DEEP EXCAVATION ADJACENT TO A MULTI-STOREYED BUILDING LATERAL SUPPORT

Gupta Sanjay
Sundaram Ravi
Singh Pushpendra
Cengrs Geotechnica Pvt. Ltd., B3/87, Safdarjung Enclave, New Delhi - 110029
cengrs@vsnl.com

ABSTRACT: To ensure safety of a tall multi-storeyed building adjacent to a deep excavation, cement grouting was done. The paper explains the site conditions and the scheme adopted. The grouting assisted in restraining lateral soil movement. Field observations confirmed that no soil movement occurred till the time the basement wall was constructed up to ground level.

1. INTRODUCTION

A 16-m deep excavation (nearly vertical cut) had been done for construction of a five-storeyed building with three basements. The adjacent six-storeyed building, with basement extending to 5 m depth, is located about 6 m away from the edge of the excavation.

After heavy rains, a part of the boundary wall of the adjacent building, which was at a distance of less than 0.5 m from the edge of the excavation, collapsed. This raised concerns regarding the safety of the heavily loaded building.

The building owners feared that, with time, the soils adjacent to the excavation might progressively collapse and endanger the safety of their building. The soil wedge that fell along with the boundary wall lent credence to this opinion. A photograph showing the site condition after the boundary wall collapse is presented on Fig. 1.

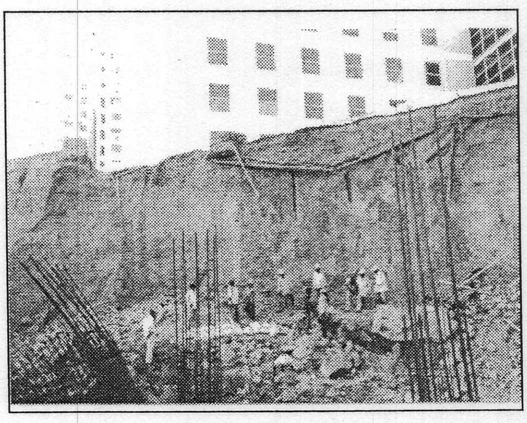

Fig. 1: Deep Excavation Adjacent to Building – Collapsed Boundary Wall

2. SITE STRATIGRAPHY

The project site is in Gurgaon, Haryana, about 20 km from Delhi. The area belongs to the Indo-Gangetic Alluvium. The soils are of Pleistocene Age (Krishan, 1982) and classify as medium dense sandy silt of low plasticity.

SPT values range from 5 to 14 to about 2.0 m depth. Below this, SPT values range from 23 to 32 to about 6.0 m depth. In the underlying soils, SPT values increase and range from 34 to 64 to 20.0 m depth. The site stratigraphy, together with SPT N values and soil properties, is illustrated on Fig.2. The results of static cone penetration test are presented on Fig.3.

3. PROPOSED LATERAL SUPPORT SYSTEM

3.1 Assessment of Site Conditions

The soils at the site are primarily Delhi Silt of low plasticity. The SPT and cone tip resistances indicate stiff to very stiff consistency to about 6.0 m depth. Below this, the soils are hard and compact.

Fig 4 presents the site plan showing the building, the excavated area and the section of the wall that failed.

As such, nearly vertical cuts at this site have been observed to be stable even to 16 m depth. However, erosion due to rain could cause instability. The boundary wall was too close to the edge of the excavation. The authors are of the opinion that the exposed soils beneath the wall foundation got saturated during rains. This resulted in development of a slip circle, which caused failure.

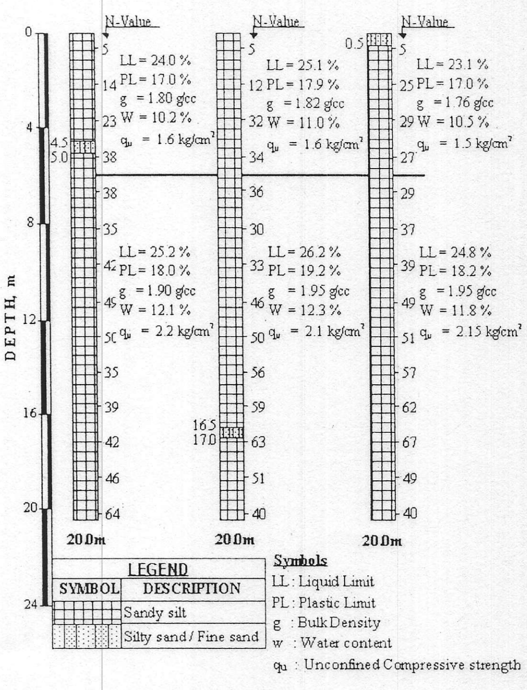

Fig.2: Borehole Data

Reviewing the site conditions, the building adjacent to the excavation appears to be safe in the present condition. However, to ensure safety of the building during the entire construction period, precautionary measures should be taken so that further collapse of the soils does not occur.

3.2 Cement Grouting

After review of various options, cement grouting of the soils adjacent to the existing building was selected as a time-saving and cost-effective solution. The authors have, in the past, deployed compaction grouting using cement slurry to strengthen alluvial silts of low plasticity (Sanjay Gupta et al, 1997).

