INVESTIGATION OF A BUILDING COLLAPSE IN DELHI

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ABSTRACT: Forensic investigation into the Lalita Park area building collapse apparently based on unfounded construction records and history forms the basis of this report. This 5+ storey RC framed (?) building failed all in a sudden, giving no specific sign and symptoms to the occupants. The impact of prolonged inundation of the basement, incipient seepage through the untreated basement, possible weakening of the load bearing columns by contaminated (sewerage) water, are some of the causative factors that have been looked into. After 5 days of rescue and debris removal operations, it was found that one column out of twelve failed at the upper ground floor support. Doubt rose whether this column failed by punching shear and if so can a frame building collapse just due to excessive settlement of one column only? Upon excavation of foundation it was found that the building had not suffered any foundation failure rather it was a fit case of complete structural failure.

INTRODUCTION
On 15th November 2010, around 8.15 PM, a 5+ storey building near Lalita Park, Laxmi Nagar (East Delhi), suddenly collapsed, killing 71 people and injuring 65. Over 60 families, mostly labourers were living in the cramped quarters of the 20-year-old building. Little or insufficient damp proofing measures were taken up by owner/civic authority for the basement leakage. No measures, such as pumping out of water, sealing of leakage or monitoring of foundation deterioration, have reportedly been taken up. The building was suspected to have weakened due to the heavy rains during monsoon followed by incipient seepage into the basement, which was present till Rainey well No. 10 started flushing out water in the beginning of January 2011(Fig.1).

The Government of National Capital Territory of Delhi instituted a Commission of Inquiry to look into the causes of the collapse of the building, assess the safety of built up structures in East Delhi and recommend measures to prevent similar incidents in future

In taking up forensic investigations of this building, some aspects of design, construction and maintenance actions have been studied in detail to analyze why, when, how, and what went wrong and more importantly, what are the pre-event symptoms and scenarios that led to sudden collapse.

STATUS BEFORE COLLAPSE
This building was a privately owned residential building under the jurisdiction of Municipal Corporation of Delhi (MCD). It started with one storey building in 1988, then extended to 3 storey in 1990 and then to five storey in 2005. Basic principles of constructions prescribed by BIS and NBC-2005 were hardly seen followed.

This building covered full area of plot (4.7m x 18.6m) with cantilever projections and floating walls on all three sides. It had basement of 3m depth and 12 columns which were placed at the plot boundary, thus rendering all footing to be eccentrically loaded. The entire colony comes under Yamuna flood plain yet little or no attention was given in the seepage protective measures. The constructed height (20.5m) was more than 4 times the plot width (4.7m). In addition, the overhang from ground floor to full height in the Western side was almost 50% of the base width, thus making it vulnerable to structural instability. The building had 40 odd rooms with reportedly housing more than 200 people. To such building, existing building bye-laws, development control rules, land use policy and master plan etc. can not be complied with.
BUILDING IN THE NATIONAL CAPITAL

Buildings in Delhi, whether authorized or regularized, planned or compounded, old or reconstructed, free or lease hold needs safety auditing against fire, flood, earthquake and other related hazards. Those buildings constructed even as per sanctioned plan and design also needs performance check against possible hazards. As per seismic map of the country Delhi and NCR falls under high seismic Zone – IV. Unfortunately disaster safety auditing is not routinely followed in our country. To ensure proper performance of the existing buildings and housing stock to withstand the forces of natural hazards in future, it is necessary to create mechanism for carrying out safety audit and facilitate adequate financial support for retrofitting and strengthening wherever necessary.

While problems of buildings, whether in urban villages or in the authorized colonies of Delhi are mounting up not only through wrong construction procedures but also unchecked reconstruction/remodeling of buildings are taking place by flouting all civil engineering design norms specified in the NBC-2005 and BIS codes. Basics of building safety and lifeline establishments though outlined in building bye-laws and development control rules, they need coordinated efforts for implementation.

WHY FORENSIC INVESTIGATION?

