Delhi Secretariat (Dilli Sachivalaya)

A Summary of the Seismic Evaluation and Retrofit Process

Delhi Earthquake Safety Initiative for Lifeline Buildings

Prepared by:

GeoHazards International

Delhi Public Works Department

December 15, 2008

Funded by:

Government of the National Capital Territory of Delhi

USAID Cooperative Agreements 386-A-00-02-00217 and 386-A-00-06-00170

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Executive Summary

Delhi Secretariat, also known as Dilli Sachivalaya and the Players Building, houses important Delhi government offices, including those of the Chief Minister and her Cabinet. The building is Y-shaped with three ten storey wings surrounding a central core. The Secretariat is unique among project buildings, because it is a rehabilitated building. It was originally built as athlete housing for the 1982 Asian Games but was never finished and was left open to the elements for more than fifteen years. Delhi PWD repaired and rehabilitated the building from 1998-2000. The building was restored to its original strength, which was quite weak for such an important structure, and no seismic retrofit measures were implemented at the time.

Delhi PWD began the retrofit process by gathering information. They made use of existing geotechnical investigations and of information on the building's existing condition from the rehabilitation project. The site is very close to the Yamuna River, so there were serious concerns about liquefaction. At the time of this report, these concerns had not been resolved to the peer review panel's satisfaction, and Delhi PWD was revisiting the issue. The performance criteria were Life Safety plus Damage Control (LS+DC) in the Design Basis Earthquake (DBE), and Collapse Prevention in the Maximum Considered Earthquake (MCE). A retrofit to the higher Immediate Occupancy level of performance, in which the building could be used with minor cleanup and repairs after the DBE, was deemed too invasive and difficult given the building's inherent weakness. With the selected LS+DC performance-level retrofit, if the DBE strikes Delhi, then the building would sustain damage that could be repaired in several months. Likewise, if the MCE were to strike Delhi, the building would not collapse but would be damaged beyond repair. In either case, the Chief Minister and other leaders would not be able to use their offices to manage the immediate post-disaster response; therefore, they need to develop contingency plans.

Delhi PWD conducted linear analyses of the building, and Indian Institute of Technology (IIT) Chennai conducted nonlinear static pushover analyses of the building. The major seismic deficiencies were weak upper storey columns and insufficient seismic separation between the wings and core. The retrofit scheme recommended by the peer review panel uses reinforced concrete jackets to prevent failure of the weak columns, but allows the wings and core to pound. The panel reached this compromise solution in an effort to balance disruption considerations against the problems caused by pounding. The jackets can be installed one office at a time, to reduce disruption. At the time when this report was written, retrofit design was underway. Delhi PWD is also working on designs for anchoring the building's major mechanical equipment.

The Secretariat presented formidable disruption and technical issues. Due to the officials that work there, the site has high security and a low tolerance for noise and debris. The retrofit solution presents a good compromise that improves safety, while reducing disruption. The building also illustrates the importance of good information on foundation conditions – the project was unnecessarily delayed by difficulties in modeling the foundation, due to a lack of information. Overall, the building provided a good case study of how a geometrically complex building that contains important offices can be assessed and eventually retrofitted. The Delhi Government remains committed to completing the seismic retrofit.

Project Team Members

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Introduction

The Delhi Secretariat building, also known by its Hindi-language name Dilli Sachivalaya, and its original name, the Players Building, houses the offices of the Delhi government's top officials. The Chief Minister, the top elected official, and the Cabinet all have their offices in the building. Many Delhi government departments also have offices in the building.

The building has an interesting history. It was originally built as athlete housing for the 1982 Asian Games, butit was not completed. The building was left in its unfinished condition – open to the elements – for over fifteen years. During this time, the building suffered extensive environmental damage and corrosion. Delhi PWD completely rehabilitated and repaired the building from 1998 to 2000. The rehabilitation did not include any seismic retrofit measures, despite increased seismic design requirements in subsequent revisions of the 1974 Indian building code, which was originally used to design the building.

The Secretariat was seismically assessed as part of the Delhi Earthquake Safety Initiative for Lifeline Buildings. This project was jointly funded by the Government of the National Capital Territory of Delhi and the United States Agency for International Development. GeoHazards International (GHI) formed a peer review panel of experts from India and the United States to guide Delhi PWD engineers through the seismic assessment and retrofit of five groups of important existing buildings, and to build their capacity to retrofit additional buildings in the future.

The Delhi PWD began the seismic assessment and retrofit process by gathering information on the building's design, construction, and rehabilitation and by conducting initial walk-through inspections. The information obtained during rehabilitation work proved very useful in establishing the building's condition and strength. The peer review panel visited the sites with Delhi PWD engineers in April, 2005. Due to a heavy workload and a lack of internal analysis capacity, Delhi PWD contracted out the nonlinear analyses of the building to IIT Chennai. The peer review panel reviewed the modeling assumptions, analysis methods, and results.

The nonlinear analyses showed that the building's upper stories were weak and that the wings had inadequate seismic separation from the core. The retrofit scheme recommended by the peer review panel addresses the major seismic deficiencies but was a compromise solution, constrained by disruption considerations. The scheme consists of jacketing vulnerable upper story columns and allowing the wings and core to pound. At the time when this report was written, retrofit design was underway.

Building Description

The building is an eleven story office building located off Vikas Marg. The Yamuna River flows less than one kilometer east of the complex. The building's location with respect to the river and other Delhi landmarks is shown in Figure 1.

