
AT&T Practices

Earthquake Resistant Design Guidelines for New Buildings

Contents	Page
<hr/>	
About This Document	v
Purpose	v
Scope	v
Reason(s) for Reissue	v
Responsibilities	vi
Admonishments	viii
Ordering Information	viii
How to Comment on this Document	ix
<hr/>	
1 Earthquake Hazards	1-1
1.1 Seismicity in the United States	1-1
1.2 Earthquake Hazards	1-3
<hr/>	
2 Advanced Planning Considerations	2-1
2.1 Site Selection	2-1
2.2 Structural Configuration	2-7
2.3 Structural Separations	2-11
<hr/>	
3 Design Objectives	3-1
3.1 Selection of Design Objectives	3-1
3.2 Terminology	3-2
3.3 Performance Requirements for New Buildings	3-5

Contents	Page
4 Design Methods	4-1
4.1 Selection of Design Methods	4-1
4.2 Prescriptive Methods	4-2
4.3 Performance Methods	4-3
5 Design Earthquakes	5-1
5.1 Selection of Design Earthquakes	5-1
5.2 Generalized Hazard Assessment	5-4
5.3 Site Specific Hazard Assessment	5-5
6 Special Considerations	6-1
6.1 Overview	6-1
6.2 Analysis Parameters	6-1
6.3 Energy Dissipation and Seismic Isolation	6-2
6.4 Building Instrumentation	6-8
7 Foundations	7-1
7.1 Overview	7-1
7.2 Foundation Types	7-1
7.3 Design Considerations	7-4
8 Concrete Structures	8-1
8.1 Overview	8-1
8.2 Floor Diaphragms	8-1
8.3 Shear Walls	8-3
8.4 Moment Frames	8-5
8.5 Precast Concrete	8-7
8.6 Quality Assurance	8-8

Contents	Page
<hr/>	
9 Masonry Structures	9-1
9.1 Overview	9-1
9.2 Shear Walls	9-2
9.3 Infill Walls	9-3
9.4 Quality Assurance	9-4
<hr/>	
10 Steel Structures	10-1
10.1 Overview	10-1
10.2 Moment Frames	10-2
10.3 Braced Frames	10-5
10.4 Quality Assurance	10-7
<hr/>	
11 Architectural Components	11-1
11.1 Overview	11-1
11.2 Design Considerations	11-1
<hr/>	
12 Equipment Protection	12-1
12.1 Overview	12-1
12.2 Seismic Loading	12-1
12.3 Design Considerations	12-5
<hr/>	
13 Cost Considerations	13-1
13.1 Overview	13-1
<hr/>	
A Related Standards	A-1
<hr/>	
B References	B-1

Contents

Page

Glossary

GL-1

About This Document

Purpose

This practice provides guidelines for managers with building operations responsibilities for the earthquake resistant design of new buildings or building additions. These guidelines were established in order to achieve earthquake safety in AT&T buildings consistent with the earthquake safety criteria defined by the AT&T hazard management strategy.

Scope

This document applies to all new AT&T buildings and building additions located in areas which are affected by earthquakes.

Reason(s) for Reissue

This practice is being reissued to incorporate major advances in the understanding of earthquake hazards and the developments of advanced techniques to manage the associated risks obtained from lessons learned following major recent earthquakes world wide. This experience will benefit AT&T in minimizing the exposure to seismic risk exposure in new buildings and building additions. Seis-

mic risk can be greatly reduced through careful site selection and advanced planning. Likewise, seismic safety can be enhanced through proper design and detailing as well as good quality construction.

⇒ NOTE:

AT&T 760-200-024, Issue 1, *Nuclear Design Loads*, was renumbered to AT&T 760-200-023, Issue 2.

Responsibilities

This section indicates special responsibilities which various team members are expected to provide in the context of the earthquake resistant design process. Responsibilities listed here are in addition to other responsibilities which otherwise reside with such entities.

AT&T Building Engineer

- Coordinates involvement of AT&T organizations as required in advanced planning considerations (Section 2)
- Assembles and coordinates design team with appropriate experience to perform the design
- Identifies facility classification and performance objectives (Section 3)
- Facilitates selection of the design methodology (Section 4)
- Coordinates determination of appropriate design hazards (Section 5)
- Coordinates design team in feasibility review of energy dissipation and base isolation systems as required (Section 6)
- Coordinates deployment of building accelerometers as required (Section 6)
- Coordinates design of structural systems (Sections 7 through 10)
- Coordinates construction quality assurance programs (Sections 8 through 10)
- Coordinates earthquake protection design of architectural components (Section 11)
- Coordinates earthquake protection design of building mechanical and electrical equipment (Section 12).

Structural Engineer

- Supports AT&T Building Engineer as required in performance objective feasibility evaluation (Section 3)
- Selects appropriate design methodologies and performs the analysis in accordance with the desired performance objectives (Section 4)
- Performs generalized hazard assessment as required (Section 5)
- Advises on the feasibility of energy dissipation and seismic isolation systems as required (Section 6)
- Provides technical support for the deployment of building accelerometers (Section 6)
- Designs structural systems (Sections 7 through 10)
- Develops construction quality assurance programs (Sections 8 through 10)
- Provides technical support to the Architect for the earthquake protection design of architectural components (Section 11)
- Provides technical support to the Systems Engineer for the earthquake protection design of building mechanical and electrical equipment (Section 12)
- Observes construction to ensure compliance with the intent of the design.

Architect

- Performs earthquake protection design of architectural components (Section 11).

Systems Engineer

- Provides technical support for the earthquake protection design of building mechanical and electrical equipment (Section 12).

Geotechnical Engineer

- Determines soil characteristics for generalized or site specific hazard assessment (Section 5)
- Performs soil-structure interaction analysis as required (Section 6)
- Provides technical support for the earthquake protection design of foundations (Section 7).

Seismologist

- Performs site-specific hazard assessment as required (Section 5).

Engineering Review Panel

- Provides peer review for the implementation of energy dissipation and base isolation systems as required (Section 6).

Local Building Official

- Reviews design to ensure compliance with the requirements of the jurisdiction.

Admonishments

This practice is intended to serve as a guideline for earthquake resistant design. It is not intended to serve as a building code. It is important and necessary to comply with all relevant jurisdictional requirements and prevailing building codes in the design and construction of new buildings under the provisions of this practice. Guidelines provided in this practice, when employed by qualified professionals, are intended to improve the earthquake resistant design quality of AT&T facilities. However, no warranty is provided as to the particular earthquake risk in any given facility.

Ordering Information

To obtain additional copies of this document, contact the Customer Information Center at:

TOLL FREE: **1-800-432-6600** (USA)
 1-800-255-1242 (Canada)
TOLL: **1-317-352-8557** (Worldwide)
FAX: **1-317-352-8484**

Use the document numerical identifier and issue number (i.e., AT&T 760-200-024, Issue 2) when ordering this document.

How to Comment on this Document

To suggest changes to the information in this document or to notify the authors of errors in this document, please submit the comment form located at the end of this document. If the comment form is missing, send your comments and recommendations to:

AT&T
Documentation Services District
ATTN: Documentation Manger
Room 30-MZB-40
1600 Osgood Street
N. Andover, MA 01845
attmail!powerdoc
!powerdoc@att.mail.net

Earthquake Hazards

1

Contents	Page
1.1 Seismicity in the United States	1-1
1.1.1 Plate Tectonics	1-1
1.1.2 Seismic Maps	1-2
1.1.3 Earthquake Frequency	1-2
1.2 Earthquake Hazards	1-3
1.2.1 Ground Shaking	1-3
1.2.2 Surface Fault Rupture	1-4
1.2.3 Liquefaction	1-4
1.2.4 Compaction	1-4
1.2.5 Landsliding	1-5

Contents

Page

Earthquake Hazards

1

1.1 Seismicity in the United States

1.1.1 Plate Tectonics

Earthquake Origin — The crust of the Earth averages 45 miles in thickness and is composed of about a dozen large, irregularly shaped plates that slide over, under, and past each other on top of the partly molten mantle. When these plates become locked together, stresses build over time until the plates eventually break free. The ground vibration resulting from this release of energy is known as an earthquake.

Transform Faults — Earthquakes occur most frequently at the boundaries where the plates meet. Plates which slide past each other create what are known as transform faults in the Earth's crust. This type of boundary is perhaps best exemplified by the San Andreas fault along the California coast. Earthquakes at transform faults generally occur within 20 miles of the surface.

