Lucknow Metro Rail Project: A Geotechnical Evaluation of the Proposal

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Introduction

Metro Rails provide efficient mode of transport for large cities. Lucknow is spread over an area of 240 sq. km. and its population was 5 million according to in 1991 census. Three fold increase in population since 1947 coupled with unplanned development has left this cultural citadel of Oudh empire with no scope for widening of roads and improving the vehicular traffic system. The Housing and Urban Development Department, Govt. of U. P. proposed underground Metro Rail Project for Lucknow to a cumulative length of 60 km at an approximate cost of Rs. 6000 to 7000 crores (News Item, The Times of India 22nd Feb-2008). Presently, N-S and E-W corridors have been proposed. The N-S corridor consists of two routes, one from Amausi to Kursi Road (Gudamba) and another from SGPGI to Rajajipuram via Charbagh. In E-W corridor, Bara Imambara is proposed to be connected to Sultanpur Road and Hazaratganj with Faizabad Road (Fig. 1). The Delhi Metro Rail Corporation (DMRC) has been assigned to prepare the feasibility report.

Geomorphic Setting

The district is devoid of any conspicuous relief. Monotony of flattish terrain is broken either in the vicinity of rivers and rivulets or by the occurrence of water impounded natural depressions called palaeo- channels and tals (Fig. 2).

The 2,528 sq. km. area of Lucknow district is divisible into three geomorphic units viz. (1) Older Alluvial Plain T-2 (El. 110 to 123 m) with a few sandy mounds near Behata and Sai rivers on which forts have been made (ii) Gomati Older Flood Plain T-1 (El. 105 to 110 m) and (iii) Gomati Active Flood Plain T-0 (El. < 105 m). The Gomathi River flows at El. 95 m. Unit-1 shows relicts of palaeo-drainage system. Prominent among them are Arhar jheel, Kurdaha tal and Chand jheel where residential colonies have come up. The Unit-2 comprises erosional and depositional terraces which support food crop. The built up area in cis Gomati area is restricted to above El. 110 m, which marks the upper trace of erosional level during high floods in Gomati (HFL 111.55 m in 1960). This unit includes abandoned channels, meander cut-off, oxbow lakes, gulleys and badland topography. The Gomati Active Flood Plain Unit-3 (T-0) lies below El. 105 m and is composed of riverine sand. Fig.1 shows the disposition of all the three units falling across the metro rail corridors.

Geological Setup

The entire length of corridors passes through moderately to densely populated built up area barring the two terminus ends and is masked with Older and Newer Alluvium brought out by pre-Ganga drainage system in last 0.01 m. y. (Fig. 3).

Metro Rail routes

The Older Alluvium comprises polycyclic sequence of sand, silt and clay with kankar disseminations. In Newer Alluvium, Gomati Terrace Alluvium composed of cyclic interstratified sequence of non-oxidised grey micaceous sand, silt and clay and in Gomati Channel Alluvium, point bar/channel bar/ lateral bar's sand and over-bank silt are

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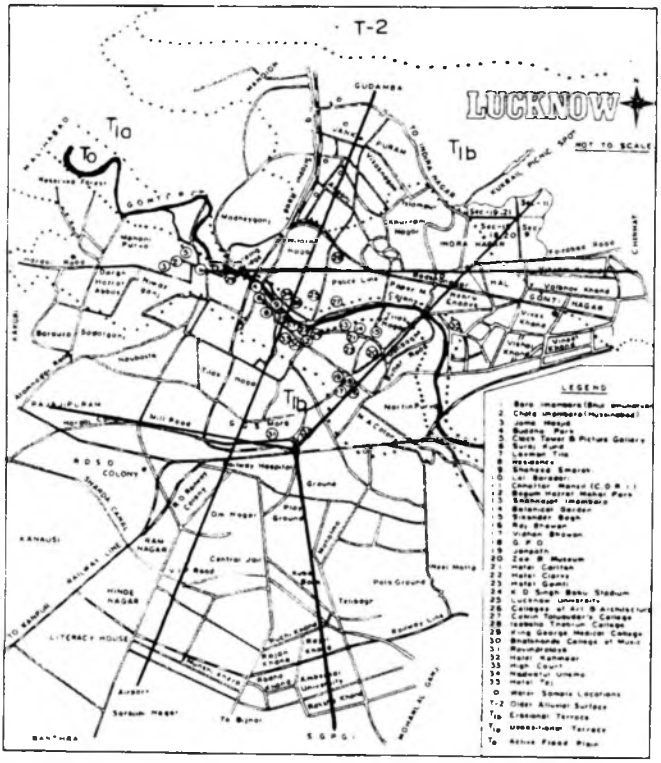

