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IRAN

Final breakthrough for Shiraz metro

Hamed Jamshidi and Hamed Moammeri detail the construction methods used on the metro

SHIRAZ, capital of Fars Province, is the largest city in southern Iran with a population exceeding 1.2 million in the city and over 1.7 million in the metropolitan area. Work on a metro began in 2001.

Shiraz urban railway organisation (SURO) was established by virtue of municipality rules to be the client for the planning and construction of the Shiraz Metro. With an alignment length of 24.5km, Line 1 comprises 21 stations.

SURO selected the joint venture of Metra and Behan Sadd to project-manage the job.

Four different methods were applied to the construction of the metro due to prevailing geotechnical and groundwater conditions, and also to the problem of traffic (table 1).

Table 1: Tunnelling methods used for different lots

Method statement	Lot length (km)
Twin tunnels excavated by two EPB TBMs (NFM 6.88m diameter)	12.5
NATM (heading & bench)	1.5
Cut & cover	8
Open cut and 'at grade'	2.5
Total	24.5

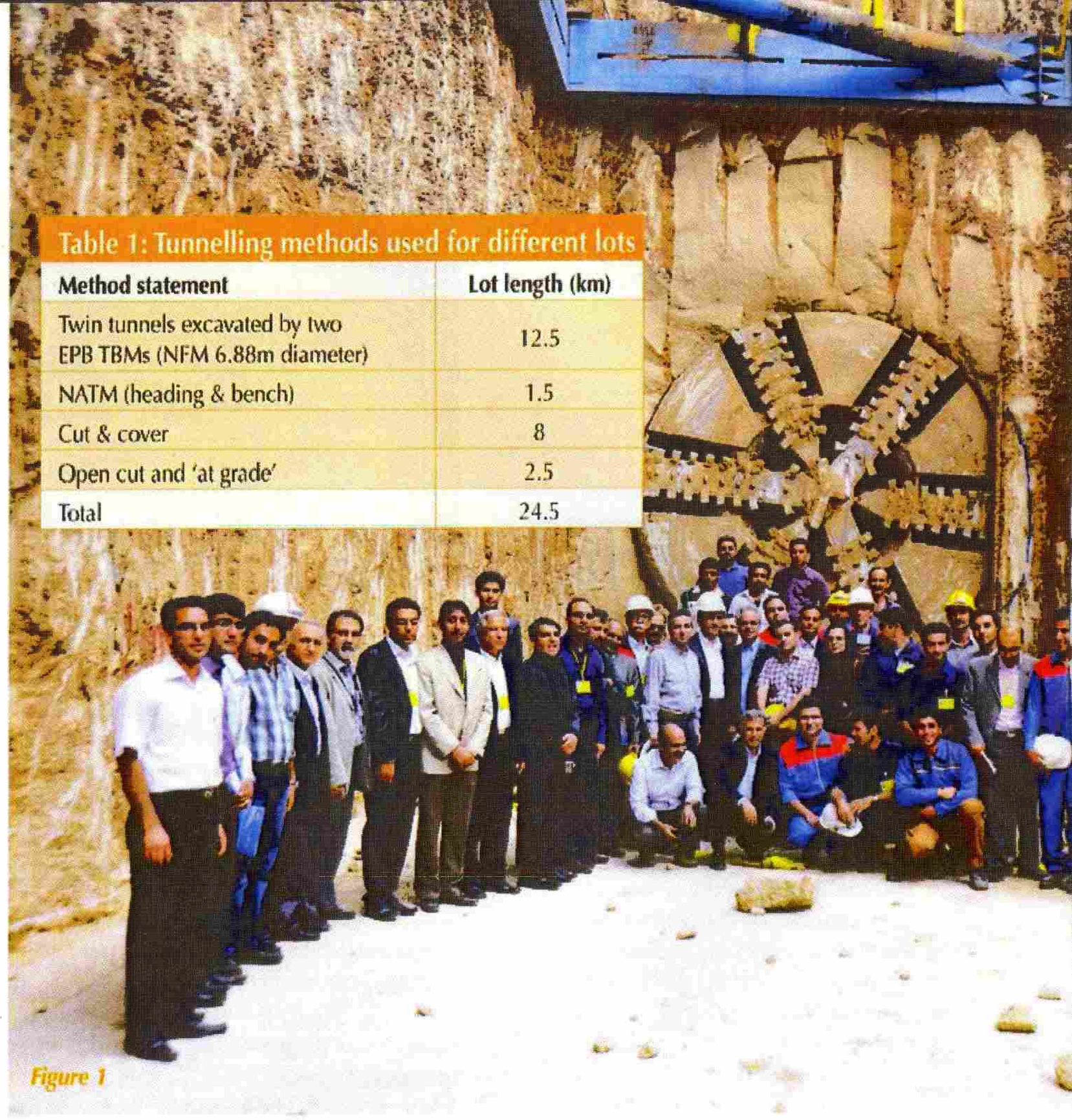


Figure 1

EPB TUNNELLING

As table 1 shows, the longest part of the project comprises twin tunnels, each 12.5km long with an excavated diameter of 6.88m and final diameter of 6m. These have been bored through alluvium and under groundwater.

The two EPB TBMs from NFM completed their drives in October 2010. In so doing, they recorded one of the longest EPB tunnelling drives for a machine worldwide.

Figure 2 shows one of the machines in the NFM factory.

Bamrah Company was selected as the main contractor and all works were carried out under the supervision of Omran Mohit Zist Company. The general specifications of the EPB-TBM bored lot are summarised in Table 2.

PROGRESS RATES

Excavation of the tunnels began in November 2004, and was completed in October 2010, which means that 25km of EPB tunnelling took around six years.

Table 3 shows the annual progress of the machines in each year of construction, while Table 4 shows their progress over various time periods.

INNOVATIONS IN TBM RESTART

As a result of the special conditions of the project, and the mutual contract between the client and contractor, some of the stations along the route were excavated before the arrival of the TBMs. The main aim was to save time and

