Case Studies of Failure of Basements During Monsoon

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ABSTRACT

The paper presents case studies of failure of basements due to uplift during monsoon and highlights common errors in estimation of uplift pressures and indicates nature of remedial measures. Basements are designed considering the foundation parameters given in the geotechnical investigation report and uplift pressure is based on the level of Ground Water Table (GWT) indicated in bore logs. But this is not necessarily the highest water level occurring in monsoon. Presence of nalla nearby, which may flow full in monsoon or the temporary flooding can considerably increases the uplift pressure. Paper presents 5 case studies in which basements were severely damaged due to uplift leading to stoppage of construction and necessitating costly repairs involving reconstruction, anchoring and grouting. It is concluded that basement designers need to allow for uplift pressure likely to occur in monsoon. Construction condition in monsoon also needs to be studied.

1. INTRODUCTION

Provision of basements is becoming increasingly common in the multi-storey buildings in metropolitan cities to provide car parking areas. They are also useful for housing the equipment for various services. Basements are permitted free of FSI and since the land costs are very high, such a concession becomes very useful and builders invariably go in for one or two or sometimes even three basements. The structural designer does consider uplift but many basements get damaged during monsoon due to uplift particularly if the construction is only partly complete. Where do the designers go wrong?

Paper presents 5 case studies of the buildings in which basements got severely damaged due to uplift during monsoon. Obviously uplift pressures were underestimated.

2. CASE STUDY 1

Uplift Like a Ship in Water

At a site in Bandra a basement raft, 600 mm thick, covering an area of 18m * 30 m was placed at 3.5 m depth below ground. The overburden was fill and silty clay (murrum) overlying volcanic Tuff, as shown in the bore log given in Fig.1. Ground water was within 1 m depth. Continuous dewatering was adopted during raft and basement wall construction but was stopped when floor slab construction began. Within a few days it was noticed that basement was lifting up like a ship in water. The lift was uneven and varied from zero to 560 mm but there was no cracking of raft or walls. Table 1 shows the lifts observed at all corners.

Remedial Measures

(a) Drainage boreholes, 200 mm dia., were executed around the building and simultaneous dewatering was commenced. Building slowly started down and rested on the founding strata, albeit unevenly. Perfect seating was not possible due to presence of boulders and cobbles which had fallen from the sides and rolled underneath the raft when basement uplifted. Residual lift persisted as indicated in the Table 1 below.

(b) Sand Cement (1:1) grouting, was next undertaken through the 20 Nos. ‘Nx’ size holes specially drilled through the raft and which went 5m below in to the founding Tuff strata. Grouting pressure was limited to 100 KPa. 32 mm dia. high yield strength deformed steel bars were inserted in the grout holes before finally sealing them.

Table 1: Observed Lifts of Basement Corner Points

<table>
<thead>
<tr>
<th>Building Corner</th>
<th>Initial Lift Above Founding Level</th>
<th>Final Lift Above Founding Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>North East</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>North West</td>
<td>345mm</td>
<td>95mm</td>
</tr>
<tr>
<td>South East</td>
<td>210mm</td>
<td>75mm</td>
</tr>
<tr>
<td>South West</td>
<td>560mm</td>
<td>188mm</td>
</tr>
</tbody>
</table>

3. CASE STUDIES 2 AND 3

Uplift Due to Water in Nearby Nalla

At two sites in Andheri, nallas existed near the proposed structures. Boreholes (Fig.1), showed water table much
below the ground level. During monsoon however they started overflowing and created excessive uplift pressure. With buildings aligned more or less parallel to Nalla, raft cracked in the transverse direction with cracking extending at some places in the sidewalls.

At Andheri Marol site, (Case Study 2), reconstruction required raising of the basement and increasing the raft counter weight.

At Andheri East site, (Case Study 3), the building was planned with a basement and 2 wings of 7 storeys each with 530 sqm. plan area per floor. Basement raft and columns had been cast and the superstructure was under construction. During heavy rains the adjoining Nalla started overflowing. One of the wings (closer to Nalla), got lifted up (destroying the tiled water proofing) with uplift varying from ‘nil’ to 200 mm. Tilt was seen in many columns and basement raft had cracked in transverse direction. Footings on the crack line were damaged and tie beams connecting footings were sheared with diagonal cracks near the supports. In basement retaining walls also had parallel vertical cracks in 3 bays. Raft was founded on fractured basalt rock which seem to have provided easy access to water creating excessive uplift pressure.

Remedial measures involved complete reconstruction of the damaged wing and grouting of fractured foundation rock and installing of two types of passive anchors. 60 anchors of 50 T capacity (3 Tor rods of 32mm dia in 125 mm dia, holes of 6.5 m depth) and 48 anchors of 33 T capacity (2 Tor rods of 32 mm dia in 4.5 m deep holes of 125mm dia) were installed to resist the estimated uplift. Neat cement grout, 0.5 W:C ratio with non-shrink additive, SUNPLEX , at a dose of 330g per 50 kg cement, was pumped in the grout holes with pressures limited to 150KPa. Foundation grouting along the transverse line of cracking of the raft showed remarkably high consumption of grout.

4. CASE STUDY 4
At this site in Pune, the building was founded on a hard basalt rock strata but the site was sloping. No water table was observed during geotechnical investigation. During monsoon, the surface run-off along the basement wall lead to uplift which was not anticipated. Basement anchors were required to be installed.

5. CASE STUDY 5
At this site located in expansive black cotton soil in Indore, M.P., a five star hotel had been constructed. Column footings rested on stiff silty clay strata below the upper expansive soil but basement raft was placed higher on the compacted murrum fill, which was also placed behind the basement walls. The temporary flooding during heavy monsoon lead to uplift of raft, arch type hogging and cracking and damaged the sensitive equipment placed thereon. The repairs involved reconstruction of the basement raft with peripheral drains.

6. CONCLUSIONS
(a) Consider highest water level of nearby Nalla for uplift pressure.
(b) Water due to temporary flooding can induce very high uplift with water acting through the back fill behind basement walls.
(c) Flowing water by the side of basement during monsoon can induce uplift.
(d) Above aspects should be carefully looked into to decide an appropriate uplift water pressure for basement design, particularly if the construction is only partly complete.

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REFERENCES
Uday Geotechnical Engineers Pvt. Ltd. (1996) Soil investigation report for proposed hostel building site in Bandra East, Mumbai.