Fig. 1: Map showing the three geomorphic units of Lucknow and proposed

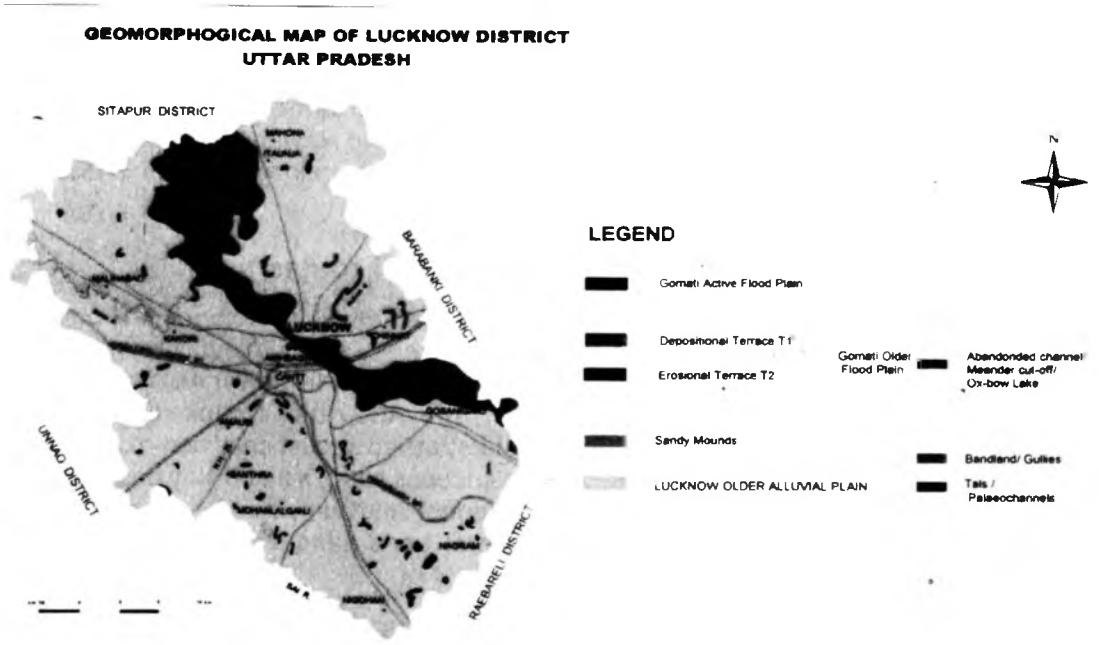

Fig. 2: Geomorphological map of Lucknow district.

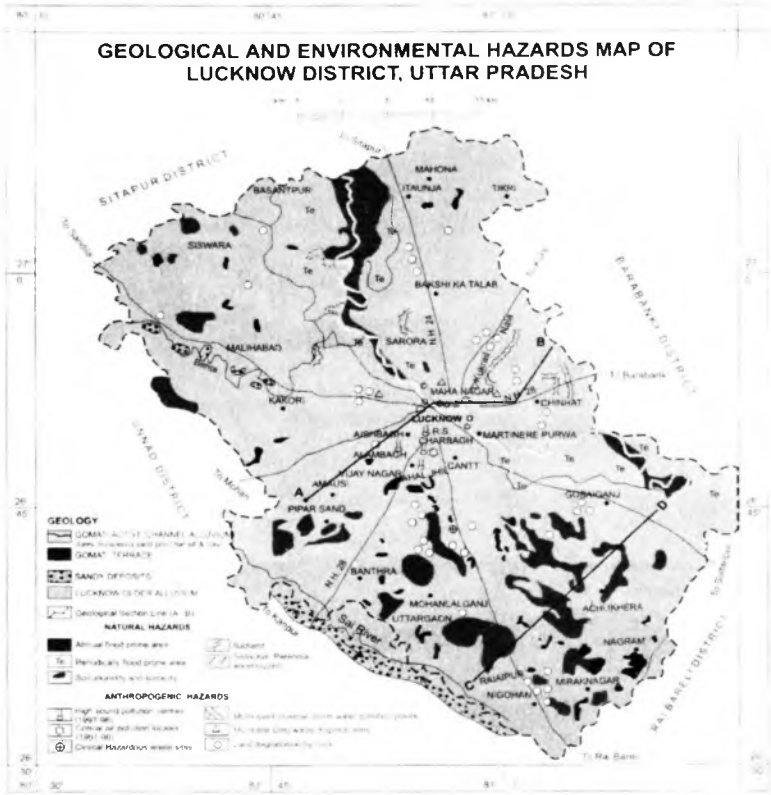

Fig. 3: Geological and environmental hazards map of Lucknow district.

found. Basement rock lies at more than 630 m depth from the surface. The C.G.W.B. drill hole data reveals that there is facies change both laterally and vertically (Fig-4).