Grouting at closely spaced points can effectively create a grout curtain. This can provide sufficient lateral support to the soils adjacent to the building foundation.

3.3 The Scheme

Two rows of grout holes were drilled just adjacent to the basement line of the existing building in the stretch close to the deep excavation. Along each row, the spacing between the grout holes was kept about 1.0 m.

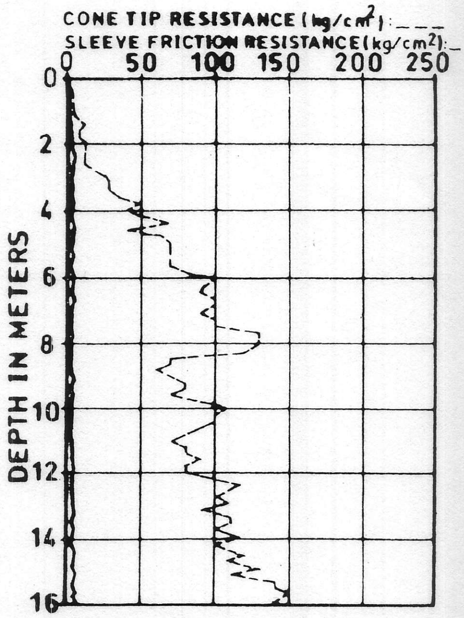

Fig. 3: Static Cone Penetration Test Results

The first row immediately beyond the basement raft was drilled to 9-10 m depth, i.e. 4-5 m below basement level. The second row of grout holes was made 1 m away from the first row, to 11 m depth.

A 20-mm diameter conduit pipe was placed in the hole. A concrete plug was placed in the grout hole at 3-m depth below ground level to seal the hole and to ensure that the soil below the foundation level is strengthened.

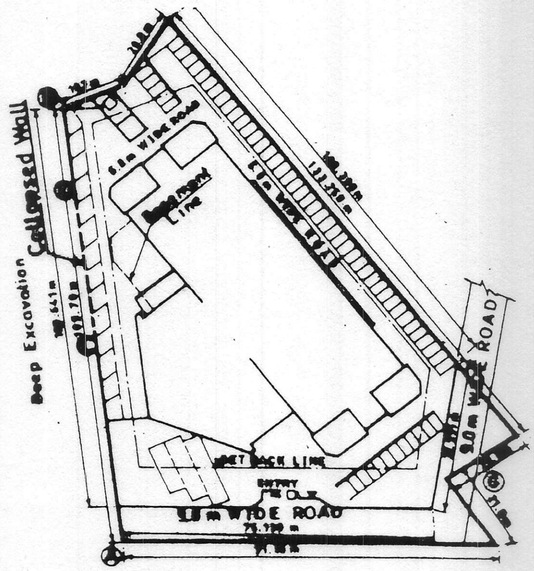

Fig. 4: Site Plan

In silty soils, the grout, under pressure, compresses the surrounding soils, opens up cracks and fills them. Micro-fine level cement permeates and binds the particles. The cement grouting in such soils essentially works as compaction grout.

3.4 Grouting Procedure

The grout was prepared by mixing 50 kg (1 bag) of cement in 100 litres of water (1:3 by volume). Before injecting the cement grout, about 15-20 litres of water was pumped in for creating passage / openings for easy movement of grout.

The cement slurry was then pumped into the hole, initially under a pressure of 0.5 to 1.0 kg/ cm^2 and gradually increased to 2 kg/ cm^2. A mechanized grout pump with a 10-HP engine was used. The cement slurry was agitated continuously during the pumping process.

The injection of the cement slurry was continued until refusal to further grout intake was met under a steady pressure of 2 kg/cm^2. A typical section of the grout hole is presented on Fig. 5.

