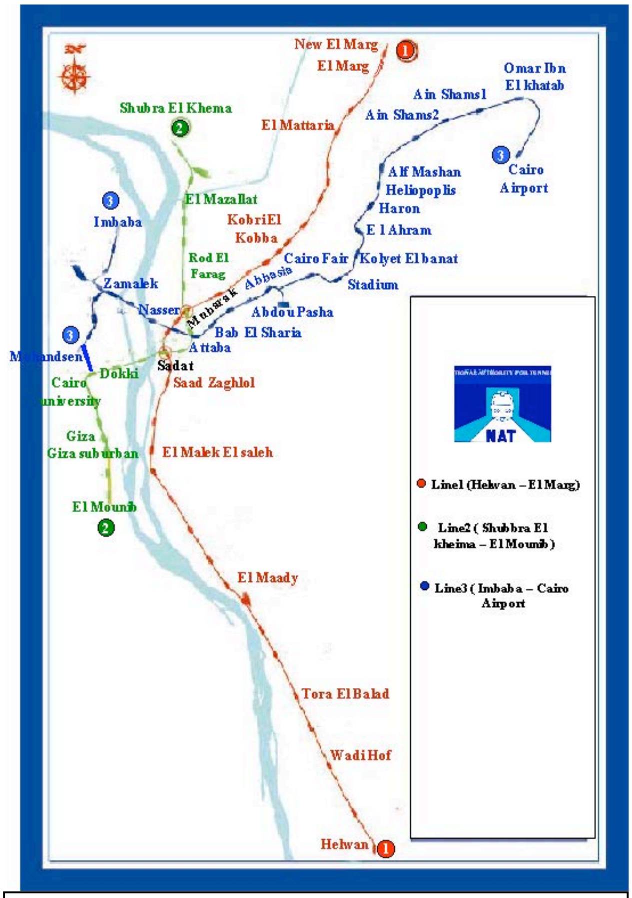
INTRODUCTION

Straddling the River Nile, Greater Cairo has had, and still has, an ever-growing demand for efficient public transport. With a population of about 10 million in the late sixties, Cairo was one of the World's densely populated cities. In the early seventies, through a joint venture with French and Egyptian Consultants, the Egyptian Ministry of Transport carried out a transport study for the Greater Cairo area. The result of that study was the production of a master plan for a metro system, with three lines. Due to some financial constraints, a start could not be made on this ambitious project until November 1981, when a contract was signed for the construction of Line No. 1. Phase1 – 28 km from Helwan to Ramses Square (Mubarake Station) including 4.5 km tunnel in the center of the city of Cairo with a duration of 48 months for project . Unfortunately the project faced plenty of difficulties the most acute were : Traffic Congestions and Diversion of Public Utilities intersecting with the tunnel section of the project .
Until the first of April 1983, though 18 months had elapsed from the project period (1/3 of the period) the volume of work verified was only 4% .



Map of Greatery Cairo showing Metro lines

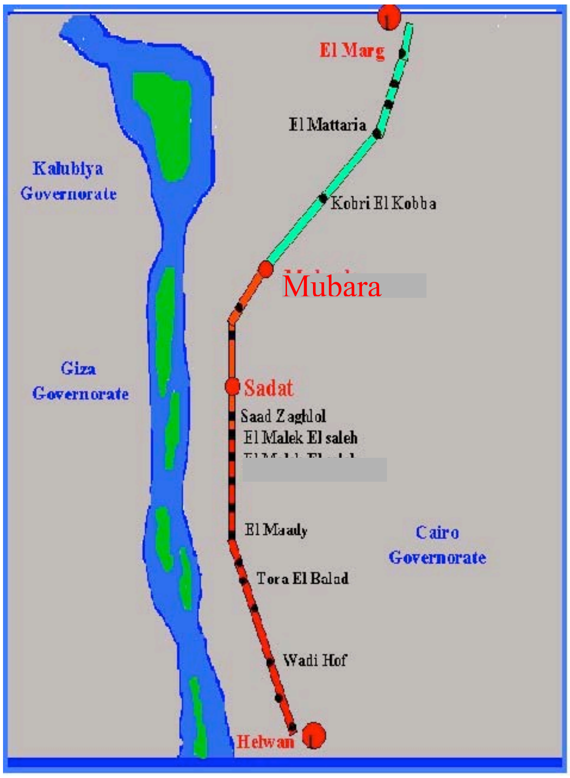
At that stage General Engineer M.E. Abd El Salam was appointed to take charge of the project as the Chairman of what was called Greater Cairo Metro Organization, an Organization related to the Egyptian National Railways ENR . He began by establishing a new independent Authority not only for the Metro projects but also for the tunnelling and underground works in Egypt . In August 1983, he succeeded to obtain a Decree from the Egyptian Parliament to establish that organization under the name of the National Authority for Tunnels NAT . The main object of this Authority is to : study, design, contract, control and construction management for Tunnelling and Underground projects either in Egypt or abroad .