Figure 2: NFM EPB TBM

Figure 1: one of the machines in the factory and tunnel

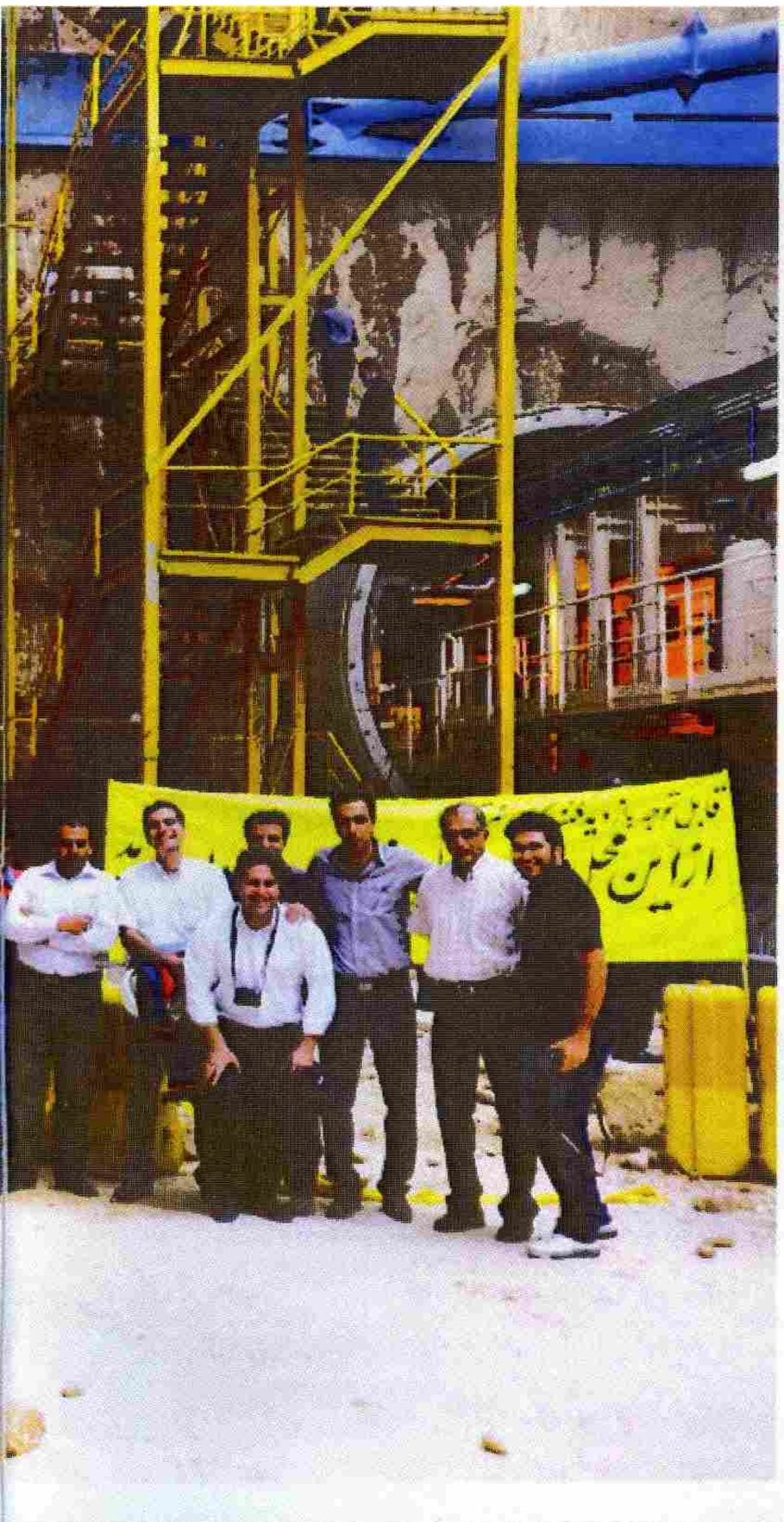
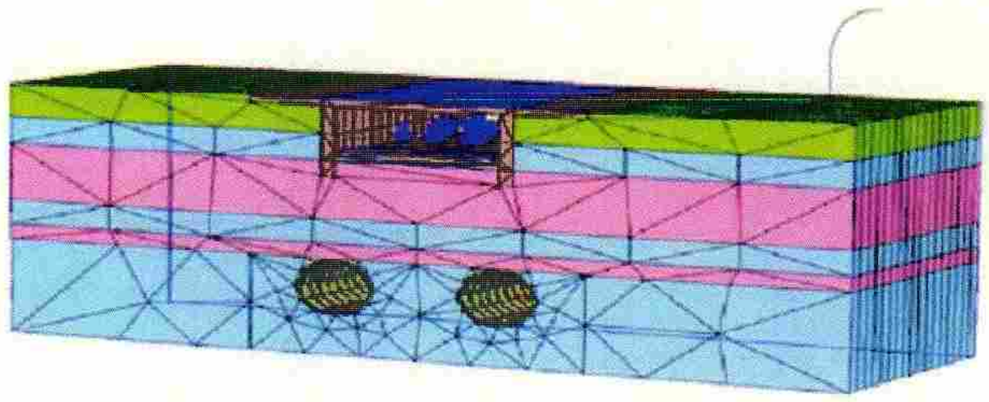


Table 2: General specifications of EPB section	
Length of tunnels	2 x 12.5km
Method statement	Tunnelling by two EPB TBMs
Soil type	Silty clay with layer thickness of 1-3m with lenses of sand and gravel
Groundwater conditions	Excavation of 10.5km in saturated soil and 2km in dry conditions
Overburden	Min. 7m; max. 19m
Distance between tunnel walls	4-8m
Lining type	Concrete segments
Segment arrangement	1+2+2+1 (1 key + 4 rhomboidal + 1 counter key) connected by rod and dowel
Segment thickness	300mm
Segment length	1.4m
Distance between stations	900m
Number of stations passed by TBM	15 stations
Number of already earth-moved stations and TBM movement on cradle	7 stations
Number of breakthroughs into stations for each tunnel	7
Number of hyperbaric operations	8
Max. operational pressure in hyperbaric	1.55bar
Number of fatalities for 25km of EPB tunnelling	1

IRAN



Zand underpass numerical modelling

→ use some of the stations as new launch shafts. This also meant that the length of mucking could be reduced. Generally, TBM-launching shafts were relocated four times during the project.