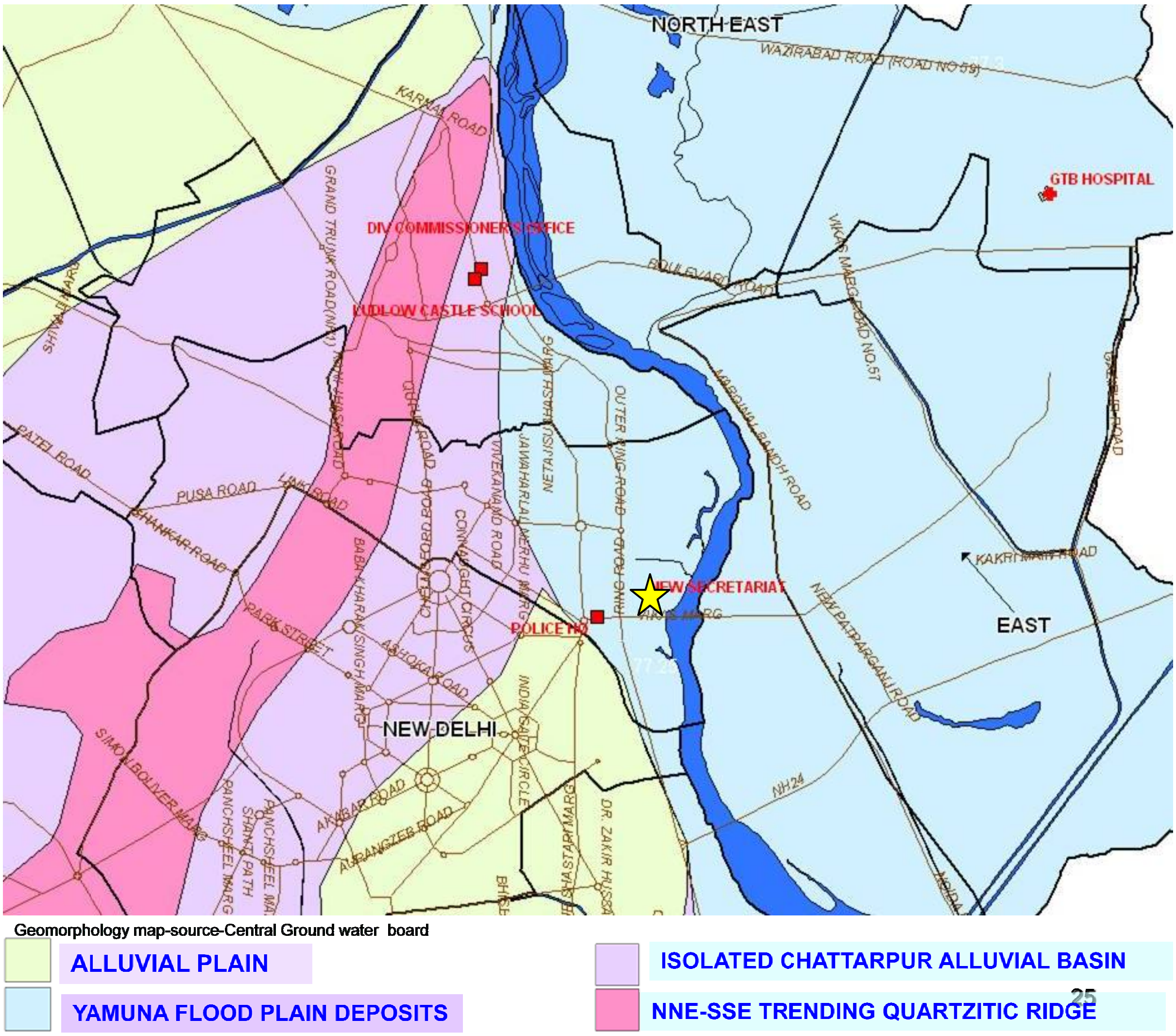


Figure 1. Location of office complex

The building is Y-shaped in plan with three ten storey wings equally spaced around a central core. The ground and first stories of the building are larger than the tower stories, and there are several nearby structures, as the site plan in Figure 2 shows. Figure 3 shows an exterior view of the building after rehabilitation, with Wing A on the left hand side. The wings step back, one bay at a time, beginning at the sixth story, so that the top story has a very small plan area. Figure 4 shows a typical intermediate story floor plan. The building has numerous irregularities both in plan and in elevation, as well as insufficient seismic separation between the wings and central core. The central core is detached from the adjoining wings with 25 mm non-seismic separation joints throughout the height of the building, which means that the wings will pound against the core during an earthquake. The floor plates are vertically aligned, however, so pounding will not cause columns to collapse.

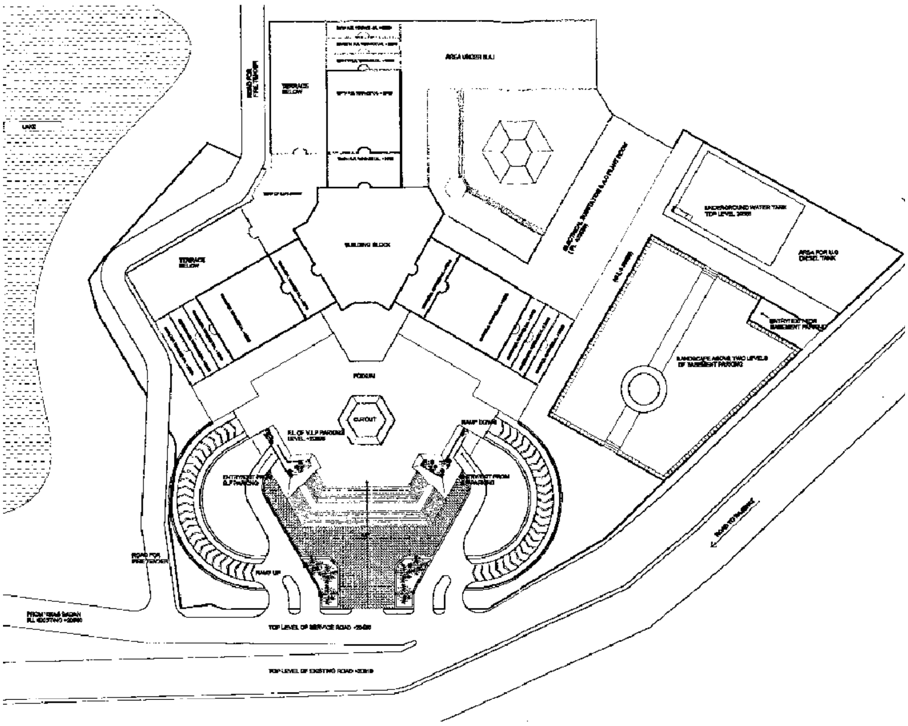


Figure 2. Site plan

Figure 3. South (front) elevation. Wing A is on the left side of the photo.

The building is a reinforced concrete frame with few well-connected infill walls. The building has a solid reinforced concrete wall around elevator lifts in the central core. Interior partitions are mainly lightweight concrete, rather than brick masonry. The foundation consists of 400 mm (16 in) and 450 mm (18in) diameter piles to a depth of 24 m (80 ft). The frame does not have ductile details; 8 mm (5/16 in) and 10 mm (3/8 in) stirrups are typically provided at 250 mm (10 in) on center, which is roughly depth divided by two for both columns and beams. There are no ties through the joints, as Figure 5 shows. The frame was designed for a base shear coefficient of three-percent of g. Lateral resistance is provided almost solely by the frame, since the building has no RC shear walls and few masonry infill walls.

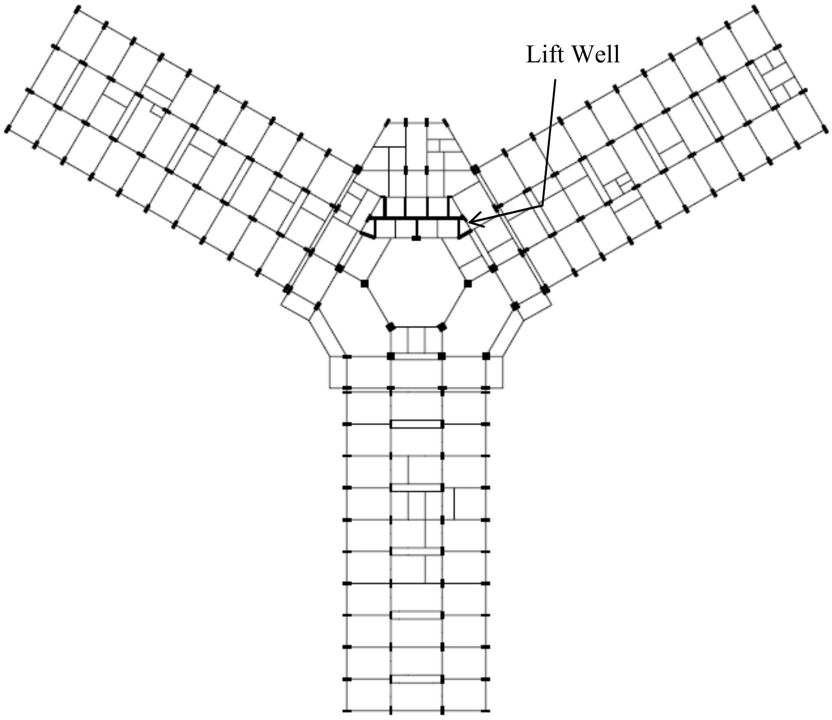


Figure 4. Typical intermediate story plan view showing the three wings and central core

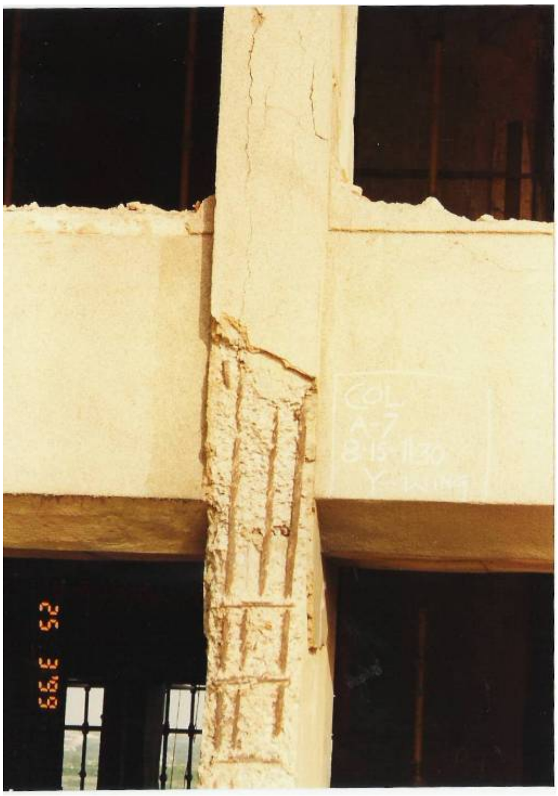


Figure 5. Column before rehabilitation showing tie spacing and deterioration

Because of the recent building rehabilitation, Delhi PWD did not conduct independent condition assessments but instead, relied on information obtained during the rehabilitation. The rehabilitation process restored the building to close to its original strength. Unfortunately, the original construction and material quality were fair to poor. The concrete had relatively low strength.