Soil characteristics

Lucknow district offers two types of soils namely, residual and river borne. The country rock underlies the residual soil at great depth and the soil is overlain by alternative layers of clay and sand with the clay getting stiffer on increase in depth. Some sandy mounds of more than 4-5 m height from the ground level have been observed near Mohanlalganj, Malihabad and Gosaiganj. The river borne sand occurs along the channels of old rivers resting on normal soil below. The geo-mechanical properties of the 25 samples collected from various places 1 m below the ground level reveal that the soil of Sai catchment is non- plastic (ML) while that of Gomati catchments is non-plastic to plastic (CL-ML) (Fig. 5). In all the samples for which Atterberg limits were worked out, shrinkage limit is lower than the plastic index. This indicates that the soil has greater potential of shrinking (Chandra and Kumar, 2003).

Ground water potential

Study of data from boreholes drilled by CGWB and State Government in the district indicates the presence of five groups of aquifers down to a depth of 636.37 m. They include (i) up to a depth of 110 m, (ii) 116 to 174m, (iil) 150 to 270 m (iv) 257 to 356 m and (v) below 305 m. These aquifers are separated by a clay layer. Lucknow City utilises water for drinking from aquifers raging in depths from 8 to 147 m and 214 to 251 m.

The first and second aquifer zones contain fine grained sand with occasional gravel and coarse sand. Fluctuation in water level

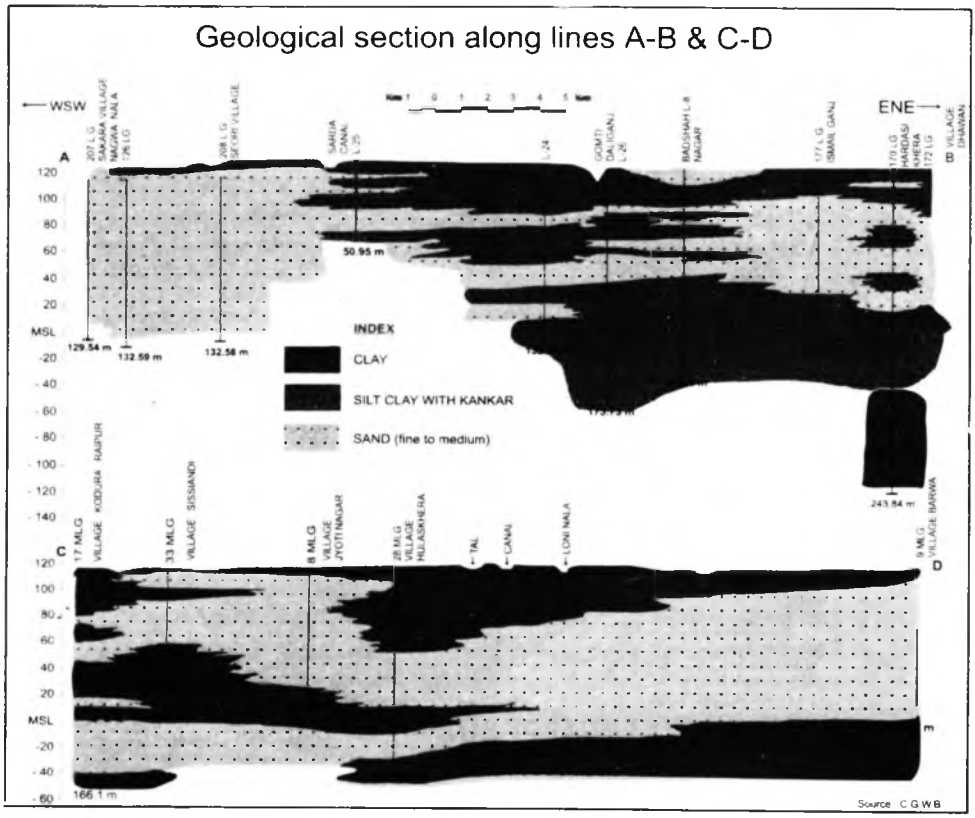

Fig. 4: Geological section along AB & CD lines of Fig. 3 showing facies variation.