Normally beam-column frame type buildings do not collapse all in a sudden unless subjected to sudden shock or blast. One outer column was found punched to the foundation possibly by weakening of the soil due to prolonged water logging. However, in routine design of foundation, water logging or inundation causes maximum of 50% reduction in safe bearing capacity, which is normally taken into account in all foundation design. Therefore, weakening of foundation due to stagnant water and seepage can’t be the only possibility.

It is proposed to carry out forensic investigation of the collapsed building, including excavation of foundation and checking consistency of the sub-soil profile from weakening, if any, by stored water and/or continued deterioration of the superstructure for overuse or overloading from ongoing activity inside the building before collapse.

FORENSIC GEOTECHNICAL ENGINEERING

Forensic analysis in geotechnical engineering involves scientific and legalistic investigations and deductions to detect the causes as well as the process of distress in a structure, which are attributed to geotechnical origin. Cases of remedied installations where the analysis and evaluation of adopted remedial measures with regard to their effectiveness and economy may be subjected to judicial scrutiny also fall under this purview. The normally adopted standard procedures of testing, analysis, design and construction are not adequate for the forensic analysis in majority of cases. The test parameters and design assumptions will have to be representative of the actual conditions encountered at site. The forensic geotechnical engineer (who is different than the expert witness) should be able to justify the selection of these parameters in a court of law. Hence he has to be not only thorough in his field of specialization, but should also be familiar with legal procedures.

Many modern codes of practice are based on limit states design principles. These codes clearly define the standards of performance required for various design situations or limit states. Eurocode EN 1990 defines the two main limit states as the ultimate and serviceability limit states. In broad terms, the ultimate limit state deals with the stability of the structure (or of its component parts) whereas the serviceability limit states must be satisfied. This firmly establishes the principle that unsatisfactorily performance of a structure in terms of serviceability is equally as much a failure as its collapse.

INSPECTION OF SUBSTRUCTURE

The basement wall of one full brick thick retains the soil in all three directions as shown in Fig. 2. It passes by the plot boundary with no bonding with the columns. All columns seen at the basement are of varied dimension and C3 was found only at the basement. Fig. 2 shows irregular nature of beam-column-slab junction seen at the basement.

Fig. 2 Plan of the building with projections on three sides and position of 12 columns at the plot boundary, foundation of Col. C4, C8 and C10 were inspected. Irregular beam column support seen at the basement and original building as noted in 2007.
On the eastern side another three storey building with partial basement exists. This building too had eccentric footing as it also covered entire plot area. Buildings covering entire plot are most common in East Delhi, thus raising doubts on the integrity of the isolated eccentric footing. It is also clear from Fig. 2 that columns are not spaced in simple geometry, they are placed along the boundary wall just enough to match with the wall geometry.

Fig. 3 Excavation of basement boundary wall near Col. C8

On excavation of the basement boundary wall (Fig. 3) it was found that there is hardly any appropriate strip footing. There are no seepage protection measures in the wall. As water table went up to the ground surface during last monsoon, many buildings with basement developed crevices. Basement floor of this particular building had only one layer of bricks with no traces of lean concrete or any other compacted building materials beneath the floor. Basement was filled with mud-silt and traces of scouring were found. The junction between basement and column has been found eroded out. Yet none of the foundation showed any sign of significant settlement. Fig. 4 shows the crashed column C10. It has leaned inside, which could not be

CAUSE OF FAILURE

1. It is reported that the entire building had more than 40 odd rooms with thin brick walls as partition. Services, sewages and utility pipes were placed and pierced at random orientation. Usage of the floor spaces varied greatly, such as tent house materials dumped at the basement, dry food storage at the ground floor, scores of sewing machines at the first floor and craft making devices along with family members and roof top dwellers exceeding 200 in no.