Site Seismic Hazard

Ground Shaking

The ground shaking hazard for the purposes of engineering design was defined by the seismic zoning map and response spectrum given in *Indian Standard 1893 (Part 1):2002 Criteria for Earthquake Resistant Design of Structures*. For Delhi, the Maximum Considered Earthquake (MCE) peak ground acceleration (PGA) is 0.24 g. The project did not have the time, political backing, or funding to conduct site-specific hazard analyses. Some existing studies helped panel members to assess, in a very limited sense, whether the code values were appropriate for design. A study of seismic hazard by Iyengar (2000) indicates that acceleration between 0.18 and 0.23 g can be expected at rock level for an earthquake with a 2% probability of exceedance in 50 years (this corresponds to an earthquake with a return period of 2500 years). An older analysis by Khattri (1992) suggests that Delhi will see shaking on the order of 0.2g from an event with a 10% probability of exceedance in 50 years (this corresponds to an earthquake with a return period of 475 years). Shaking will be stronger at soil sites due to site amplification, and the Indian Meteorological Department is preparing a microzonation map that will quantify the amplification in various areas. The Global Seismic Hazard Assessment Project (GSHAP) map gives a PGA of about 0.14g for Delhi.

However, these probabilistic assessments were made without the benefit of extensive earth science studies to better define the hazards posed by local seismic sources and the likely size and recurrence interval for Himalayan events. GHI anticipates that current and future studies by earth scientists will lead to better quantification of Delhi's seismic hazard and to revision of the design shaking values. Based on the currently available earth science information and studies discussed above, the peer review panel did not view the code values as unconservative.

Geotechnical Conditions

The building sits on approximately 3.5 m (12 ft) of fill, which overlies sandy soils with low plasticity. Geotechnical investigations show that some clay layers exist below 28 m (92 ft). As Figure 1 shows, the site is located on recent alluvial sediments deposited by the Yamuna River, currently about 200m away. The river ran through the site several hundred years ago but abandoned the channel. The site is not located near slopes, or fault traces, so it is not threatened by landslides or fault rupture. The site's proximity to the Yamuna River means that either lateral spreading or liquefaction could occur.

Delhi PWD conducted geotechnical investigations at the time of the building's remodel, and further investigations were carried out for a parking structure built nearby. The former investigation included four boreholes drilled to depths of 40 meters, and standard penetration tests. Based on the data collected, Delhi PWD determined that liquefaction was unlikely, but the peer review panel remained concerned about the potential for liquefaction at the site. As of the final peer panel meeting, Delhi PWD had not demonstrated convincing evidence that the site would not liquefy. Delhi PWD had difficulty performing proper liquefaction potential analyses because of a lack of data and a lack of support from some panel members, who believed that liquefaction was not a major concern.

Design Criteria

The peer review panel recommended the use of a two-level performance criterion for all project buildings. Relations between the performance level, the design earthquakes in the IS 1893 code, and the peak ground acceleration are shown in the table below. The peer panel attempted to relate the retrofit performance criteria back to the Life Safety performance intended by the IS 1893 code provisions, and decided that recommended criteria for enhanced performance are philosophically equivalent to designing the building to life safety for a larger ground motion.

	Design Basis Earthquake		Maximum Considered Earthquake	
Buildings	Performance Level	PGA (g)	Performance Level	PGA (g)
Hospitals	Immediate Occupancy*	0.12	Life Safety	0.24
Non-hospitals	Life Safety + Damage Control*	0.12	Collapse Prevention	0.24

*These performance criteria are considered to be philosophically equivalent to using I=2.0 for hospitals and I=1.5 for non-hospitals, which give Life Safety performance at 0.24g for hospitals and 0.18g for non-hospitals. Any actual designs using IS 1893 will use 0.24g for hospitals and 0.18g for non-hospitals.

Buildings	PGA (g) for which above criteria correspond to Life Safety using IS 1893
Hospitals	0.24
Non-hospitals	0.18

Despite the importance of the offices housed in the building, the peer review panel concluded that life safety plus damage control performance was an appropriate compromise. Given the building's inherent weaknesses, it seemed unlikely that a retrofit could achieve high seismic performance while also minimizing disruption.

Structural Assessment and Analysis

Delhi PWD performed an initial assessment using the ASCE 31 Tier 1 Checklist and conducted linear analyses of the three blocks. IIT Chennai performed eigenvalue and nonlinear static pushover analyses of the wings and core, both individually and stitched together.

ASCE Tier 1 Checklist

Noncompliant items from the ASCE 31 Tier 1 Checklist included:

- Wings inadequately separated from core
- Soft storey at ground floor
- Vertical discontinuities at wing A staircases
- Geometry

The Tier 1 checklist did not identify the building's major deficiencies: weak upper story columns and overstressed piles in the foundation under the central core. The building demonstrates that the checklist should be a first step in a more thorough evaluation and should be used with care and engineering judgment.

Linear Analysis

Linear response spectrum analyses of Wing A showed that the first floor columns fail due to a soft storey, and that some columns above the sixth story also fail because of inadequate strength. The longitudinal reinforcement in the columns reduces drastically above the sixth floor level, but the member cross sections remain the same. Further reduction in longitudinal strength at the tenth floor caused all the columns at that level to fail. The linear analyses identified some of the major weaknesses but did not indicate which failure mode would occur first.

Nonlinear Analysis

IIT Chennai performed numerous nonlinear analyses, which are documented in detail in their report to Delhi PWD entitled "Pushover Analysis of Delhi Secretariat Building" and submitted in November, 2007. IIT Chennai began by carrying out nonlinear static pushover analyses of Wing A. The building's unusual geometry complicated the pushover analysis process. IIT Chennai performed nonlinear static pushover analyses in both directions on a three-dimensional model of the full building, shown in Figure 6. The behavior of the pile foundation was a major technical issue, and IIT Chennai analyzed the building with different foundation assumptions to try to understand the behavior. Reinforcement details for the piles were not available, so IIT Chennai made assumptions about their capacity. Detailed descriptions of the modeling assumptions and analyses can be found in the report by IIT Chennai mentioned above. Modeling and analytical assumptions common to all the buildings, which were determined by consensus at the third meeting of the peer panel, are listed below:

- Shear walls will be modeled as wide columns
- Masonry infill walls will be modeled as braces with properties of equivalent struts
- Expected material strengths will be used: characteristic strength for concrete, 1.15 times mean Fy for steel
- Masonry material properties will be modeled using test results from IITs
- The IS 1893 parabolic distribution will be used for all buildings, with additional measures to take into account higher modes in the Police Headquarters building
- Foundations will be initially modeled as rigid, with springs added as necessary, with the addition of retrofit measures like shear walls
- The coefficient method from U.S. Federal Emergency Management Agency Report FEMA 440 will be used to determine target displacements
- Both moment and shear hinges will be placed at column ends