Engineer M.E. Abd El Salam was the Chairman of NAT for 15 years from 1983 to 1998, during that period he took the complete responsibility for the implementation of plenty of underground works and tunnels, the most important are lines 1 and 2 from the Greater Cairo Metro Network which are summarized herein after .

LINE NO. 1

Line No. 1, which forms the backbone of the system, passes through the most important residential and business districts of the city. The line was formed by connecting the existing railway line from Helwan in the south of the city, to the existing railway line to El Marg in the north east, by means of a new underground line beneath the Central Business District (C.B.D) of Cairo. The total length of the line is 44 km including 34 stations. The route passes through very congested areas, extremely close to buildings and public structures. The selection of the route therefore made maximum use of existing streets, publicly owned land and open space, to minimise the need for demolition, underpinning, or expropriation.

Work on the project commenced in 1982 when President Hosni Mubarak gave the instruction to proceed. The work was executed and put into operation in phases. The first phase, the southern section from Helwan to Mubarak Station in Ramses Square, included the 4.5-km long underground section. There are five stations on the underground section, including two that were constructed with a lower box to form the shell of interchange stations for Line No. 2.



Route of Metro Line

The second phase, between Mubarak and El Marg Stations, is completely at ground level. The President inaugurated Phase 1 in September 1987 and Phase 2 followed in April 1989.

SUBSURFACE CONDITIONS IN CENTRAL CAIRO

The City of Cairo is located at the point where the Nile Delta commences. Central Cairo has therefore been built over several hundred meters of recent alluvial and diluvial deposits, underlain by the Upper Eocene limestone marine formations. It has been postulated that the Nile developed its course through this area after the down-faulting of a huge limestone block, bounded on the east by the Mokattam cliff and in the west, by the Pyramids plateau. The meandering and significant changes in the course of the river throughout the ages, have quite clearly been the major sources of soils deposited in the Cairo area.

Appreciable fluctuations in the level of the Nile, combined with the shifting of the water courses, has resulted in sand deposits, alternating in an intricate manner, with layers and pockets of silt and clay. Additionally, as a result of the infilling of some of the old branch channels and lakes, mainly during the nineteenth century, a mixed surface layer of silt, clay, sand bricks, pottery and blocks of limestone are commonly encountered.

Consequently, the main features of the soil are surface layers of variable thickness, from 3 to 8 m, then clayey silt and silty clay layers, with pockets of very fine sand, underlain by a deep seated medium-to-fine sand. Lenses of silt and clay are found occasionally in the sandy layer, which grades frequently to silty sand. The water table is at a depth of between 1.5 to 3 m below the surface. Since the construction of the Aswan High Dam, the fluctuation in groundwater level is limited to ± 0.5 m. The groundwater has a high sulphate content.

DESIGN CONCEPT

Line 1 was designed to carry 60,000 passengers per hour in each direction, in electrically powered trains comprising 9 cars each, with headway of 2.5 minutes with a maximum speed of 100 km/hr and a track gauge of 1.435m.

Considering the prevailing subsurface conditions, the proximity of the underground line to existing buildings and to minimise costs, the cut-and-cover method of construction was adopted for the tunnel and stations.