Innovative methods were used to move the TBMs through these excavated stations and to relaunch them. This included the use of pre-fabricated concrete cradles and a staggered arrangement of segments to allow their use as pushing frames.

SENSITIVE STRUCTURES

The machines bored beneath Qadir Bridge and the Zand underpass. Both structures were very sensitive, especially Zand passage, which has a length of 900m and is located in the historical part of the city.

The contractor therefore designed these parts of the drive carefully and was able to pass both of the structures successfully. Figure 6 shows numerical modelling of the conditions.

HYPERBARIC OPERATION

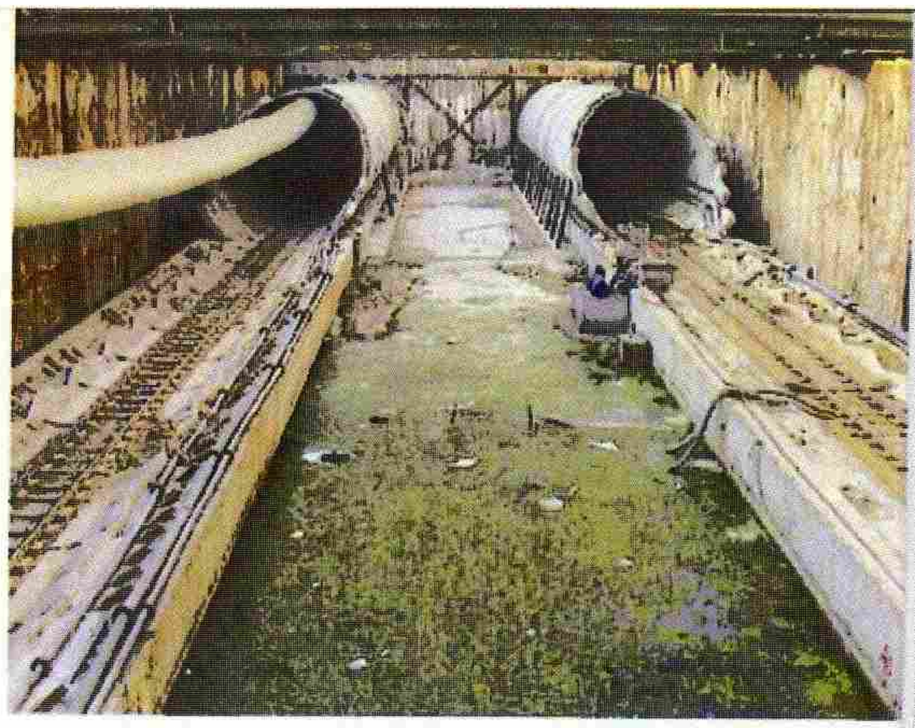
A section of the Zand underpass was located in the historical area. On the other hand, a high overburden and abrasive ground conditions along this section of the alignment forced the execution of four hyperbaric operations under working pressures of 1.55bar.

CONCLUSION

Figure 1 shows the final breakthrough of the second machine into the disassembly shaft, which was celebrated on October 2010.

Excavation of these twin tunnels on Shiraz Metro Line 1 could be considered as one of the most successful EPB jobs in the world – not only because of the long drives, but also for catering for these conditions in the design and manufacture of the TBMs.

Now, both machines are being overhauled and being prepared for a similar job on Line 2.



Concrete TBM cradles

Table 3: Machine progress (years)

Year	Excavation length (km)
1	3.1
2	4.41
3	5.4
4	4.8
5	3.3
6	3.95

Table 4: Machine progress (time periods)

Max. daily progress of one TBM	30m
Max. daily progress of both TBMs	47m
Max. weekly progress of one TBM	164m
Max. weekly progress of both TBMs	224m
Max. monthly progress of one TBM	542m
Max. monthly progress of both TBMs	919m

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