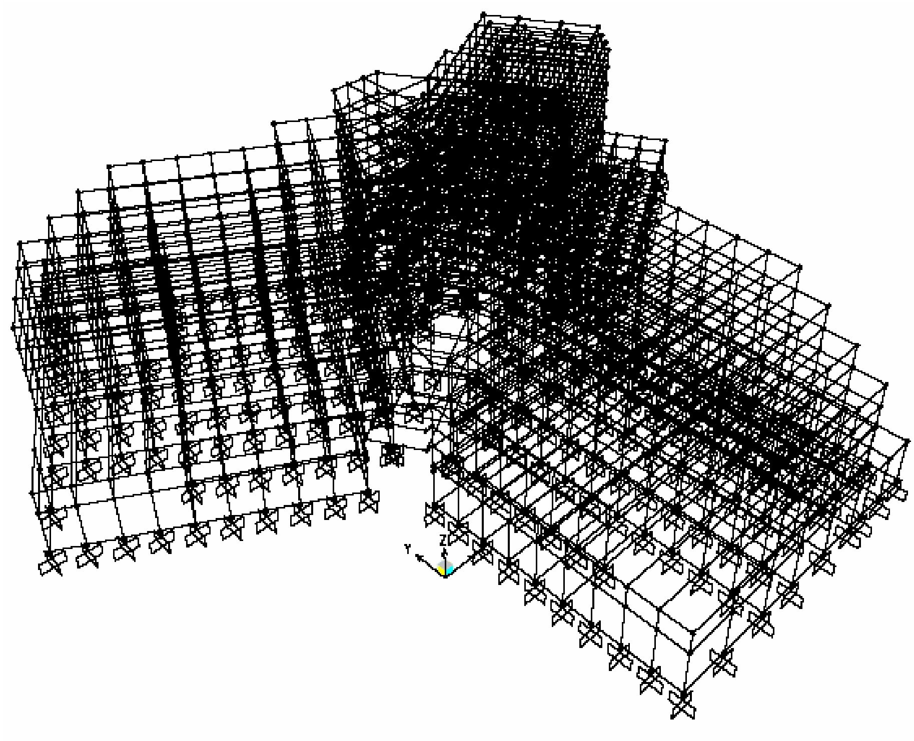


Figure 6. Three-dimensional model of the building

IIT Chennai's findings included the following major points:

- The piles in the central core and some in the blocks fail in axial compression before the DBE target displacement. Accurately modeling pile capacity is critical to obtaining meaningful results.
- Upper storey columns fail before the DBE target displacement because of inadequate reinforcement. A storey mechanism forms in the top storey.
- Pounding will occur between the wings and core, due to insufficient seismic separation.

The nonlinear analyses described above do not include analyses with the final recommended retrofit scheme in place. These analyses were in progress when this report was written.

Retrofit Scheme Selection

Recommended Retrofit Scheme

After investigating several alternate schemes, the peer review panel recommended the following scheme:

- Jacket the columns in the upper stories that are currently failing in a non-ductile manner. Jackets will provide adequate shear strength and confinement to force a highly ductile flexure failure.
- Accept pounding between the wings and core, and let the upper story columns dissipate the energy through ductile yielding.

The jackets can be applied one room at a time, to reduce disruption. The Alternative Schemes Investigated section below contains a chronological narrative that explains how and why Delhi PWD, the peer panel, and IIT Chennai arrived at the above scheme. Disruption considerations and (to a much lesser extent) technical challenges governed the selection process. At the time when this report was written, the scheme was undergoing design and refinement by analysis, so no drawings were available.

Anticipated Performance After Retrofit

The main building is expected to perform at a level above life safety for the DBE. Improved performance for smaller earthquakes can be obtained by anchoring and bracing building systems, equipment and utilities.

Alternative Schemes Investigated

IIT Chennai and Delhi PWD proposed several potential retrofit schemes to address the building's major seismic deficiencies: weak columns in the upper stories, and inadequate seismic separation between the wings and core. The retrofit decision-making process was complicated by the presence of high-level officials in the buildings. Disruption was the most important consideration in selecting potential retrofit schemes.

The most instructive means of describing the alternate schemes, and more importantly, why they were suggested, is through a chronological narrative. This narrative was compiled from meeting summary reports, analysis reports by IIT Chennai, reports and presentations by Delhi PWD, and correspondence. The summary is arranged in chronological order by major meetings where results were reported and discussed. The narrative traces the evolution of proposed retrofit alternatives and of the project team's collective understanding of the building's seismic behavior.

<u>First peer review panel meeting and site visits (May 7, 2005)</u>
Delhi PWD gathered basic information about the building, including the structural drawings for all three phases. Prior to the meeting, peer panel members visited the site with Delhi PWD to make first-hand observations. Mr. Mukund Joshi was selected as the Engineering Team Leader for the building. Building users expressed a desire for Immediate Occupancy performance. Peer panel members suggested general concepts for retrofit, including dampers, steel frames, and shear walls.

<u>Second peer review panel meeting (Aug. 8-12, 2005)</u>
Delhi PWD reported the results of the ASCE 31 Tier 1 analysis and linear analyses, which showed that the building had several seismic vulnerabilities, including a soft story, inadequate seismic separation, discontinuous elements, and weak upper story columns. Peer review panel members recommended nonlinear static analysis to better understand building behavior. Peer panel members agreed that the wings could not be stiffened enough to prevent pounding, and they discussed the options for addressing pounding between the wings and core: let pounding happen, install dampers, or tie the wings and core together. All retrofit schemes proposed later would use one of these options. The peer panel recommended tying buildings together.

<u>Meetings of the India-based peer review panel members (Sept. 30, Oct. 27, Nov. 7, 2005)</u>
Delhi PWD selected IIT Chennai to carry out the pushover analysis of the building.

<u>Third peer review panel meeting (Dec. 5-9, 2005)</u>
Participants decided on a two-level performance criterion for the building: Life Safety plus Damage Control (LS+DC) for the Design Basis Earthquake (DBE) with peak ground acceleration (PGA) equal to

0.18g; and Collapse Prevention (CP) for the Maximum Considered Earthquake (MCE) with PGA equal to 0.24g. IIT Chennai presented preliminary results of nonlinear static analyses, which showed failures in the upper storeys. Meeting participants proposed several alternate retrofit schemes for further investigation. These alternate schemes will be identified with capital letters, to simplify tracking when they are subsequently mentioned in this summary.

Scheme A: Wings and core stitched together, with megaframe at ends of wings.

Scheme B: Wings and core stitched together, with shear walls at ends of wings (at each setback);columns below discontinuous shear walls would be wrapped with FRP or jacketed with steel.

Scheme C: Wings and core stitched together, with new additions at end of each wing to contain the lateral force resisting system and to provide added floor space.

Scheme D: Wings not stitched to core, transverse shear walls added near wing/core junction, either frame or shear walls added at ends of wings.

<u>Meetings of the India-based peer review panel members (Dec. 21 & 29, 2005, Jan. 13, 2006)</u>
Participants discussed using inverted T-shaped shear walls at the ends of the wings (*Scheme E*).

<u>Mini-panel meeting (September 1, 2006)</u>
IIT Chennai did not attend, but Mr. Joshi presented their views. IIT Chennai favored a buckling-restrained brace scheme, while Mr. Joshi favored dampers. Mr. Holmes outlined a feasibility check for the use of dampers. Panel members and Mr. Joshi agreed that schemes involving shear walls (*Schemes B, D* and *E*) are unrealistic due to disruption considerations. Panel members added to the list of options *Scheme F*: column wrapping in upper stories, wings and core stitched together. Mr. Holmes recommended that IIT Chennai investigate *Scheme F* first, because it is less disruptive.

<u>Meeting of the US-based peer panel members with Hari Kumar (November 29, 2006)</u>
Mr. Kumar presented the results of IIT Chennai's analysis, which shows that the piles are still failing. The US-based members of the peer panel asked questions about the pile capacities and failure mode, and introduced *Scheme G* for consideration: soften the core shear walls to reduce the demands on the piles, tie the building together and jacket columns.

<u>Fourth peer review panel meeting (January 29-31, 2007)</u>
IIT Chennai reported that the top three stories fail by storey mechanisms. Peer panel determined that piles are unlikely to fail. Panel members suggested *Scheme H*: Remove top three stories of wings, but this was rejected as too disruptive. Panel members discussed *Scheme I*: Open seismic joint between wings and core and strengthen wings with column jackets. Peer panel members still recommended retrofit options that include tying the building together.

<u>Fifth peer review panel meeting (September 10, 2007)</u>
The peer review panel recommended *Scheme F,* with the modification that the wings be stitched to the core at only two or three locations to prevent disruption of the Chief Minister's office located in the core. Foundation modeling governs the analysis results, so peer panel members recommended more rigorous modeling.