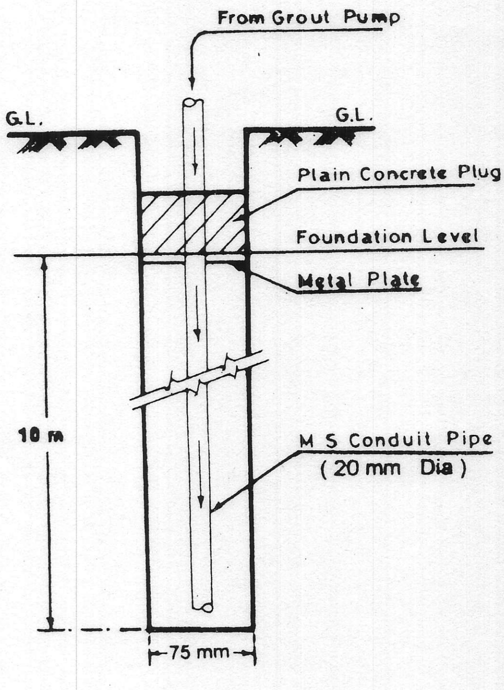

Fig. 5: Schematic of Grout Hole

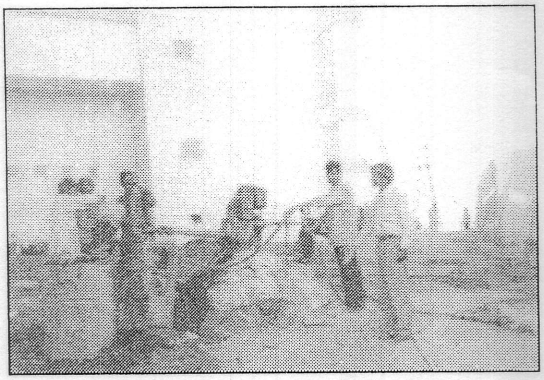

Fig. 6: Grouting in Progress

As a precautionary measure, only alternate holes were taken up for grouting. Boring and grouting for the intermediate points were taken up only after the adjacent hole was grouted. Fig. 6 shows the grout pump injecting cement slurry.

4.0 FIELD RESULTS

A sketch showing the layout of the grout holes and the grout consumption in each hole is presented on Fig. 7. As such, the results indicate that the sandy silt is fairly stiff in condition. However, a few localized zones with somewhat higher grout intake were observed.

A total of 84 points were grouted. The cumulative cement consumption was about 245 bags. The grouting activity was completed within one week. This clearly demonstrates savings in cost and time in comparison to contiguous piles, sheet piles, etc.

The grout curtain thus formed effectively created a cut-off wall to protect the building from disturbance that may be caused by any lateral movement of soil in the excavation area.

The authors continued to observe the excavation after grouting. Nearly 8 months have passed since then. No soil movement or localized zones of distress has been observed.

In the meanwhile, the building construction is also in progress at a fast pace. Fig.8 shows the retaining wall of the basement nearly complete up to ground level. After placing backfill behind the wall, the boundary wall was re-constructed. The foundations for the wall consist of 300 mm diameter auger piles installed to 10 m depth.

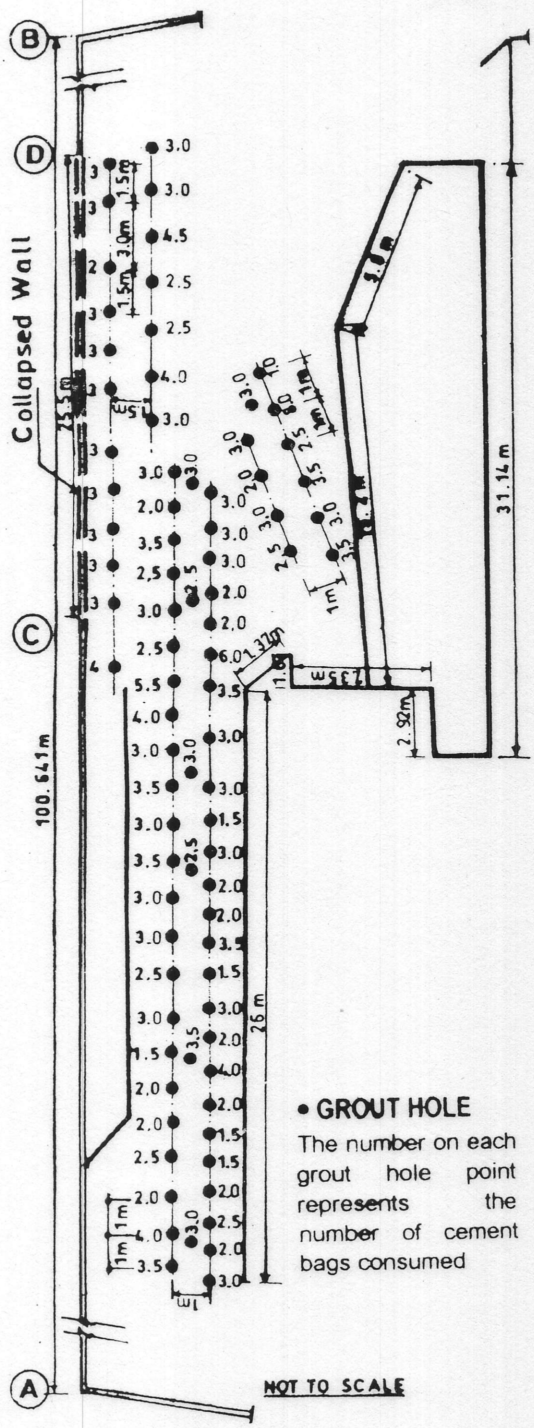

Fig. 7: Grout Hole Layout and Grout Intake

Fig. 8: Retaining Wall constructed up to GL

5. CONCLUDING REMARKS

The paper demonstrates the successful implementation of a simple, yet effective method to solve the problem. The grouting not only arrested lateral ground movement effectively but also generated confidence among all concerned that the adjoining building will not be affected during the construction period.

REFERENCES

Sanjay Gupta, Ravi Sundaram, Ramamurthy, T and Sinha, S.N. (1997). Cement Grouting in Delhi Silt A Field Study, *Proc. Indian Geotechnical Conference, IGC-97, Vadodara,* 255-258.

Krishnan, M.S. (1982). Geology of India and Burma, *CBS Publishers & Distributors, Delhi.*