Subduction Zones — The boundary of a plate which overrides another, pushing it down to the mantle, is known as a subduction zone. The Cascadia subduction zone between Northern California and Vancouver Island, as well as the Alaska subduction zone near southern Alaska and the Aleutian Islands, are considered to be the largest tectonically active fault systems in North America. Earthquakes at subduction zones are likely to occur deeper than earthquakes at transform faults.

Interior Plate Earthquakes — Earthquakes can also occur within plate interiors. As plates continue to move and plate boundaries change over geologic time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within continents can cause earthquakes in response to stresses that originate at the edges of the plate or deeper in the crust. Examples of such zones include the Wasatch Fault Zone in Utah, Idaho, Montana, and Wyoming, as well as the New Madrid Fault Zone in Missouri, Illinois, Arkansas, Kentucky, and Tennessee.

1.1.2 Seismic Maps

Zone Map — Regional seismic activity is illustrated by the map shown in Figure 1-1. This map, excerpted from the Uniform Building Code (UBC) [Reference 21], divides the country into several zones representing relative seismic hazard. This map provides a qualitative seismic-risk guideline and reflects the relative frequency of earthquakes in various regions of the country, with the most seismically active areas defined as zone 4. This map does not provide information regarding the actual hazard or expected earthquake magnitude, which could be the same regardless of the zone.

For example, the three largest known earthquakes in the continental United States had magnitudes exceeding 8 and occurred on the New Madrid Fault Zone near Memphis, which is currently designated as zone 3. Likewise, a location in seismic zone 1 can be affected by moderate

earthquakes, as evidenced by the magnitude 5.6 earthquake in Texas on April 14, 1995.

Hazard Map — A refined assessment of national seismic hazard is provided by the map in Figure 1-2 [Reference 15]. This map depicts estimated peak ground accelerations for design basis earthquakes considering known sources of seismicity throughout the country. This results in an improved definition of seismic hazard considering earthquake frequency.

The use of zone or hazard maps corresponds to the particular design method selected to assess structural performance in an earthquake as described in Section 5.

1.1.3 Earthquake Frequency

Around the world, an average of 35 earthquakes occur every day. An earthquake of at least magnitude 6.5 occurs weekly, and an average of 18 magnitude 7.0 to 7.9 earthquakes and one magnitude 8.0 earthquake occur every year. While many of these events occur in seabeds or in sparsely populated areas, earthquakes can affect populated areas at any time. The U.S. Geological Survey (USGS) has estimated the following probabilities regarding earthquake occurrence in the United States:

- In the San Francisco Bay Area, there is a 67% probability that an earthquake of magnitude 7 or greater will occur in the next 30 years [Reference 30].
- In Southern California, there is a 60% probability that an earthquake of magnitude 7.5 or greater will occur on the San Andreas Fault during in the next 30 years. There is also a 50% probability that an earthquake of magnitude 6.5 or greater will occur on the San Jacinto Fault near San Bernardino in the next 30 years [Reference 29].
- Near Memphis, Tennessee, the probability of an earthquake exceeding magnitude 6.3 is more than 50% in the next 30 years, and there is approximately a 25% probability that this earthquake will exceed magnitude 7.5 [Reference 18].
- Earthquake probabilities in other areas, including Salt Lake City, the Pacific Northwest, and the Eastern Seaboard, are currently being evaluated.

1.2 Earthquake Hazards

1.2.1 Ground Shaking

Motion Amplification — Ground shaking is the primary hazard associated with earthquakes. Ground shaking includes both horizontal and vertical accelerations which can last up to several minutes during major earthquakes. The dominant frequencies of a typical strong-motion earthquake generally ranges from 1 to 10 Hz, though higher frequencies may be experienced at hard rock sites and lower frequencies at soft soil sites. Lower frequencies can also occur in stiffer soils depending on the distance to the earthquake source, as observed in Oakland, California, following the 1989 Loma Prieta Earthquake. Structures possessing natural frequencies of vibration in the dominant frequency range are more responsive and susceptible to the earthquake excitations than structures with frequencies outside this range.

Motion Attenuation — Generally, sites located remotely from the zone of fault rupture experience less severe ground motion than do sites located close to the fault. The attenuation of the intensity of shaking with distance from the fault depends on many factors including regional geology, fault type, earthquake depth, and earthquake magnitude. Local soil conditions can also amplify and modify the character of ground motion at individual sites to produce more intense effects than at sites closer to the fault, as exemplified by the severe damage sustained in San Francisco's Marina District during the 1989 Loma Prieta Earthquake 60 miles away, as well as by Mexico City during the 1985 Mexico Earthquake 240 miles away. The attenuation of earthquake motion with distance can vary significantly from one region to another. Earthquakes in California, for example, tend to decay exponen-

tially with distance. However, Central and Eastern U.S. earthquakes, as well as subduction zone earthquakes, tend to attenuate very slowly and are felt over much larger distances than similar magnitude earthquakes in California.

1.2.2 Surface Fault Rupture

Surface fault rupture is the direct manifestation of the movement that has occurred along a fault, projected to the ground surface. It consists of a concentrated, permanent deformation of the ground surface, and in major earthquakes can extend along the trace of the fault for many miles. This deformation can be in a horizontal and/or vertical direction. Depending on the type of soils present at the site, the zone of ground deformation associated with fault rupture may be limited to a band a few inches wide located directly over the fault, or it may spread out over several hundred feet. A ground surface rupture involving more than a few inches of movement within a concentrated area will cause major damage to structures that cross it. Fault displacements associated with great earthquakes may be as large as 30 feet. In general, the precise location and total length of faults are not known because they are covered by alluvium. Fault displacements produce forces so great that the best method of limiting damage to structures is to avoid building in areas close to ground traces of active faults.

1.2.3 Liquefaction

Liquefaction is the sudden loss of bearing strength that can occur when saturated, cohesionless soils (sands and silts) are strongly and repetitively vibrated. The consequences of liquefaction can include lateral spreading, landslides, a quick condition (loss of bearing capacity or tilting), and differential settling of the ground. Liquefaction typically occurs in loose sand deposits within 15 feet of the ground surface when there is subsurface ground water above a depth of 20 feet. Shallow ground water and loose soil are usually localized conditions resulting either from natural or human-made causes. As a result, site-specific data are necessary to determine if liquefaction may occur at a specific location.

1.2.4 Compaction

Compaction of loose soils and poorly consolidated alluvium can occur as a result of strong seismic shaking, causing uniform or differential settlement of building foundations. Buildings supported on deep foundations such as piles are more resistant to such settlements. However, in the 1985 Mexico City Earthquake, buildings supported on piles experienced substantial damage due to differential settlements between pile-supported buildings and non-pile-supported slabs-on-grade. Substantial compaction may occur in broad flat valley areas recently depleted of ground water due to the collapse of underground voids created by the water loss.

1.2.5 Landsliding

Earthquakes can trigger landslides in areas that are already landslide prone. Landslides are most common on slopes of more than 15% and can generally be anticipated along the edges of mesas and on slopes adjacent to drainage courses. In the 1964 Alaska Earthquake, landslides in Anchorage caused destruction and total loss of many residences and commercial buildings.