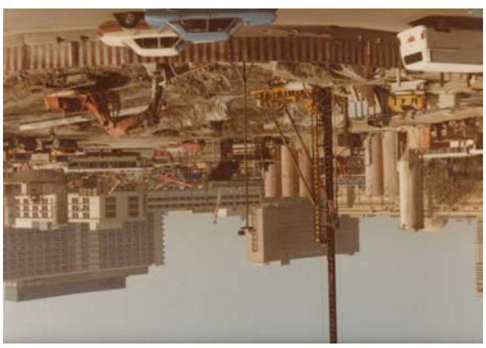
Open Excavation in Main Streets Close to Buildings & Traffic for

The longitudinal profile was established as near as possible to ground level in order to limit earthworks below the water table. Diaphragm walls were used to support the sides of the excavation during the phases of construction and these became part of the structure by being joined to the raft and roof, forming the cross section of the tunnel and stations. Depending on the thickness or depth required, these walls were either precast units or cast in-situ.

The soil between and under the toes of the diaphragm walls was grouted using cement/bentonite followed by a soft silica gel, to form a plug, the level of which was calculated to give the required stability to the bottom of the subsequent excavation works. The function of the plug was to reduce the permeability of the soil to permit dewatering of the excavation, with limited discharge and without affecting the level of the groundwater outside the walls of the tunnel, to ensure the stability of adjacent buildings.

METHOD OF CONSTRUCTION

The first stage of the works was the construction of the necessary diversions of public utilities, either temporarily or permanently. Trenching for the walls was carried out using cement/bentonite slurry, for the precast walls (usually in tunnel sections) and bentonite slurry for the cast in-situ walls (usually in the stations). When the trenching reached the designed level, the precast wall sections were placed or concrete was tremmied, to form the sidewalls of the sections. The precast panels, in the tunnel sections, were 0.45 x 2.5 m x 12 m long, with every tenth panel incorporating a refuge recess. Each joint was fitted with an



interlocking water stop.

Open Excavation For Tahrir Station in One of the Biggest

According to depth, the in-situ diaphragm walls varied from 0.6 to 1 m in thickness. The soil mass located between the two lines of diaphragm walls was divided into stretches by lateral cement/bentonite cut-off walls. Within these stretches, injection tubes were drilled and cement/bentonite slurry, followed by soft silica gel, was injected at the designed level of the plug, the permeability of which was checked by a pumping test.

Depending on the period of authorisation for each work site, the excavation was carried out either bottom up or top down. In the bottom up construction, two levels of temporary strutting were provided above the raft slab but in the top down construction, there was only one level of strutting between the roof and raft slabs. The internal dimensions of the completed sections were 6 x 8.8 m for the tunnel and 6 x 18.8 m for the stations.

ELECTRICAL/MECHANICAL WORKS

The power supply comes from the 66 kV national network, through two different sources and four lines, to which the main high voltage station is connected. This station feeds the metro network through 20 kV lines, running along the metro line. The alternating current (AC) is modified to direct current (DC) through the rectifier stations to produce 1500 V fed to the catenary. The transformers in the light power stations provide 380 V for lighting and ancillary services. The modern systems of fire detection and fire fighting equipment can be activated automatically or manually.

ARCHITECTURAL FEATURES OF THE UNDERGROUND STATIONS

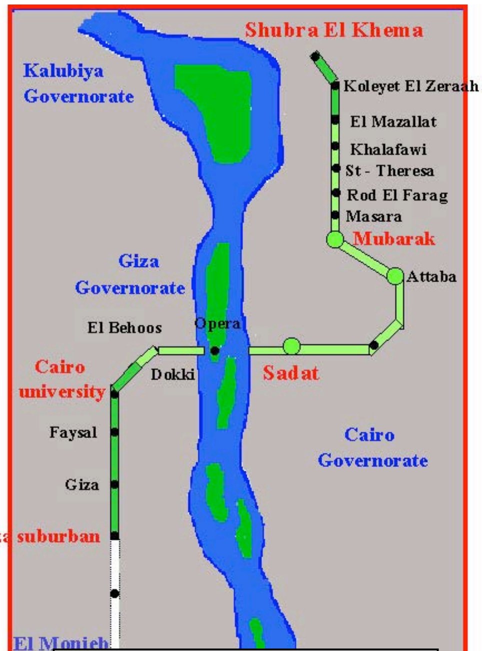
The architectural designs are aimed at emphasising the Egyptian styles and ensuring the coherence of materials and items used to facilitate the maintenance and identification of the stations. This was achieved by displaying the special logo of each station on the cream-coloured walls used in all the stations. The lighting, the seats, the flooring etc., were also designed to be uniform throughout the stations. Sadat Station is characterised by the Pharaonic style. Mubarak Station is characterised by the Islamic style, while the three other underground stations have modern, simple interiors individualised by the distribution of the station logo on the walls, at different levels and intervals. The identity of each station is associated with the colour of its logo.