2. Estimated load carried by the failed column (C10) is 108 ton and required footing size is 3mx3m. But after excavation we found footing size is hardly 0.5mx0.6m=0.3m². This means the failed column with 108 ton load was sustaining by footing of 0.3m², which is 1/30² of the required size. However, it may be inferred that loose silty-sandy soil below the footing might have undergone intense densification under sustained load over the longer period.

3. Except last year we have no registry of water logging either from MCD or from Police investigation. Prolonged water logging in Sept-October 2010 led to the weakening of soils around the basement walls and slab. Occasional pumping of water by the owner, led to the formation of crevices into the side walls and thus giving way to piping and sand boiling. Seepage from the surface drain and salt (?) stored in the basement might have weakened the load bearing concrete column. Capillary rise of the salt ion up to the ground floor gave way to the corrosion of steel at the beam-column junction.

4. After cutting concrete from the column and beam at the ground floor [C-10] we found that 3-4 bars cut piece of 1-1.2m length were lapped in such a way that amount of rebars at this junction increased by 3 times the normal requirement. It is to be noted that excessive steel are too bad for structure to collapse by sudden burst. This is what has happened exactly at the C-10 junction at the ground floor on November 15, 2010.

5. The building has undergone multi-organ structural failure due to toppling about the longer side of the building. The slender columns were oriented along the plot length, which should not be the case for normal building. This building had weak column-strong beam type structure.

6. It has apparently failed all in a sudden due to improper or rather excessive rebars juxtaposed at the ground floor beam-column [C10]-slab junction. We have traced 3 pieces of each 1-1.2m long 20mm dia rebars that were placed at this junction. Excessive rebars are
It appears that main rebars beyond 2nd floor roof have unstable configuration for so many years! remains a mystery how this building sustained such service life of this building.

There is no quality workmanship observed in the existing part of the collapsed building. The slender columns (length > twice the width) are placed along the longer side which is against BIS code. Such configurations of columns are dangerous and building could topple any time with a bang.

This building had unsupported floating wall in the western side more than 50% of the plot width. Thus it was having enough evidence of toppling anytime. It remains a mystery how this building sustained such unstable configuration for so many years!

It appears that main rebars beyond 2nd floor roof have not continued to the top floor. Such buildings can no way avoid sudden collapse.

Column sections at the basement have been jacked by half brick thick wall on 3 sides and beams were rested upon such extended columns. Such composite load bearing are detrimental to building stability.

The building has questionable structural integrity beyond 2nd floor. Though no. of severed columns seen on 1st day, they were not found intimately connected with loading frame. Columns were seen separated at bottom and top, indicating very poor bonding at supporting ends. The concept of lap joints as defined in BIS codes have been disregarded.

Partition walls of the adjacent building is just half brick thick, presuming that all loads are being taken up by beams and columns. In seismically active zone brick walls without proper rebars are highly vulnerable.

Most of the walls are half brick thick, poorly mortared and bereaved of quality plastering, thus resulting in the ingress of Yamuna river flood/ rain water infested with toxic/sewerage/microbes.

Column sizes and shapes were abruptly or rather judiciously adjusted with the wall thickness, which often becomes the criteria for architectural as well as interior design requirements. This building had above mentioned defects.

Buildings have common walls with the adjacent one and thus have eccentrically isolated column foundation. Columns with eccentric footing need special care in design and construction. In the case of this building no such care were taken. Yet the building carried all loads for more than 20 years.

CONCLUSIONS
Buildings in the locality suffer several defects during life time that go unnoticed by the erred owners/residents. MCD officials do not have any cognizable services tools to apprehend such problems for timely redressal. In the last monsoon several buildings got affected by water logging. Excepting notification to 38 buildings by MCD, no such remedial measures so far have been given to the affected buildings. Some of the owners took self styled measures such as filling the basement with “construction waste” and sealing the same for good. The long term effect such fillings in the form of “increased load to the foundation, capillary rise, dampness etc.” would pose more aggravating situation than before. It is desired to investigate all buildings with basements, primarily to check the dampness for which proper treatment may be done as per prescribed standards.

REFERENCES
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