Figure 1-1. Seismic Zone Map of the United States

AT&T — PROPRIETARY
Use pursuant to Company Instructions

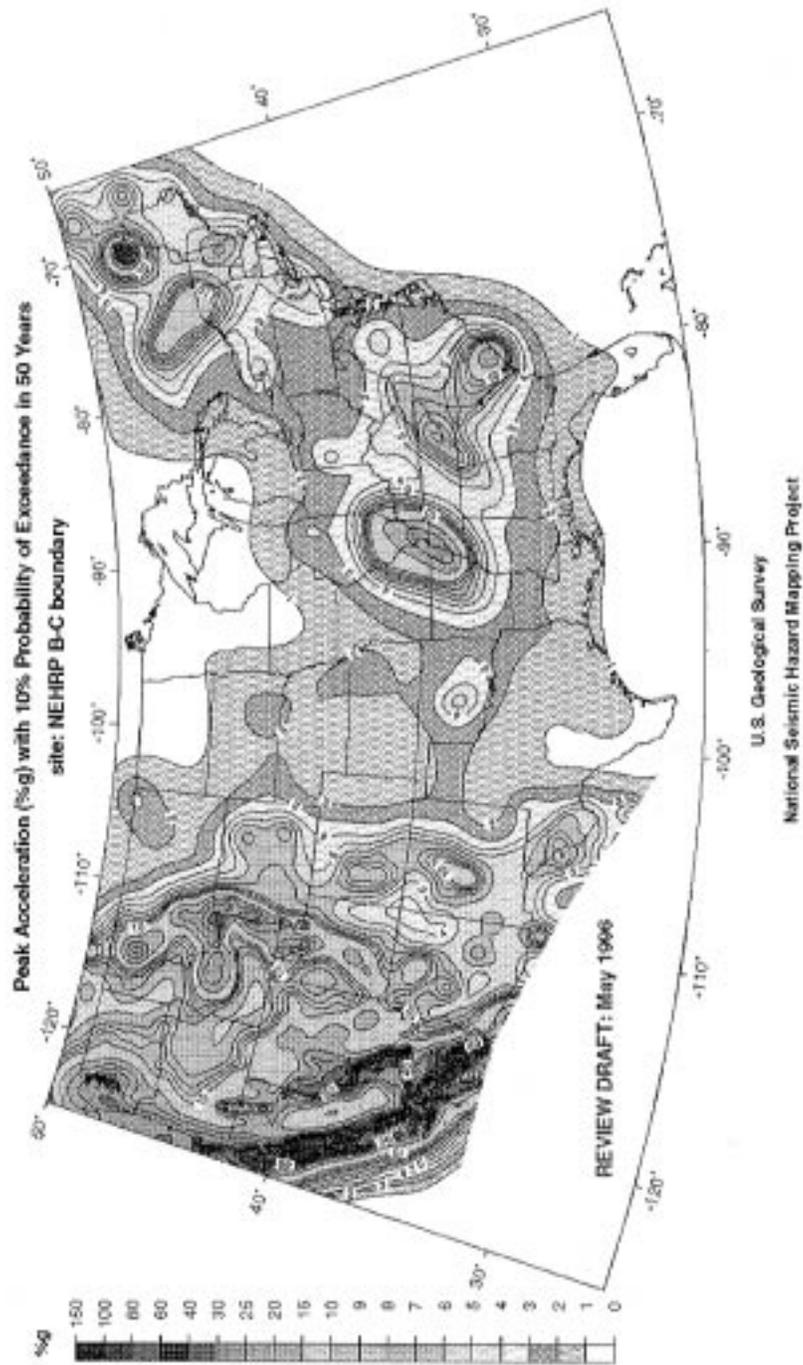


Figure 1-2. Seismic Hazard Map of the United States

AT&T — PROPRIETARY
Use pursuant to Company Instructions

Advanced Planning Considerations

2

Contents	Page
2.1 Site Selection	2-1
2.1.1 General Considerations	2-1
2.1.2 Ground Shaking Intensity	2-1
2.1.3 Near Fault Effects	2-2
2.1.4 Liquefaction Potential	2-4
2.1.5 Compaction Potential	2-4
2.1.6 Landsliding Potential	2-4
2.1.7 Other Potential Hazards	2-7
2.2 Structural Configuration	2-7
2.2.1 General Considerations	2-7
2.2.2 Regular Structures	2-7
2.2.3 Irregular Structures	2-8
2.3 Structural Separations	2-11
2.3.1 Building Pounding	2-11
2.3.2 Functional Interconnection	2-11

Contents

Page

Advanced Planning Considerations

2

2.1 Site Selection

2.1.1 General Considerations

The selection of building sites in areas likely to be affected by earthquakes requires special considerations in addition to those indicated in AT&Tfs 760-100-020, *Selection of Building Sites for Central Offices*. It is recommended that prevailing seismic hazards be identified and considered in the site selection process to avoid undue seismic risk. In particular, the site selection process should endeavor to minimize hazards due to ground shaking, liquefaction, and compaction, and to avoid hazards due to fault rupture and landsliding.

2.1.2 Ground Shaking Intensity

Considerations — Expected ground shaking intensity is a key consideration in assessing the seismic risk of a potential building site. Ground shaking intensity at a site depends on several factors, including expected ground acceleration, proximity to faults, and site soil characteristics.

General Assessment — A general assessment of ground shaking intensity for a proposed site can be made by determining the estimated Peak Ground Acceleration (PGA) using the Hazard Maps provided in Section 1.1.2. Project costs necessary to control unacceptable seismic risks can be reduced by selecting sites where the corresponding PGA is as low as possible.

Refined Assessment — A more refined assessment of ground shaking intensity can be made by considering both the expected PGA and the type of soil at the site. Sites composed of rock and stiff soils generally have lower shaking intensities than sites composed of deep stiff clays. Likewise, sites composed of medium to soft clays and sands generally have the highest intensities. Soil information can usually be obtained from City or County Planning Departments, or from the United States Geological Survey (USGS). Soil considerations may be particularly important in selecting among potential building sites in the same general area.

2.1.3 Near Fault Effects

Considerations — Sites located near faults may be exposed to additional hazards such as fault rupture and more intense ground shaking. Accordingly, it is important to avoid selecting sites near active or potentially active faults. In California, the AlquistPriolo Special Study Zone Maps, available from the California Division of Mines and Geology (CDMG), document known faults and zones of potential fault rupture (Figure 2-1). In other states, fault maps can be obtained from the USGS. This information should be used to determine the proximity of active faults to potential AT&T sites.

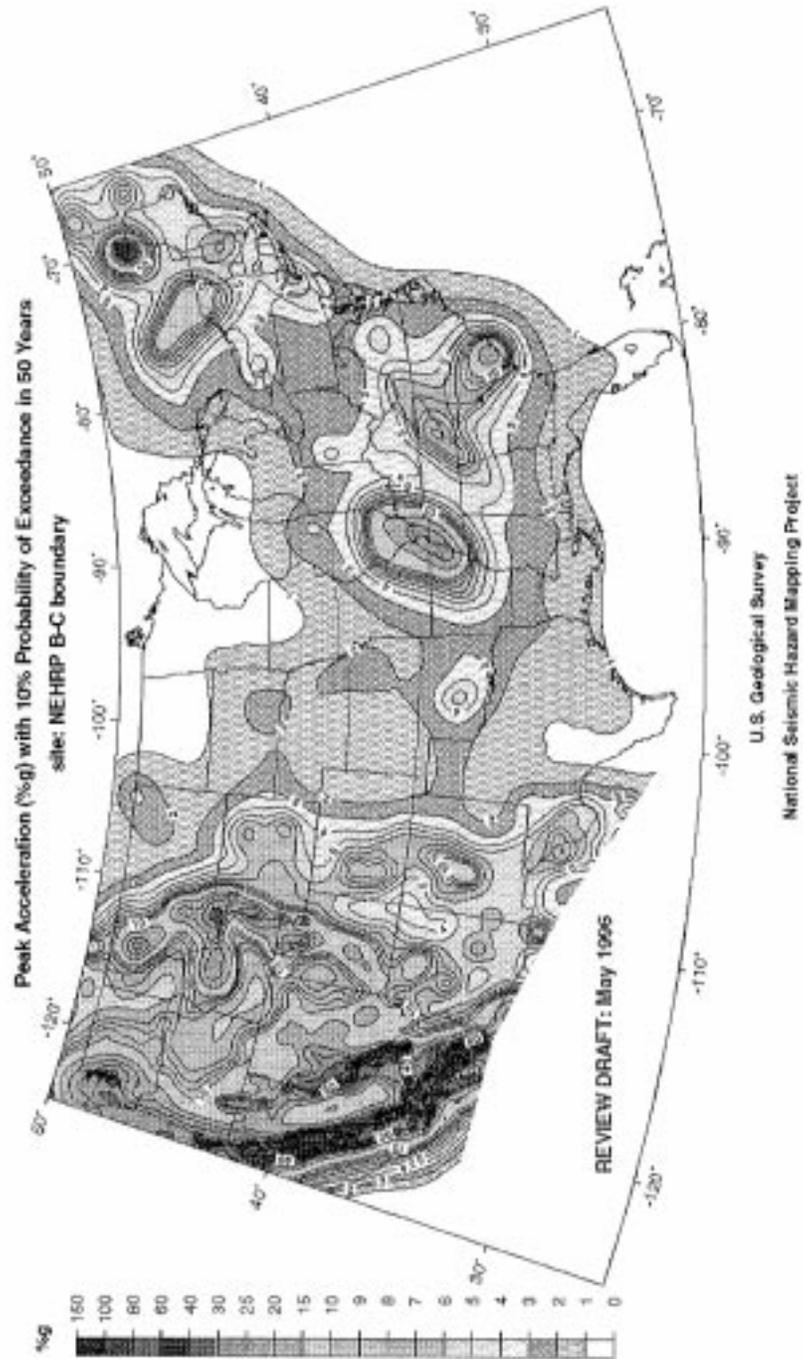


Figure 2-1. Example Map Indicating Fault Zone

AT&T — PROPRIETARY
Use pursuant to Company Instructions

Fault Rupture — Due to the enormous forces imposed on structures affected by fault rupture, all future AT&T facilities shall be located more than 2500 feet from a well-defined zone containing the traces of an active fault. Sites located closer to an active fault zone may be selected only if a site-specific seismic hazard study indicates an acceptable level of risk (see Section 5.3). In any case, sites shall not be selected where the distance to a fault zone is less than 1000 feet.