Sixth peer review panel meeting (March 6, 2008)
Peer panel recommended that IIT Madras analyze Scheme F to determine number of columns that need jacketing. Peer panel recommended reinforced concrete jackets rather than steel or FRP, because moment capacity also needs to be increased.

Seventh peer review panel meeting (March 6, 2008)
Peer panel considered *Scheme F* with additional piles, but recommended *Scheme K*:

- Jacket the columns in the upper stories that are currently failing in a non-ductile manner. Jackets will provide adequate shear strength and confinement to force a highly ductile flexure failure.
- Accept pounding between the wings and core, and allow the upper story columns to dissipate the energy through ductile yielding.
  unstitched building with column jackets (pounding would be accepted)

Delhi PWD and peer panel members viewed the pile drilling required for *Scheme F* as too disruptive. Peer panel members agreed to accept the limited effects of pounding (few columns in upper stories) as preferable to disruption. Peer review panel recommended that Delhi PWD proceed with design of the recommended scheme and that Delhi PWD anchor large mechanical equipment.

Functionality, Architectural, and Disruption Considerations

The building has significant architectural, functional and disruption issues, which affected the choice of retrofit scheme. The Chief Minister's office, the most important office in the building, is located partially in the central core. Options for work in the central core were limited, because it will be very difficult to get approval to disturb this office. Expensive architectural finishes added during the remodel need to be preserved. The lower floors have large functional spaces such as auditoriums and cafeterias, so new lateral elements in the upper stories (which are set back) could not continue to the ground. Changes to the building's plan or functional spaces are likely to meet with resistance from the government officials in affected spaces. For these reasons, Delhi PWD sought a minimally intrusive retrofit scheme that would still provide adequate performance. As the above narrative illustrates, the final scheme was selected primarily based upon disruption considerations.

Engineering Design and Construction Documents

At the time when this report was written, engineering design was in progress but not yet complete. As a result, engineering drawings, specifications, and cost estimates are not included here.

Construction and Quality Control

At the time when this report was written, the retrofit was still in the design process and had not been constructed.

Mitigation of Falling Hazards

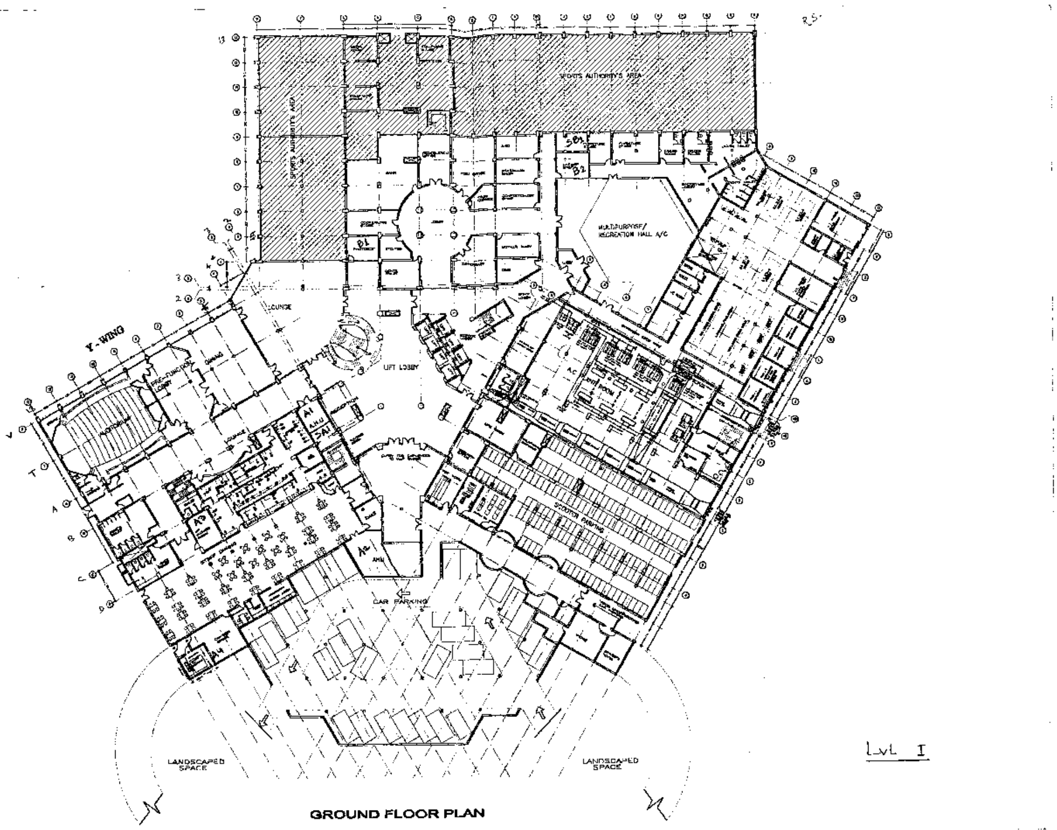
In contrast to many other buildings in Delhi, the Secretariat has suspended ceilings, central air conditioning, lightweight concrete partitions, and fire sprinklers throughout. These systems are susceptible to earthquake damage. Low levels of shaking from the distant 2005 Kashmir earthquakes damaged the false ceilings. A larger earthquake will do much more damage. The peer review panel recommended that these elements be braced, especially the fire sprinklers, to prevent loss of function. Disruption is a major challenge in a building like this, because building systems and architectural elements will need to be braced in most offices. An incremental approach may offer the most feasible solution.

The building also has major mechanical equipment that is unanchored and likely to suffer damage in an earthquake. Electrical power comes from an adjacent substation with unbraced equipment and a two story building of unknown seismic resistance. The emergency generator, elevator machinery, and air conditioning equipment need snubbers or other restrain devices. The peer panel recommended that Delhi PWD brace major equipment and address the seismic vulnerabilities of the substation.