between 0.21 m and 18.40 m in various parts of the district is observed. The maximum rise in water level is along the eastern and northern boundaries (1.5 m to 3.83 m) and declining trend (0.5 m to 1 m) is noticed in Aminabad, Aishbagh, Mahanagar and parts of Sarojini nagar and Cantonment (Chandra & Kumar, 2000)

Geotechnical Evaluation of Metro Rail Routes

The Lucknow terrain is monotonous with an elevation difference of only 28 m between the highest levels at Amausi and Kursi Road (Gudamba) (Approx. El. 123 m) and lowest at basement of Gomati River (El. 95 m). Since the growth of the city is more in NE-SW direction, the NNE-SSW line which connects the Amausi Airport with Kursi Road (Gudamba) via Charbagh Rly. Station covering a distance of 15 km has to be given priority. This line has to cross the River through geomorphic units T-2, T1 and T-0 ((Fig. 6). A host of

geotechnical problems like heavy ingress of water from tals/ponds and palaeo-channels in T-2 and subterranean flow and shrinking clay in T-1 and T-2 terraces may be encountered during tunneling. The T-0 which occurs in a small stretch across Gomati can be obviated if track is laid over a bridge in this reach with either end say at about El. 112 m in T-1 terrace.

Amausi Airport- Kursi Road (Gudamba) Line

This line would be passing through Munsi khera, Hind Nagar colony, Bargwan, Bara birva (Near Sharda Canal), Sneh Nagar, Patel Nagar, Charbagh, Naka Hindola,

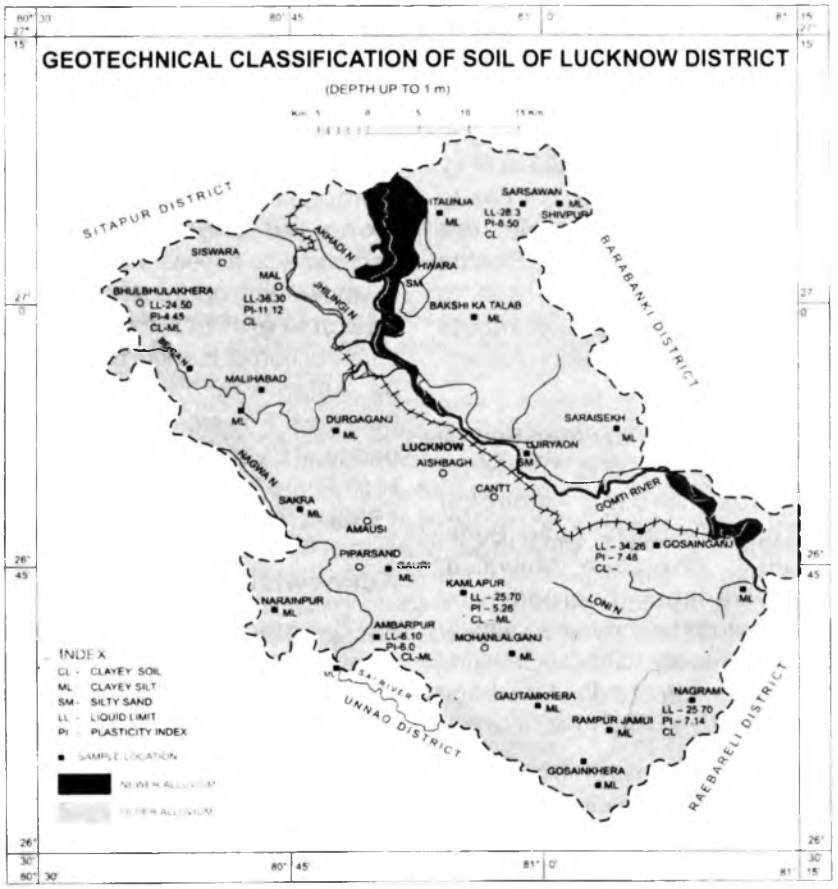

Fig. 5: Geotechnical classification of soil of Lucknow district.