Ground Shaking — Sites which are located in close proximity to an earthquake epicenter generally experience more intense ground shaking than sites further away. In particular, horizontal and vertical ground accelerations can be as much as 50% larger in the epicentral region than elsewhere. Accordingly, sites which are located within 5 miles of an active fault zone should be avoided if possible. Otherwise, a site-specific hazard study shall be performed to determine appropriate design parameters considering near fault effects (see Section 5.3).

2.1.4 Liquefaction Potential

Liquefaction may be a concern if the following conditions exist:

- The site or nearby sites have experienced historical liquefaction
- The soils are typically granular (sand and/or silt) and the groundwater table is less than 30 feet below the expected foundation depth or 50 feet below the ground surface.

These conditions can be assessed using soil information obtained from City or County Planning Departments or from the USGS (Figure 2-2). Often these agencies can provide regional maps which indicate the potential for liquefaction and other sources of ground instability. If any of the above conditions exist, site specific geotechnical studies should be performed to more accurately assess the liquefaction hazard.

2.1.5 Compaction Potential

In general, compaction can occur at sites which have relatively loose natural soils or poorly compacted fill soils. Compaction can occur in soils above and below the groundwater table, and generally includes sites which are prone to liquefaction. A general review of available soils information can identify potential compaction concerns during the site selection process.

2.1.6 Landsliding Potential

Landsliding hazards include differential movement of building foundation soils as well as rock falls or slide debris from adjacent slopes. Landsliding can occur at sites with slopes exceeding 20°, or in areas which have experienced historical landsliding. Site slopes can be estimated visually or using USGS or CDMG topo-

graphic maps. In some areas, maps of historical landslide activity or potential ground instability are available from City or County Planning Departments (Figure 2-2).

2.1.7 Other Potential Hazards

On a site-specific basis, consideration should be given to additional earthquake hazards including the following:

- Tsunami inundation in low-lying coastal areas
- Flooding due to upstream dam or pipeline failure
- Fire conflagration following earthquakes.
- AT&T 760-100-020, *Selection of Building Sites for Central Offices*, provides additional guidelines for considering flood and fire hazards during the site selection process.

2.2 Structural Configuration

2.2.1 General Considerations

Building behavior during an earthquake is highly dependent on overall building geometry and configuration. Consideration of seismic behavior in advanced building planning is therefore recommended for efficiency in earthquake-resistant design and to minimize seismic risk.

2.2.2 Regular Structures

Regular structures have no significant discontinuities in plan or vertical configuration, and thus have an inherent advantage in earthquake resistance. Regular features of a building include the following:

- Simplicity in form
- Compact shapes
- Symmetry in weight distribution
- Symmetry in lateral-load resistance
- Uniformity and continuity in story stiffness or strength
- Limited building height-to-width ratios.

2.2.3 Irregular Structures

Irregular structures have global or local discontinuities in plan or vertical configuration, and thus have an inherent disadvantage in earthquake resistance. Irregular features of a building include the following:

- Complex or long, extended building shapes (Figure 2-3)
- Eccentric weight distribution
- Asymmetric lateral-load resistance (Figure 2-4)
- In-plane and out-of-plane offsets in lateral-load resisting elements (Figure 2-5)
- Significant changes in story stiffnesses or strengths (Figure 2-6)
- Large building height-to-width ratios
- Large openings in walls or floors (Figure 2-7).

If structural design is properly conducted, certain irregularities can be incorporated into a building if necessary. It is important to recognize, however, that despite design efforts, building efficiency and performance will likely be adversely affected by including irregularities in the configuration.

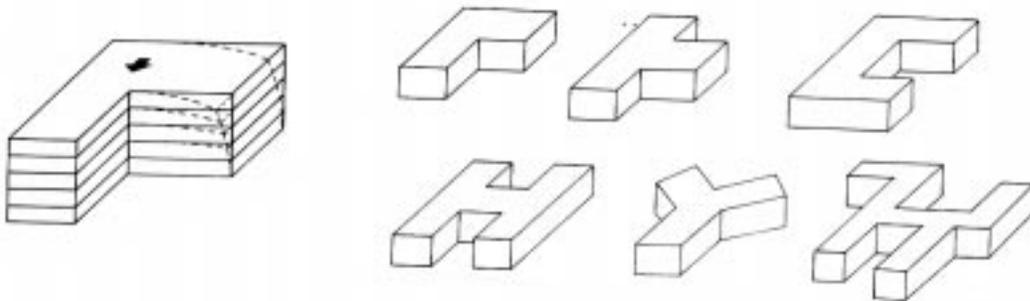


Figure 2-3. Irregular Structural Configurations

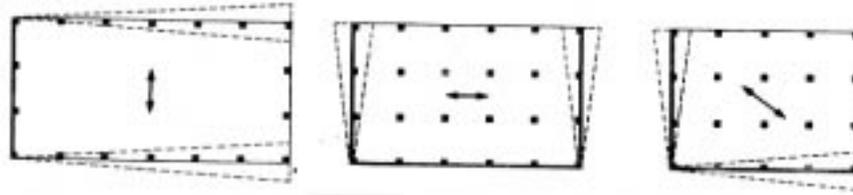


Figure 2-4. Asymmetric Lateral Load Resistance

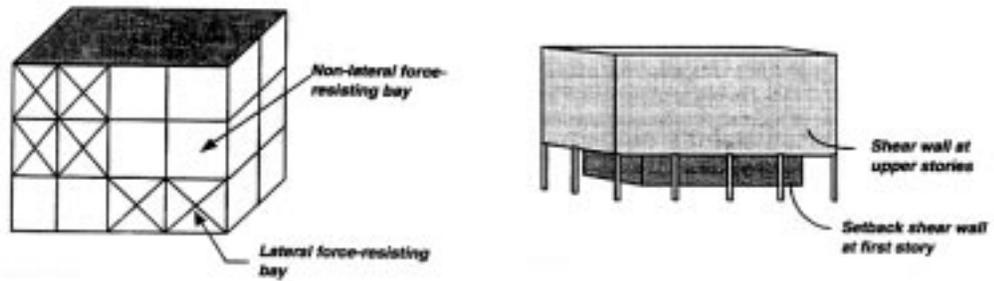


Figure 2-5. In-plane and Out-of-plane Offsets in Lateral Load-resisting Elements

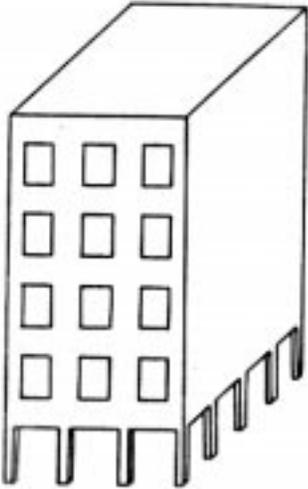


Figure 2-6. Soft Story Condition Created by Large Openings at First Floor

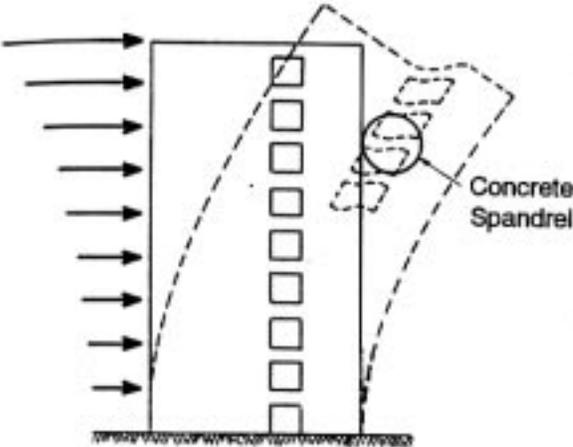


Figure 2-7. Discontinuity and Source of Damage Created by Vertically Aligned Wall Openings

2.3 Structural Separations

2.3.1 Building Pounding

When two buildings are in close proximity to each other, sufficient building separation should be provided to prevent pounding (impact) during an earthquake. Building pounding can alter the basic structural behavior and impart additional inertial loads and energy on the structures. Of particular concern is the potential for extreme local damage to structural elements at the zone of impact. Additionally, network and infrastructure systems, such as vertical condenser water piping, located between buildings will rupture if impact were to occur.