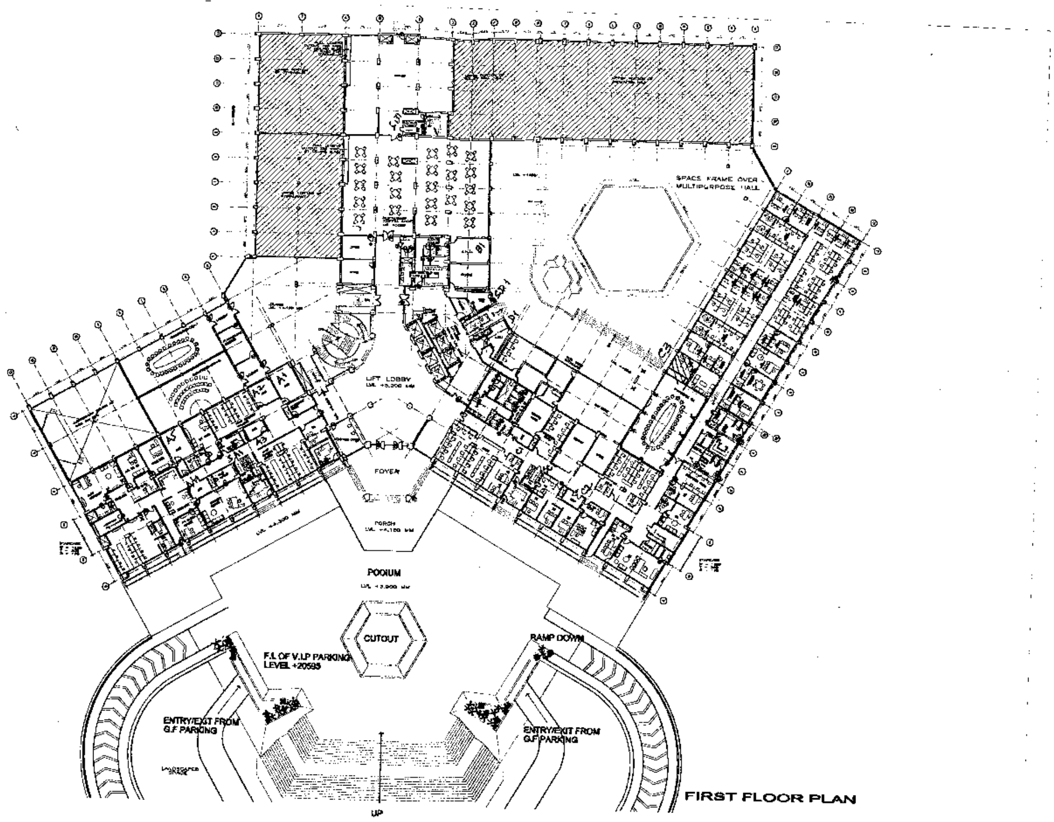
Conclusions

The Delhi Secretariat is unique among project buildings, due to its status as a rehabilitated building. The building was difficult to model and analyze because of its unusual plan shape and vertical setbacks. The foundation conditions and modeling assumptions governed the analysis results, and getting the foundation model right was very difficult and time consuming, due to a lack of information about the existing conditions. Disruption considerations governed retrofit scheme selection. In the final recommended scheme, peer panel members accepted pounding as preferable to disruption, though the effects of pounding were expected to be less of an issue than at the Police Headquarters. The scheme consists of reinforced concrete jackets around the weak upper storey columns, which prevent failure and dissipate energy during pounding. At the time when this report was prepared, IIT Madras was finalizing the column jacket design, so design drawings and cost estimates were not available. The retrofit solution will need to be applied in an incremental manner to minimize disruption, so construction may take time. Delhi PWD, the Delhi Government, and the other project participants remain committed to completing the retrofit.

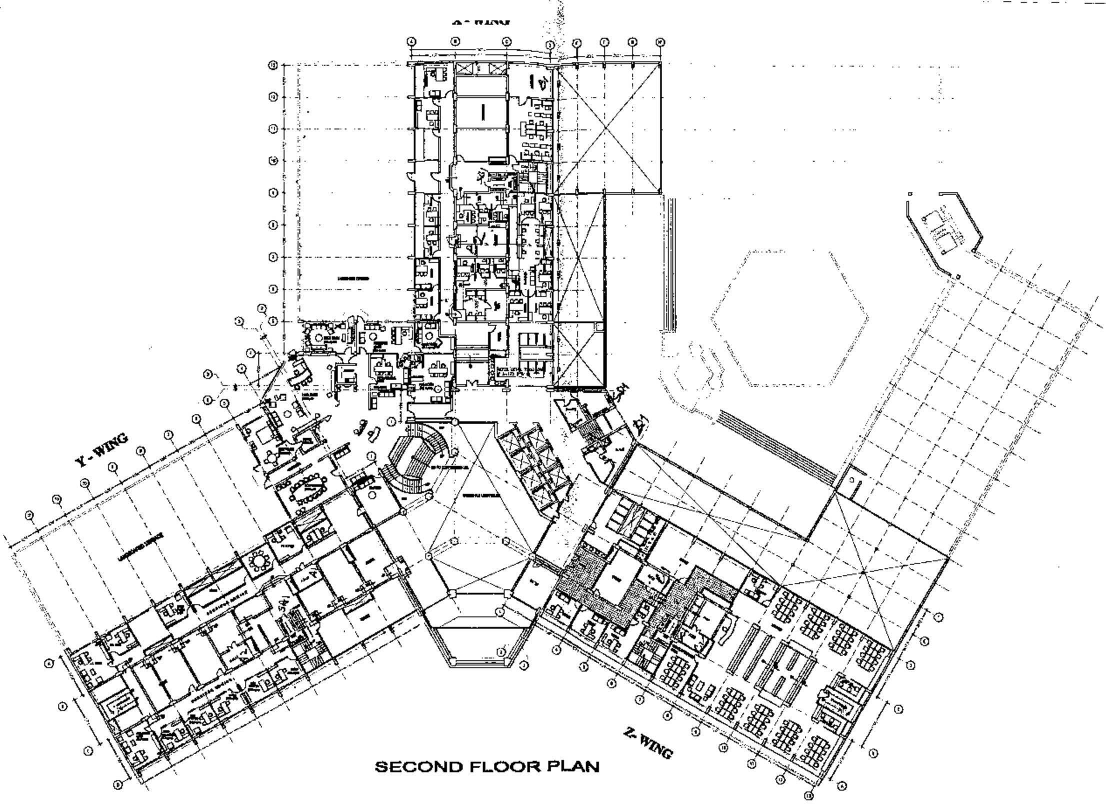
Appendix A: Selected Drawings from 1998 Rehabilitation