Islamic Interior

With the operation of this metro line on October 1987, Cairo became the first city in Africa and the Middle East, having a modern underground metro system. The Line No. 1 is a milestone for the City of Cairo, operating efficiently for about 26 years and transporting at present, about 2 million passengers per day.

LINE NO. 2

Unlike Line No. 1, Line No. 2 is a wholly new line. It extends, from Shubra El Kheima, north of the Greater Cairo, to El Monib south of Giza. The construction of the line was divided in 2 phases 1&2. phase 1 is internally divided in 2 parts (1A, 1B) and phase2 in 3 parts (2A,2B,2C). The first four phases (1A,1B,2A,2B). accomplished during the management and supervsion of Engineer M.E. Abd El Salam. The total length now is 21.6km and there are 18 stations & it is in operation since January 2005

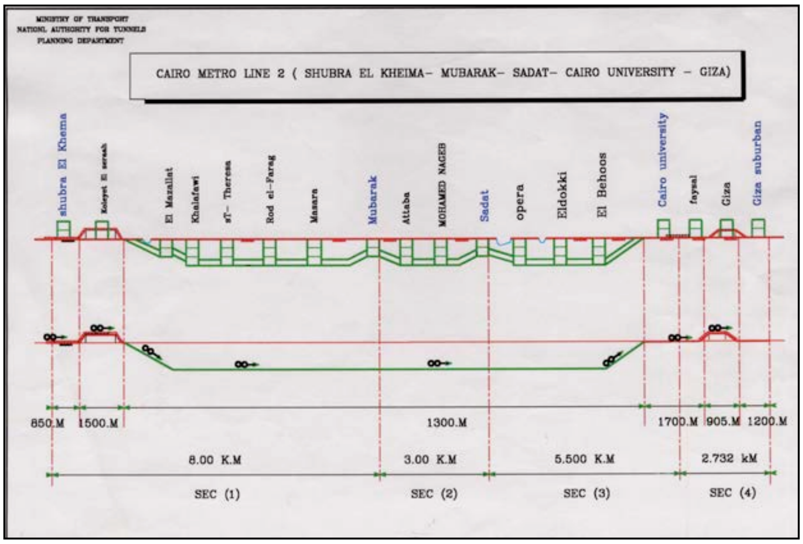


Alignment of Metro Line

Phase 1 (11 km 1A&1B) starts from Shubra El Kheima, where the line is either at grade or on viaduct, before entering into a cut-and-cover tunnel, crossing the Ismailia canal inside a cofferdam. The line then continues south in a bored tunnel to Sadat Station in Tahrir Square. The route for Phase 2A (5 km) begins at Sadat Station and runs to the west to cross under the two branches of the River Nile, then swings to the south after El Behoos Station and by cut-and-cover tunnel reaches the ground level before Cairo University Station. Phase 2B (3 km) from Cairo University Station to Giza Suburban Station, is at grade or on a viaduct.

Line No. 2 provides interchanges with Line No. 1 at Mubarak and Sadat Stations and with Line 3, when constructed, at Attaba Station. It also provides interchange with the Egyptian National Railway services at Shubra El Kheima, Mubarak, Giza and Giza Suburban Stations. Line No. 2, in operation, includes 6 km of above-ground and viaduct section, with 6 at-grade stations, cut-and-cover tunnels of length 1.8 km, bored tunnel of length 9.5 km and 10 new underground stations besides the development of the existing interchange stations. Phase 1A was inaugurated in October 1996 and Phase 1B in September 1997, followed by the inauguration of Phase 2A in April 1999 and finally, Phase 2B was inaugurated in October 2000. Despite the difficulties and challenges faced during the construction, all phases were completed on or ahead of schedule.