For planning purposes, the distance between buildings should not be closer than 4% of the height above grade at the location of potential impact. If necessary, detailed structural analyses of the buildings can be performed to justify a reduced building spacing.

2.3.2 Functional Interconnection

If functional interconnection is planned between adjacent multistory structures, relative horizontal and vertical building motion during an earthquake must be considered (Figure 2-8). During advanced building planning, consideration should be given to interconnecting network and infrastructure systems across structural separations below grade level only, or as close to grade level as possible. Where necessary, flexible connections must be used at structural separations to accommodate relative movement without system failure in accordance with the guidelines provided in Section 12.2.2.

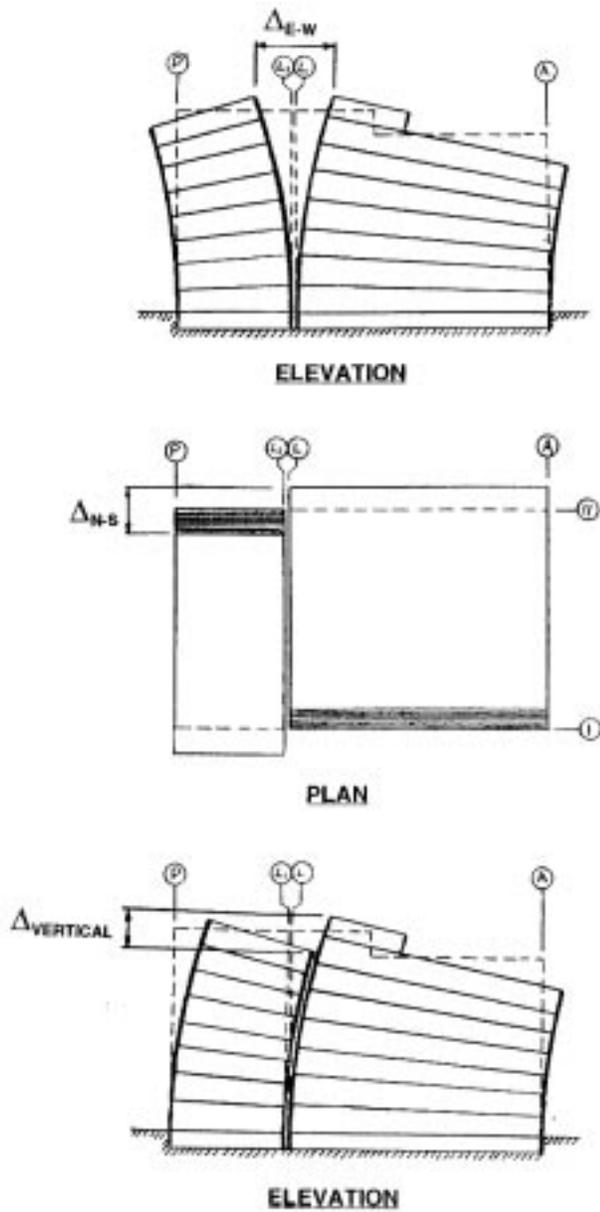


Figure 2-8. Range of Relative Motion Which Should be Considered for Adjacent Multistory Buildings.

AT&T — PROPRIETARY
Use pursuant to Company Instructions

Design Objectives

3

Contents	Page
3.1 Selection of Design Objectives	3-1
3.1.1 Background	3-1
3.1.2 Objectives	3-1
3.1.3 Scope of Work	3-2
3.2 Terminology	3-2
3.2.1 Performance Levels	3-2
3.2.2 Office and Site Categories	3-4
3.3 Performance Requirements for New Buildings	3-5

Contents

Page

Design Objectives

3

3.1 Selection of Design Objectives

3.1.1 Background

Earthquake loading is unique among the types of loads which must be considered during a structural design. This is because a major earthquake causes greater stresses and deflections in the structure than all of the other loads combined, yet the probability of a major earthquake occurring within the expected life of the structure is usually low. Accordingly, it is generally not economically practical to design structures to resist earthquakes without some acceptable level of damage.

3.1.2 Objectives

Limits of acceptable seismic performance must be established in order to control the effects of damage. Performance objectives are an expression of the desired behavior of building systems, components, and contents during varying levels of earthquakes. Performance objectives provide a basis for characterizing earthquake demands and subsequent design requirements for the building. Adequate life safety is the minimum performance level required for all AT&T facilities. In order to control the risk of network failure, enhanced performance levels are required for facilities which are critical to network operations.

3.1.3 Scope of Work

The scope of work in selecting performance levels for a building involves identifying the desired performance considering the importance of the building to AT&T operations. Varying levels of performance are often defined for a suite of earthquake intensities. For example, it may be appropriate to design a building to sustain no damage during a small earthquake, sustain light damage but remain operational during a medium earthquake, and sustain moderate repairable damage with limited operational interruption during a large earthquake. A design is considered to be well balanced if, for all intensities of earthquakes considered, the corresponding performance objectives are simultaneously met. Earthquake intensities are usually defined probabilistically as discussed in Section 5.1.3.

3.2 Terminology

3.2.1 Performance Levels

Seismic performance is generally defined using the following terms. Figure 3-1 and Figure 3-2 provide a graphical representation of these definitions [Reference 2].

Operational — The operational level limits post-earthquake damage such that normal operation of the facility can largely continue without interruption. The primary difference between the operational and immediate occupancy levels concerns the performance of equipment and infrastructure support services. To meet the operational level, emergency standby utilities are required, and the ability of major equipment items to function following an earthquake must be verified.

Immediate Occupancy — The immediate occupancy level limits post-earthquake damage such that the basic vertical and lateral force resisting structural systems retain nearly all of their pre-earthquake characteristics and strength. Under these conditions, it is expected that the occupants can remain in the building, although some cleanup, inspection, and repair may be required. Normal operations may be restricted due to limited structural damage, equipment damage, or loss of infrastructure support services.

Life Safety — The life safety level limits post-earthquake damage to provide a certain margin of safety against total or partial collapse. While injuries during the earthquake may occur, the overall risk of life threatening injury should be low. Repair of the structure may be possible, but may not be economically practical. This is the minimum performance level required for standard facilities exposed to an earthquake with a statistical return period of approximately 500 years.

Collapse Prevention — The collapse prevention level limits post-earthquake damage to the point where the structure is on the verge of experiencing partial or total collapse. Although the structure will retain its overall stability, it may not be practical to repair or reoccupy.