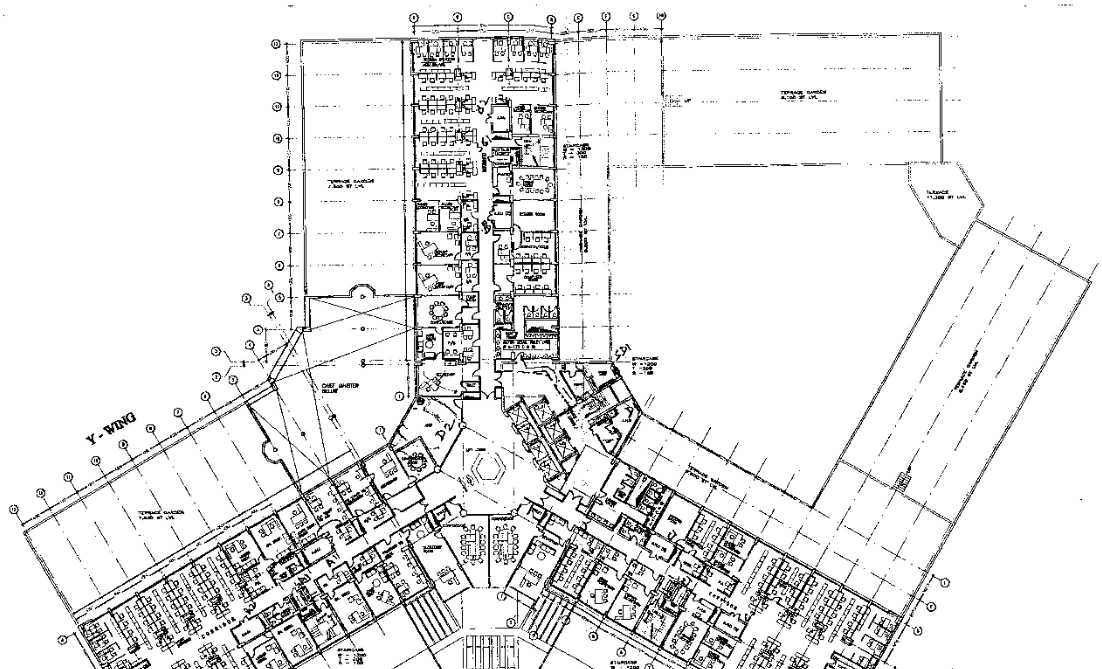
GROUND FLOOR PLAN



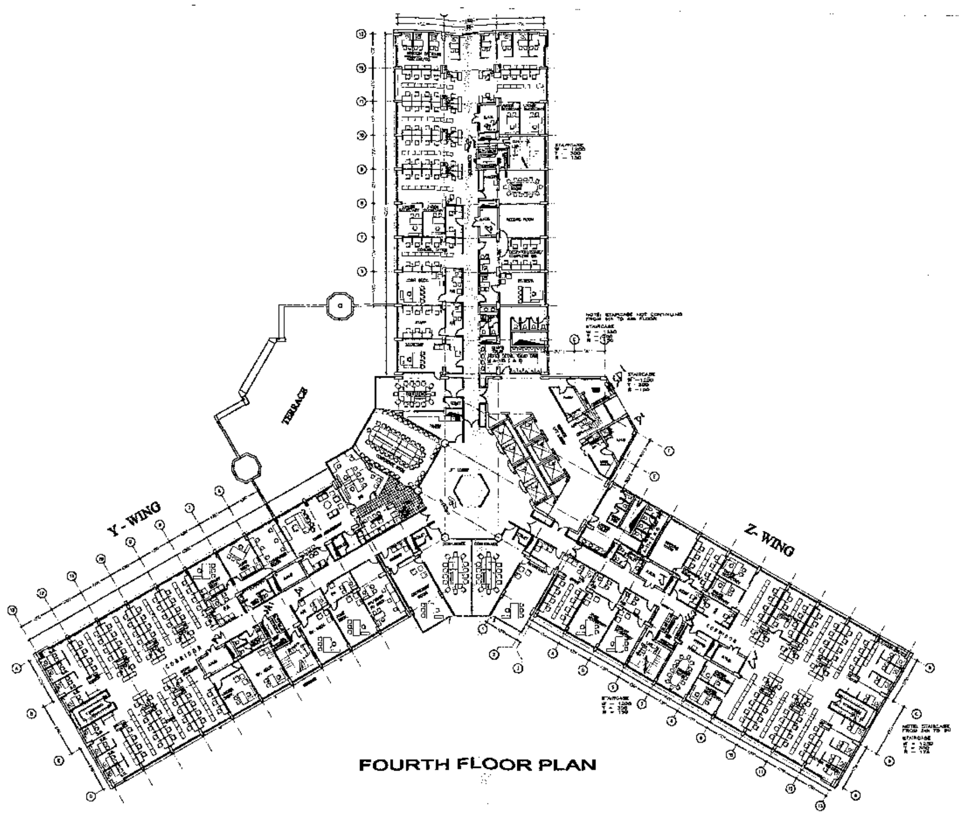
FIRST FLOOR PLAN



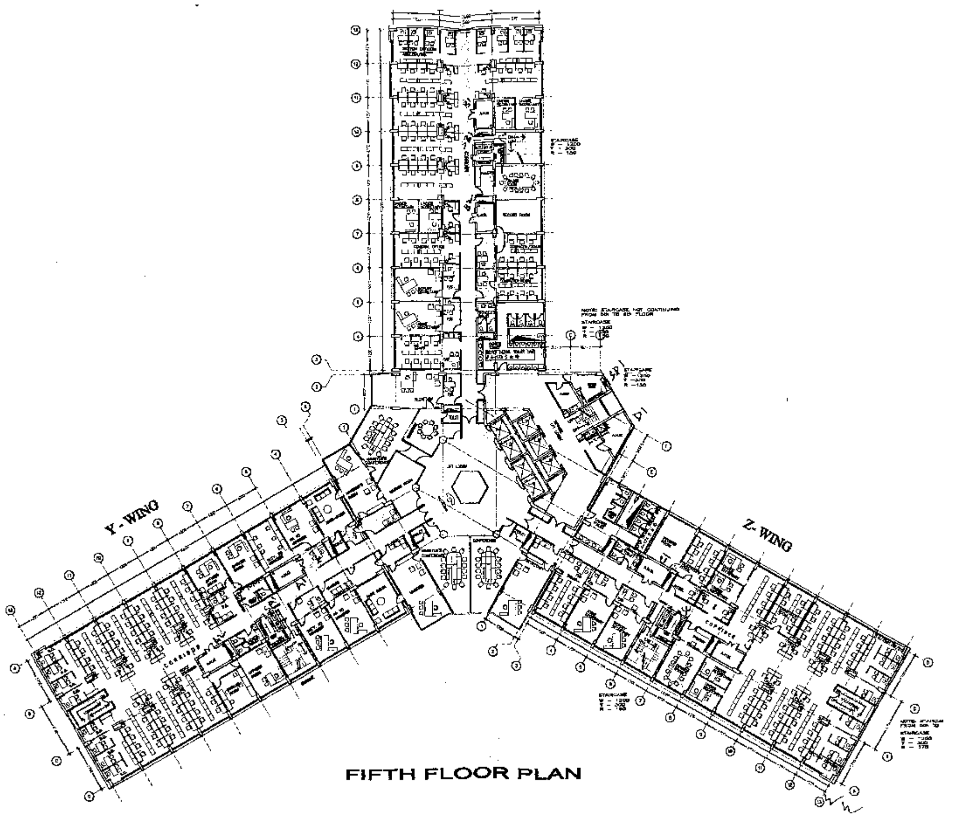
SECOND FLOOR PLAN



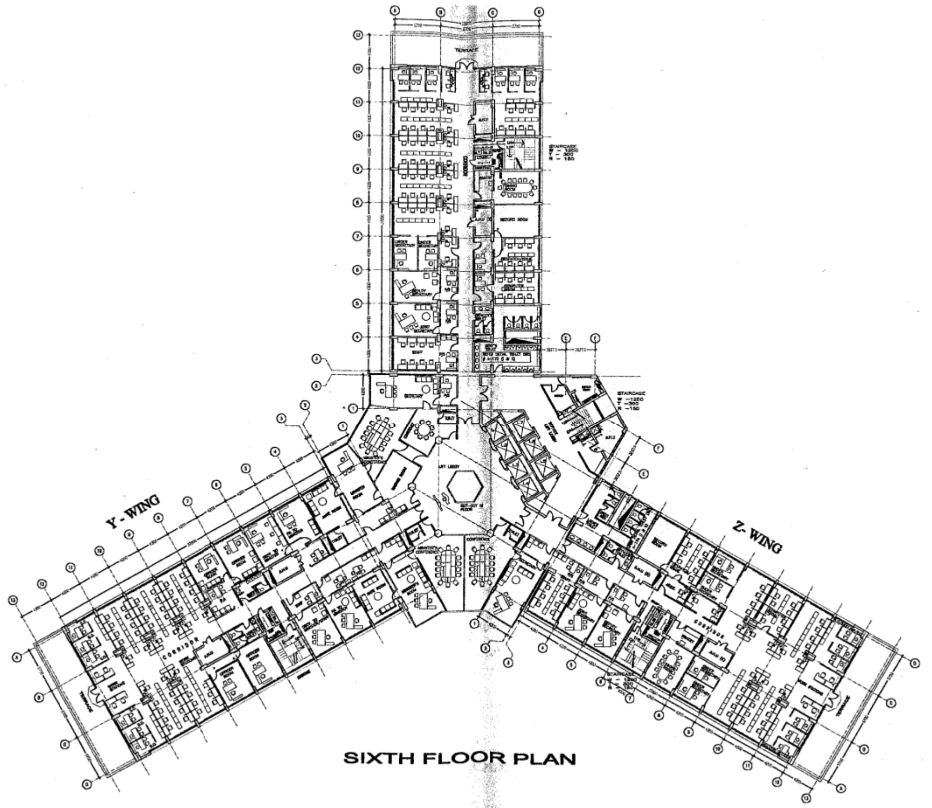
THIRD FLOOR PLAN



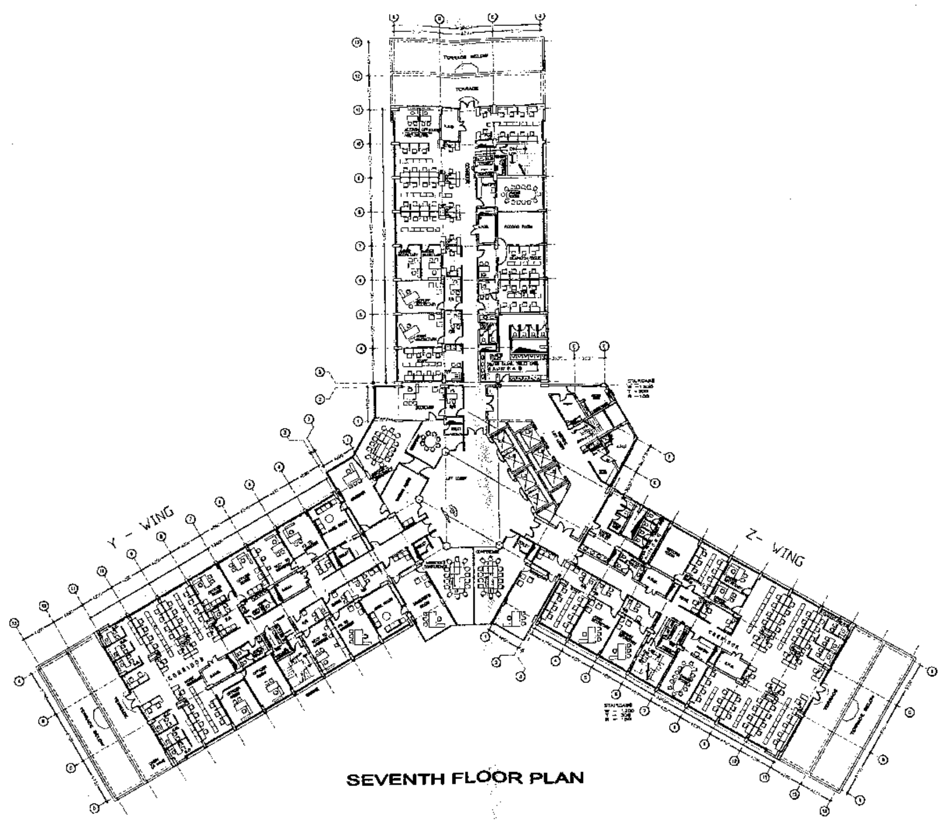
FOURTH FLOOR PLAN