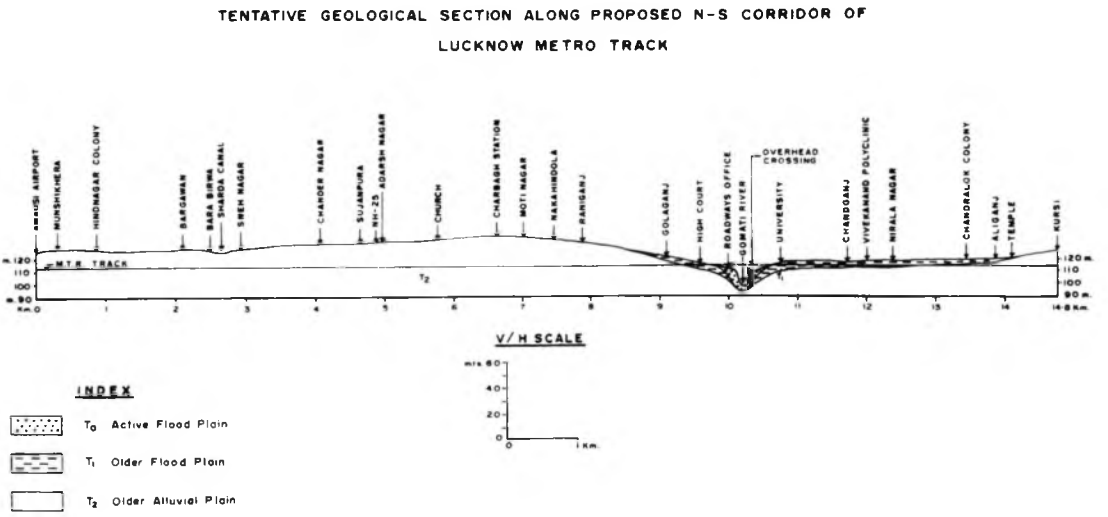

Fig. 6: Geological section along the proposed alignment of Tube Rail between Amausi Airport and Kursi.

Aminabad, High Court, Roadways offices (El. 112.6 m) all in T-1 terrace, then through Shaheed Smarak, Nadwat-el-ulma in T-0 terrace and Vivekanand Polyclinic, Kapurthala, ITI, Aliganj. Mahabir temple and finally Kursi in T-1 Terrace at El. 123 m (Fig. 6). The tunnel for most of its length has to driven by shield method. The major tals enroute viz., Arhar & Chand Jheel, Sharda Canal etc. are getting dried up due to developmental activities, so the water ingress would be faced only while negotiating palaeo-channels during monsoon.

Another section of N-S corridor from SGPGI to Rajajipuram Via Charbagh (Fig. 1) covering 9.6 km would pass through Ambedkar University, VIP road, Telibagh , Kuber Bank, Railway Hospital , Charbagh, Mawaiya, Motinagar, Malviyanagar, Eveready and Talkatora. This route also may pose similar problem as that of Amausi –Charbagh- Kursi but the west-ward section from Charbagh would be in Older Alluvial Plain T-2.

The 9 km long E-W corridor from Bara Imamabara (El. 105 m) to Sultanpur Road may pass through Residency, Hazratganj, Raj Bhawan and Sultanpur Road. It will face the problem of flowing ground and water ingress from T-1 and T-2 terraces.

The Charbagh to Faizabad Road track would pass through Hussainganj, Vidhansabha Marg, Hazratganj, NBRI, Butler Colony, Nehru Enclave, Gomtinagar, and Indira Nagar for a distance of 7.2 km. This is the most important and busy route passing through Older Alluvial Plain (T-2) and Depositional Terrace (T-1) in Nehru Enclave, Gomati Nagar and Indira Nagar. The ground will behave in the same manner as stated earlier.

Conclusions and Recommendations

U. P. Govt. has proposed N-S and E-W corridors of Metro Tube Rail covering a cumulative distance of 60 km. The track would pass through Older Alluvial Plain T-2, river terraces T-1 of pre-Ganga drainage and Active Flood Plain of Gomati (T-0). The problems like shrinkage in clay bound areas and ingress of water may have to be tackled with cautious approach and planning. A thorough sub-surface exploration by drilling along the alignment of the tracks is necessary to assess the tunneling media and to know their geotechnical properties. The authors are of the opinion that the construction of tunnels by shield method may be suitable for the geological setting of Lucknow. For crossing the Gomati River, a bridge at El. 112.6 m, i.e. above the recorded High Flood Level of Gomati (HFL 111.55m in 1960) is recommended.

Acknowledgement

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