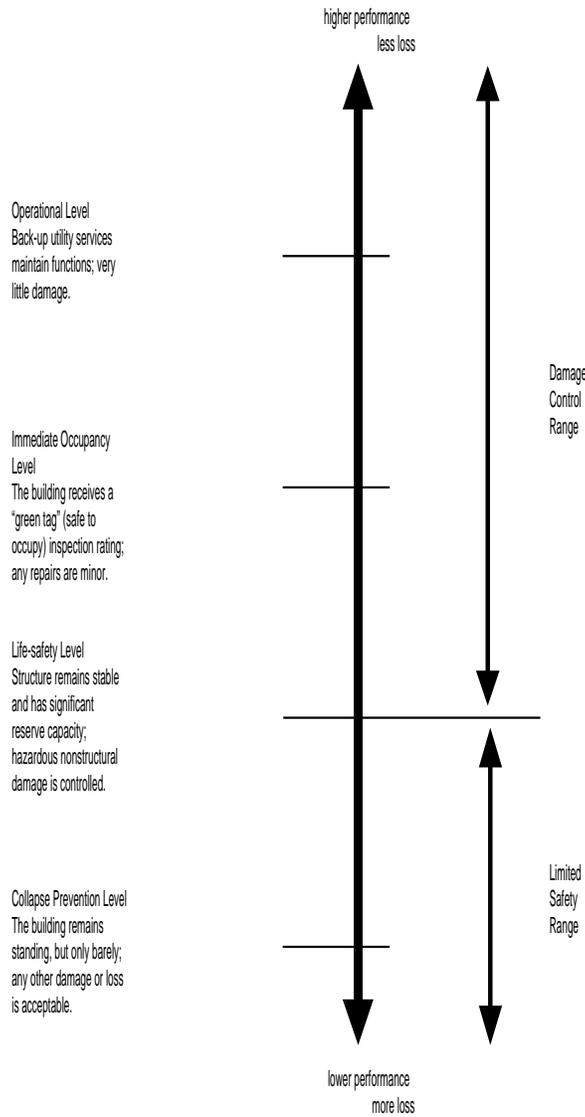


Figure 3-1. Performance Levels

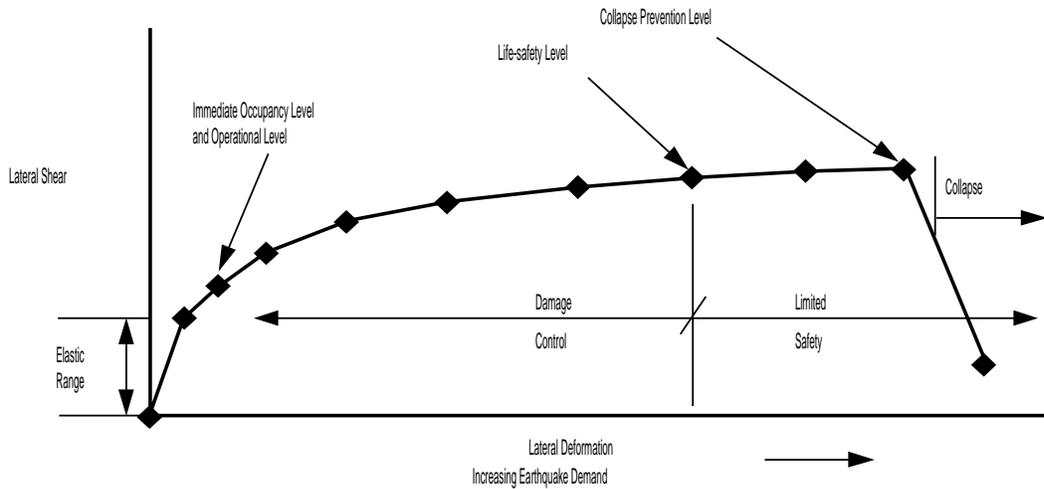


Figure 3-2. Performance Levels Relative to Increasing Deformation and Earthquake Demands

3.2.2 Office and Site Categories

The importance of a building to AT&T operations must be determined in order to define the limits of acceptable seismic performance. Office and site categories are consistent with AT&T's Infrastructure Segmentation Strategy and are defined below. Minimum performance requirements for each category are provided in Section 3.3 [Reference 19].

3.2.2.1 Network Facilities:

- *Critical Platinum and Gold Office* — A service outage in a Critical Platinum and Gold Office can have a serious to catastrophic impact on network operations and hence to the AT&T brand name. Critical Platinum and Gold Offices generally include sites with one or more 4ESS, sites with non-restorable circuits, and sites which service critical customers.
- *Major Office* — A service outage in a Major Office can have a major impact on some customers, but the overall impact to the AT&T brand name may be minimal. These offices generally include significant switching locations which are not considered to be Critical Offices.
- *Node Office* — A service outage in a Node Office can have a major impact to specific customers, but the overall impact to the AT&T brand name would be less than for Major Offices. Node Offices generally include locations with significant terminating traffic which are not considered to be Major or Critical Offices.
- *Network Sites* — All other network locations which are not assigned to the Critical, Major, or Node Office categories are defined as Network Sites.

3.2.2.2 Other Facilities:

- *Essential Buildings* — Essential Buildings include locations which support critical functions, but do not contain network equipment. This category may include regional headquarters office buildings, buildings housing emergency response and control centers, and buildings housing supply and repair operations.
- *Standard Buildings* — Standard Buildings include all other AT&T facilities not included in the above categories. This category may include buildings providing administrative office space which, in the event of earthquake damage, could be temporarily relocated to alternate facilities.

3.3 Performance Requirements for New Buildings

Table 3-1 specifies the minimum performance objectives required for all new AT&T facilities. The use of more stringent performance requirements should be considered only if a lower seismic risk is deemed necessary, and if the associated benefit can be justified relative to the additional project cost. The use of less stringent performance requirements should not be considered except in cases specifically authorized by the Power and Infrastructure Development District.

Table 3-1. Performance Requirements for New Buildings

Building Function		Performance Levels	Design Earthquake	
			Return Period (years)	Probability of Exceedance in 50 Years
Network Facilities	Critical Office (Platinum & Gold)	Life Safety	2500	2%
		Operational	1000	5%
	Major Office	Life Safety	1500	3%
		Operational	600	8%
	Node Office	Life Safety	1000	5%
		Operational	500	10%
Network Site	Life Safety	500	10%	
Other Facilities	Essential	Life Safety	1000	5%
		Operational	500	10%
	Standard	Life Safety	500	10%

Design Methods

4

Contents	Page
4.1 Selection of Design Methods	4-1
4.1.1 Objectives	4-1
4.1.2 Scope of Work	4-1
4.2 Prescriptive Methods	4-2
4.2.1 Methodology	4-2
4.2.2 Considerations	4-2
4.2.3 Applicability	4-2
4.2.4 UBC Method	4-2
4.2.5 NEHRP Method	4-3
4.3 Performance Methods	4-3
4.3.1 Methodology	4-3
4.3.2 Considerations	4-4
4.3.3 Applicability	4-4
4.3.4 Inelastic Demand Ratio Method	4-4
4.3.5 Capacity Spectrum Method	4-5
4.3.6 Nonlinear Time History Analysis Method	4-7

Contents

Page

Design Methods

4

4.1 Selection of Design Methods

4.1.1 Objectives

There are two general methods which can be used to analyze and design a structure to meet the desired performance objectives. Earthquake-resistant design has historically been based on a prescriptive design approach to ensure that buildings possess a minimum lateral capacity. This method implicitly defines structural performance to protect life safety, but has limited ability to address serviceability. With advances in engineering technology, however, it is becoming possible to explicitly design a structure to meet multiple performance objectives. This performance-based design approach is intended to address not only life safety, but also serviceability of the structure following an earthquake. The design team is responsible for using the most appropriate design method for the project considering the advantages and limitations of each approach. Acceptable design methods are described below.

4.1.2 Scope of Work

The scope of work includes selecting an appropriate design method to ensure that the performance objectives for the facility are met. Once the method is selected, structural analysis and design development can proceed.

4.2 Prescriptive Methods

4.2.1 Methodology

Prescriptive methods implicitly control earthquake performance by requiring buildings to resist a minimum specified lateral force. This lateral force is a function of the building weight, and is determined by selecting coefficients based on regional seismicity, site soil properties, natural structural periods of vibration, facility importance, and the type of structural system used for lateral resistance. Limitations on structural configuration and special requirements for structural detailing and construction quality assurance are included in the approach to ensure that structures behave acceptably.

4.2.2 Considerations

Advantages — Prescriptive methods are well-defined and commonly used for earthquake-resistant design. These methods have generally proven to be adequate for facilities which have life safety as the primary objective.

Limitations — Prescriptive methods are intended to provide a minimum standard for life safety, but have limited ability to address serviceability. Building performance is implicitly defined in a manner that cannot be quantified by the user. It is generally not evident what design changes should be made in order to obtain different performance from that implicit in the approach.

4.2.3 Applicability

Prescriptive methods may be used only for the design of new AT&T buildings classified as Network Sites or Standard Buildings as defined in Section 3.2.2. The UBC and NEHRP methods described below are acceptable prescriptive methods for AT&T facilities. All other buildings shall be designed using performance methods described in Section 4.3.

4.2.4 UBC Method

Description — The minimum lateral force required by the UBC [Reference 21] method is expressed in terms of a total base shear, V , given by the following equation:

$$V = ZICW / R_w$$

where: Z = coefficient dependent on the seismic zone (Figure 2-1).

- I = facility importance coefficient
- C = spectral amplification coefficient considering soil characteristics and natural structural frequency
- W = total weight of the building
- R_w = coefficient that reflects the type of construction, ductility, and energy-dissipation capacity of the lateral load-resisting system.

Analysis Requirements — Structural analyses are typically performed to distribute the total specified lateral load to individual structural elements and to determine the expected structural displacements. Generally for prescriptive-based design, elastic static or dynamic response spectrum analyses are sufficient. The selection of static or dynamic analysis shall be made in accordance with the requirements of the UBC, with the exception that all AT&T structures exceeding 65 feet in height shall be analyzed using dynamic response spectrum methods.

Design Requirements — All requirements for structural capacity, lateral drift, and structural detailing specified in the UBC shall be met.

4.2.5 NEHRP Method

Description — An alternate prescriptive method has been developed for the National Earthquake Hazards Reduction Program (NEHRP) and presented in FEMA Report 222A [Reference 10]. Although there are some differences between this method and the UBC method, including an alternate formulation of lateral load coefficients, both methods are similar and should yield equivalent designs.