The whole line includes: 6.2km at grade, 1.2km. on viaduct & 13km. bored tunnel.



Longitudinal Section of line No.2

BORED TUNNEL

For the bored tunnel section, a single tunnel, 8.35m in internal diameter was constructed using two bentonite slurry shield TBMs, 'Hatshepsut' and 'Nefertiti' (named after the names of two famous Querens in Ancient Egyptain History) for Phase 1. Each of these TBMs was 9.43m in diameter and articulated to follow the designed alignment. The shield used an electro-mechanical erector, a computerised guidance system (CAP) supported by conventional laser for survey control and four sets of injection pipes embedded in the tailskin for grouting of the annular voids. For phase 2A, only one of the TBMs (Nefertiti) was used.

Bored Tunnel

Nefertiti Tunnelling Boring

The TBM progress rate has been exceptional for tunnels of similar diameter and ground conditions, with average rate of 20 m/day reaching 30 m in some days. The tunnel was bored mainly through sand layers, containing lenses of silts and clays or gravel and infrequently layers of cobbles and sometimes boulders. The TBM provision to grout the tail void through the tailskin of the shield kept the amount of settlement very small with an average of 13 mm.

The tunnel has a bolted precast concrete segmental lining, each ring consisting of seven segments and a key, each 1.5 m wide and 400 mm thick. The tail void grout, the elastomeric gasket supplemented by the hydrophilic seal between the segments and the watertightness additive to the segment concrete are factors contributed to achieve the excellent watertightness in the tunnel.

CROSSING THE RIVER NILE

For the first time in history, the River Nile was crossed by a bored tunnel underneath the bed of its two branches. Appropriate safety measures were taken before starting this operation to minimise expected risks. These measures included providing the TMB with a stone crusher to deal with large boulders if encountered. It is worthy to mention that the construction of the tunnel under the narrow western branch (150 m long) and the wide eastern branch (470 m long) was completed safely in 7 and 17 days, respectively.

Alignment of River Nile 2 Boared Tunnel

STATION CONSTRUCTION

The underground stations are typically 150 m long, 21 m wide and have three levels. They have been built using top down construction between diaphragm walls 1.2 m thick and extending down to 55 m below ground level. The stations are up to 23 m below ground level and with a water table 21 m above this. Soil injection was used to form a low permeability plug, 7 m thick, at the base of the walls.

Underground station under

The principles used for the architectural features are similar to those of Line no.1. Each station has logo reflecting the Egyptian arts and cultures. All the stations are equipped with ventilation, escalators, elevators, entry and exit control systems, an automatic ticket system, smoke and fire detection and public address system.

ELECTRICAL / MECHANICAL WORKS

Power of the system is provided from Ramses High Voltage station and distributed by 400 km of cables of 20 kv network. The Centralized Control Point (CCP) in Ramses Complex controls and monitors the power distribution and is also the communication centre of the metro network. The signalling system incorporates fully automatic and manual driving modes.

Trains are equipped with software which allows automatic, semi-automatic and manual operations. The designed maximum speed is 80 km/h with a minimum headway of 105 seconds. Maintenance of the rolling stock is carried out at workshops at Shubra El Kheima capable of carrying out from light maintenance works to major overhauls using the most advanced equipment and computerised maintenance systems.

Repair Workshop of

Train in line 2

Line 2 is operating efficiently and successfully transporting at present 1.2 million passengers per day. With the successful operation of Line 1 and Line 2 together, the beneficial impact of the metro network on the public transport of Cairo is appreciated by all its citizens and there is public pressure for an early start of Line No. 3 of total length of 34.2km. which now its first phase of 4.3km. is in operation & the second phase of 7.2km.is due to be operatedin the first quarter of year 2014 .