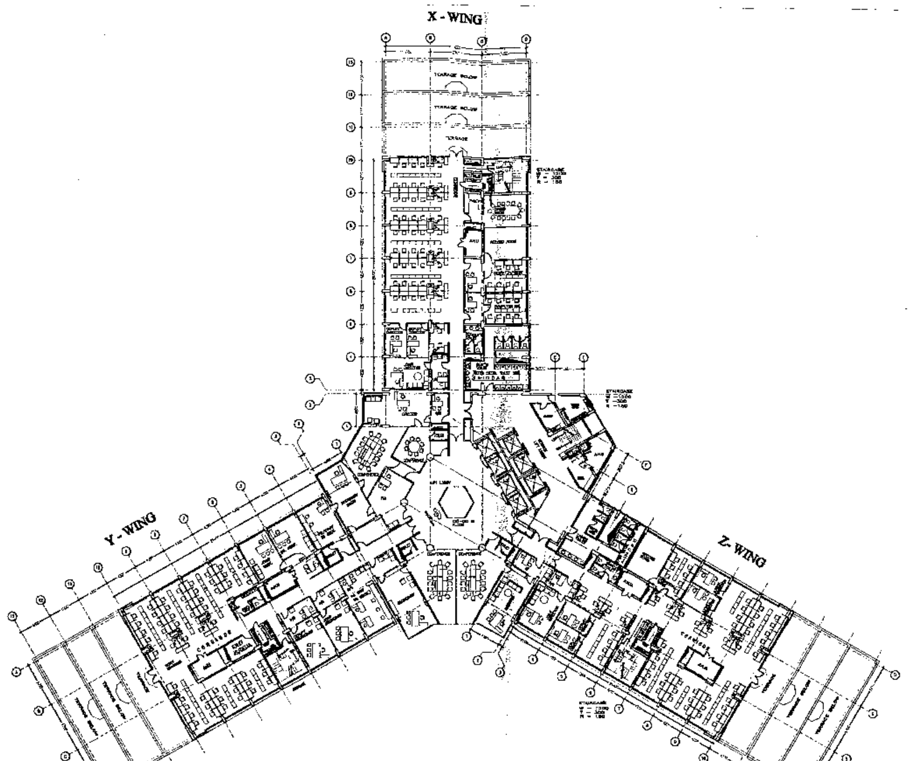
FIFTH FLOOR PLAN



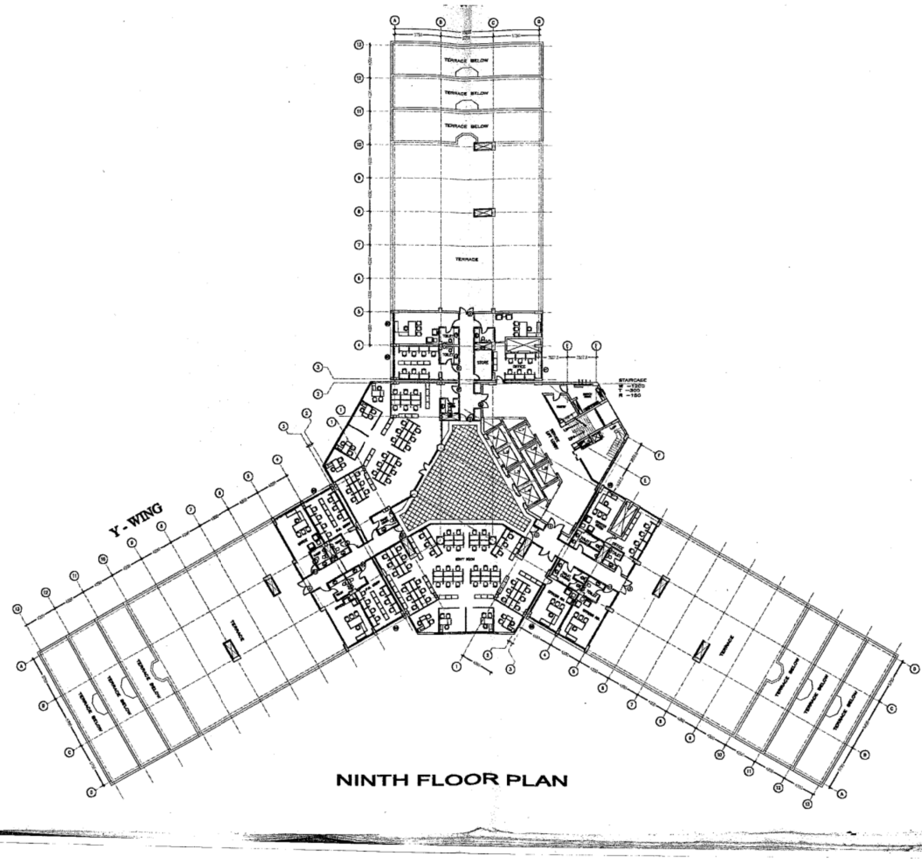
SIXTH FLOOR PLAN



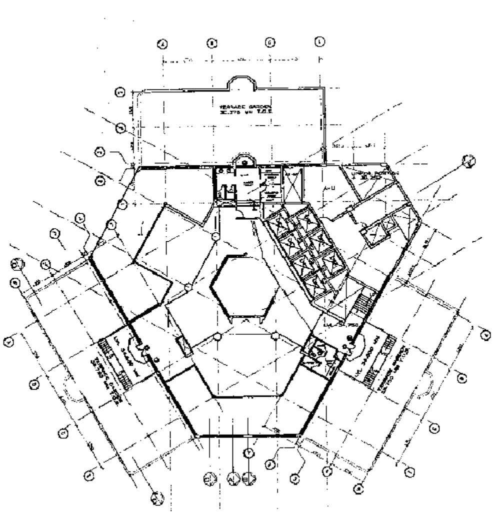
SEVENTH FLOOR PLAN



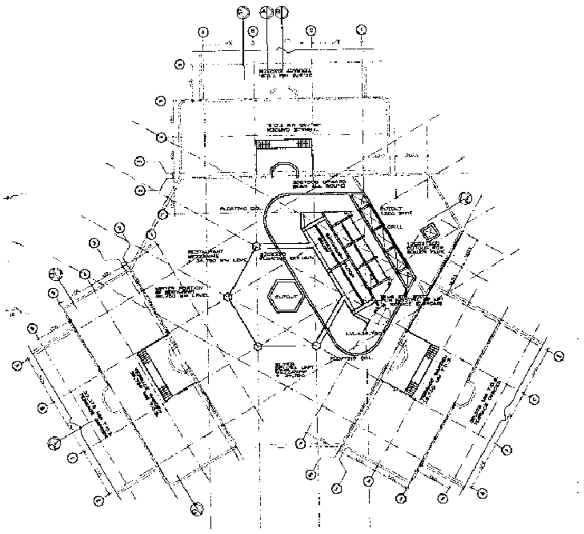
EIGHT FLOOR PLAN



NINTH FLOOR PLAN



TENTH FLOOR PLAN



MACHINE ROOM PLAN