Analysis Requirements — Static or dynamic response spectrum analyses shall be performed as required by NEHRP with the exception that all AT&T structures exceeding 65 feet in height shall be analyzed using dynamic response spectrum methods.

Design Requirements — All requirements for structural capacity, lateral drift, and structural detailing specified by NEHRP shall be met.

4.3 Performance Methods

4.3.1 Methodology

Performance methods allow an explicit evaluation of structural performance for design earthquakes of differing magnitudes. Several approaches can be used, ranging from simplified approximate methods to more complex and accurate methods. These include an Inelastic Demand Ratio method which uses elastic

analysis procedures, a Capacity Spectrum method considering simplified inelastic response, and nonlinear time history analyses which tracks actual structural behavior throughout a design earthquake. Each of these methods allows an explicit assessment of expected structural deformation and associated damage for various levels of earthquake loading. In general, structural configuration and detailing requirements and construction quality assurance in performance-based design are similar to the prescriptive methods.

4.3.2 Considerations

Advantages — Performance methods provide a means of determining the extent and implications of structural damage for various magnitudes of earthquakes. This improved insight into structural behavior enables meeting the desired performance objectives in an efficient and cost-effective manner.

Limitations — Performance-based design is a relatively new approach to earthquake engineering, and analysis methods and design practices are continuing to be developed and verified. Accordingly, the following conditions are imposed for all AT&T facilities designed using performance methods:

- Prior to beginning the design, concurrence from the local Building Official regarding the proposed design methodology shall be obtained.
- The structural engineer responsible for performance-based designs shall have prior experience in using the selected approach and shall be fully aware of new developments in the field.

4.3.3 Applicability

Performance methods may be used for the design of all new AT&T buildings. The performance methods described below have been used in the past for the design of critical facilities, including central offices, military complexes, and nuclear power plants. All are considered acceptable for the design of AT&T facilities, subject to the limitations defined in Section 4.3.2.

4.3.4 Inelastic Demand Ratio Method

Description — The Inelastic Demand Ratio (IDR) method is a simplified approach to performance-based design. In this approach, the structure is assumed to remain elastic and full design earthquake loads are applied. Since inelastic behavior is usually allowed, the calculated seismic demands typically exceed the strength of the structural elements. The amount by which the strength is exceeded provides a measure of the expected damage and performance of the structure. Using this data, the structural design is refined to ensure that the performance objectives for the facility are met in an efficient manner. [Reference 2] shall be used as a guideline for this approach.

Performance Assessment — To assess structural behavior for a specific performance level, force demand to capacity ratios are calculated for each component of the structure. These values are then compared to numeric acceptance criteria established for various performance levels for the type of element being designed. For example, a concrete shear wall may be deemed acceptable if the force demand to capacity ratios do not exceed 2 for an operational assessment using a 500 year earthquake, and 3 for a life safety assessment using a 1000 year earthquake. [Reference 2] provides the appropriate numeric acceptance criteria for various performance levels.

Analysis Requirements — All analysis requirements specified in [Reference 2] shall be met.

Design Requirements — All structural detailing requirements specified in the UBC shall be met.

4.3.5 Capacity Spectrum Method

Description — The Capacity Spectrum Method (CSM) allows a graphical assessment of expected structural performance considering approximate inelastic behavior for each magnitude of design earthquake considered. The expected performance can then be assessed relative to the desired performance objectives to verify the adequacy of the design. The general steps involved in this method are as follows:

- The inelastic capacity of the building is determined by performing a “push-over” analysis. This is accomplished by applying lateral load to a mathematical model until some components reach their yield point. Yielding elements are then softened to represent structural damage, and loads are increased until the next element yields. The process is continued until the model predicts collapse.
- The applied lateral force and roof displacement coordinates determined from the pushover analysis described above are used to plot the inelastic capacity curve for the building (Figure 4-1).
- Using a consistent coordinate system, the design earthquake response spectrum is overlaid on the structural capacity curve. Various levels of damping can be represented in the demand curve to consider the energy-dissipation effects of inelastic behavior.

Performance Assessment —

- The intersection of the demand and capacity curves represents an estimate of the displacement induced on the structure by the design earthquake. The relative location of this intersection on the capacity curve provides an indication of the expected structural performance.
- The design is revised as required and the above steps are repeated until all of the desired performance objectives are met in the most efficient manner.

Analysis Requirements — Structural modeling shall be performed using realistic nonlinear material and component properties including stiffness, strength, and deformability. These shall be based on experimental and analytical information as well as sound judgment. Global building analysis shall be performed considering the response of all participating elements, and shall consider the effects of gravity loads. Sensitivity studies considering potential variations in structural properties shall be performed as necessary to bound the overall response. [Reference 2] and [Reference 3] shall serve as a guideline for material property definition, global modeling considerations, and CSM analysis requirements and procedures.

Design Requirements — All structural detailing requirements specified in the UBC shall be met.

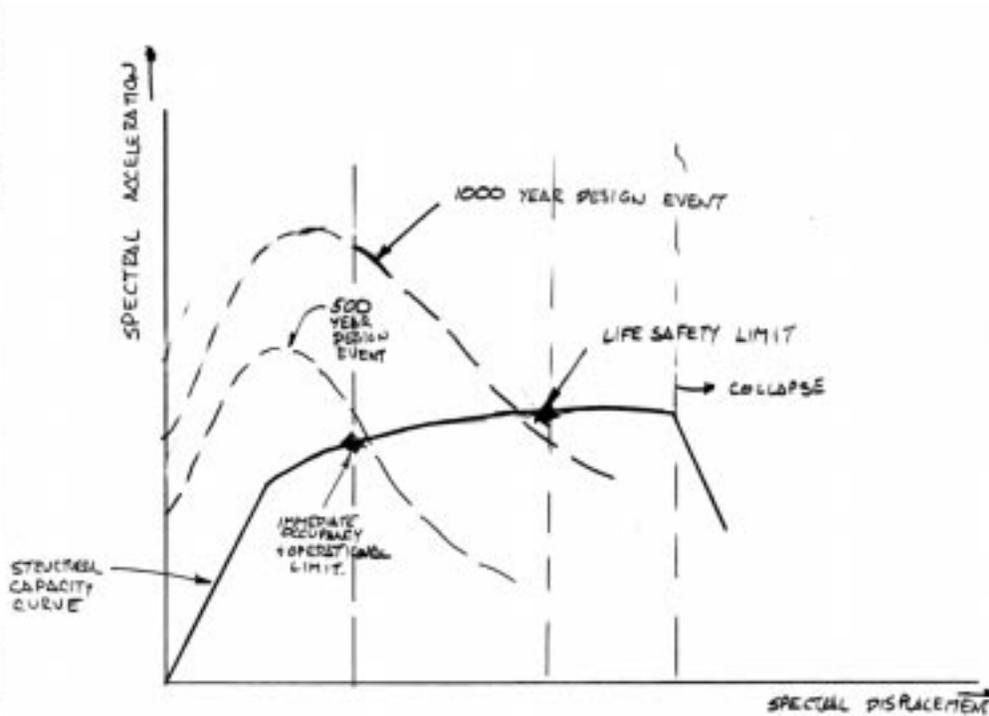


Figure 4-1. Graphical Performance Evaluation using the Capacity Spectrum Method

4.3.6 Nonlinear Time History Analysis Method

Description — Nonlinear time history analysis method is the most accurate analysis method for assessing structural behavior. In this approach, force and deformation demands resulting from design earthquakes are computed explicitly for the structure throughout a design event. The results of this analysis, however, are usually sensitive to assumptions made regarding structural material properties and ground motion input. Accordingly, the procedure is complex and requires experience to ensure meaningful results. Nevertheless, this method has been successfully applied to many types of structures, and may be particularly appropriate in assessing structures in which significant nonlinear behavior is expected.

Performance Assessment — To assess structural behavior for a specific performance level, deformation demands for each component of the structure are compared to acceptable deformation criteria established for various performance levels for the type of element being designed. For example, a concrete shear wall may be deemed acceptable if the rotation deformation does not exceed 0.005 for an operational assessment using a 500 year earthquake, and 0.010 for a life safety assessment using a 1000 year earthquake. Reference 2 provides the appropriate deformation acceptance criteria for various performance levels.

Analysis Requirements — Structural modeling shall be performed using realistic nonlinear material and component properties including stiffness, strength, and deformability. These shall be based on experimental and analytical information as well as sound judgment. Global building analysis shall be performed considering the response of all participating elements, and shall consider the effects of gravity loads. Sensitivity studies considering potential variations in structural properties shall be performed as necessary to bound the overall response. Sensitivity studies shall also be performed on the ground motion input applied to the building. A minimum of four time histories shall be used to analyze the structure for each design event considered. [Reference 2] shall serve as a guideline for material property definition, global modeling considerations, and analysis requirements and procedures.

Design Requirements — All structural detailing requirements specified in the UBC shall be met.

Design Earthquakes

5

Contents	Page
5.1 Selection of Design Earthquakes	5-1
5.1.1 Objectives	5-1
5.1.2 Scope of Work	5-1
5.1.3 Basis of Design Hazard	5-2
5.2 Generalized Hazard Assessment	5-4
5.2.1 Description	5-4
5.2.2 Applicability	5-4
5.2.3 Methods	5-4
5.2.4 Limitations	5-5
5.3 Site Specific Hazard Assessment	5-5
5.3.1 Description	5-5
5.3.2 Applicability	5-5
5.3.3 Methods	5-5

Contents

Page

Design Earthquakes

5

5.1 Selection of Design Earthquakes

5.1.1 Objectives

In order to analyze and design a structure to resist earthquakes, site seismic hazards must be identified and quantified. In selecting an appropriate design earthquake, consideration must be given to the location of the structure relative to known faults, regional and site specific geology, and the desired structural performance objectives.

5.1.2 Scope of Work

For most sites, earthquake hazards can be sufficiently defined by determining the intensity of expected ground shaking at the site. This can generally be accomplished by defining site response coefficients, response spectra, and/or ground motion time histories (Figure 5-1). If other earthquake hazards exist, then additional parameters may need to be defined, such as expected ground settlement due to compaction or liquefaction. Depending on the site hazards and structural performance objectives, the generalized or site specific methods described in Section 5.2 and Section 5.2 can be used to determine the seismic design parameters.

5.1.3 Basis of Design Hazard

Probabilistic — Design earthquakes are typically defined on a statistical basis considering regional sources of seismicity. Specifically, site ground motion is usually determined based on the probability that more severe demands will be experienced in a 50-year period (probability of exceedance). Refer to Section 3.3 for the probabilistic design events which are to be considered.

Deterministic — For sites which are within a few miles of a major active fault, it may be appropriate to determine site ground motion based on a specific magnitude earthquake likely to occur on the fault. This deterministic expression of the site hazard is usually defined in addition to the probabilistic hazard, and must not be less than the minimum hazard required by Section 3.3.

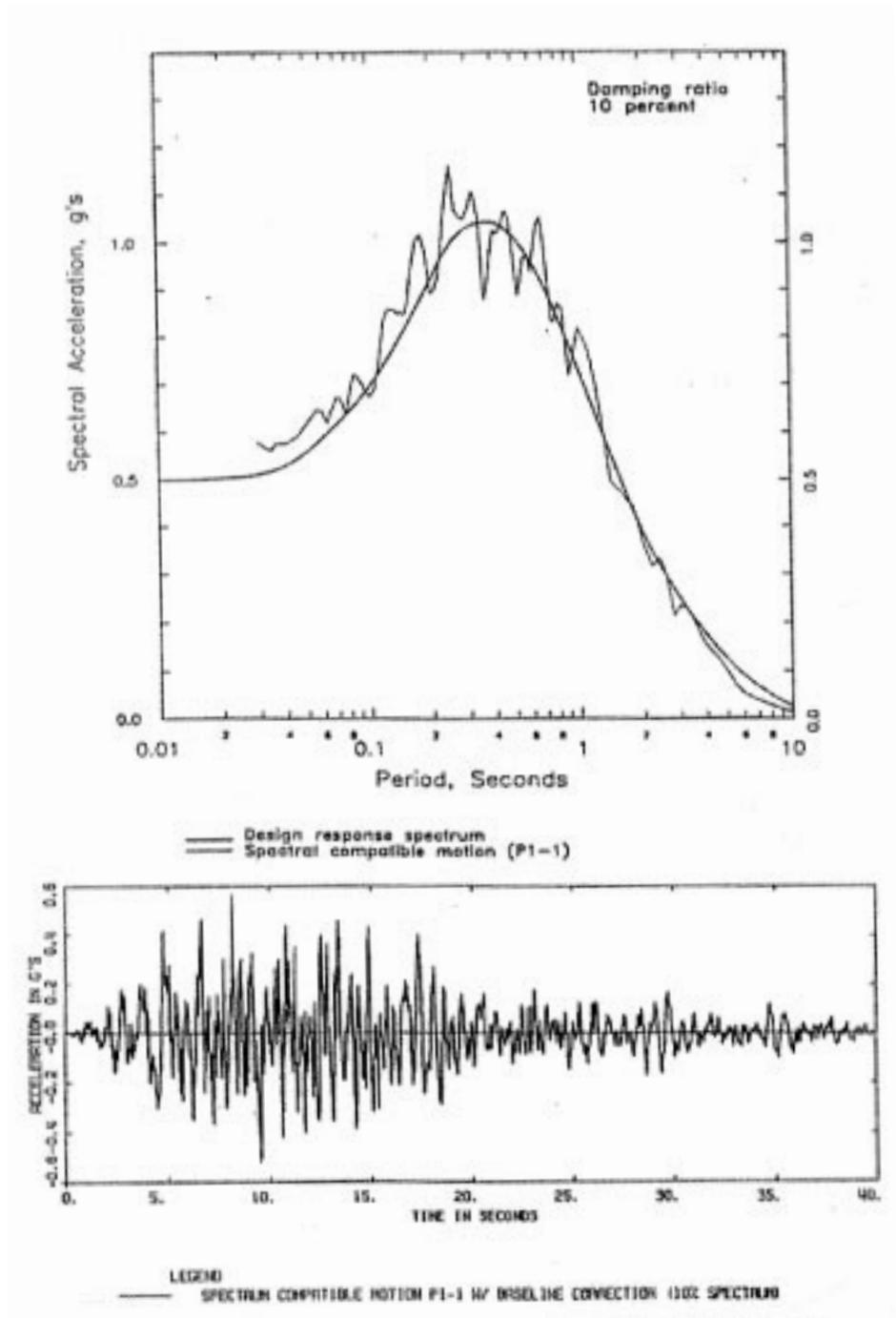


Figure 5-1. Example Design Response Spectrum and Ground Motion Time History

AT&T — PROPRIETARY
Use pursuant to Company Instructions

5.2 Generalized Hazard Assessment

5.2.1 Description

The generalized hazard assessment procedure is a probabilistic approach to determine site ground shaking. In this approach, published maps provide the expected regional PGA for the assumed earthquake probability of exceedance. The characteristics of the site soils are factored with the PGA to determine the appropriate design ground motion. Two generalized methods are available and are described in Section 5.2.3.

5.2.2 Applicability

The generalized hazard assessment is a rapid method of approximating ground shaking hazards. This procedure may only be used if all of the following conditions apply. Otherwise, a site specific hazard assessment as described in Section 5.3 shall be performed.

- The facility is classified as a Network Site or Standard Building as defined in Section 3.2.2.
- The site is greater than 5 miles from an active fault
- The site soil profile has less than 10 feet of very soft clays or other soils
- The soils are not vulnerable to liquefaction, compaction, and other geotechnical failures.

5.2.3 Methods

Zone Maps (UBC) — The generalized method currently used by the UBC to define ground shaking hazards is based on zone maps (Figure 1-1). Each zone is assigned a seismic zone “Z” factor which represents the effective peak ground acceleration for the region assuming a 10% probability of exceedance in 50 years. Based on the soil profile, soil “S” factors are used to account for the effects of local geology in the ground motion.

Hazard Maps (NEHRP) — A more refined generalized method has recently been developed for the National Earthquake Hazard Reduction Program (NEHRP) to account for a wider range of exceedance probabilities and soil conditions [Reference 10]. Hazard maps are used to determine peak ground acceleration and velocity values for the desired exceedance probability (50%, 20%, 10%, 5%, 2%), and then adjusted to account for the effects of local geology. The map in Figure 1-2 illustrates USGS ground acceleration estimates for a 10% probability of exceedance and provides the basis for the refined NEHRP hazard method.

5.2.4 Limitations

The two generalized methods for approximating ground shaking intensity generally yield similar results. It is important to note, however, that the generalized method must be consistent with the method used to evaluate the building performance described in Section 4. For example, if prescriptive-based UBC method is used, then the zone maps are applicable in determining the generalized hazard.

5.3 Site Specific Hazard Assessment

5.3.1 Description

A site specific hazard assessment can provide improved accuracy of earthquake hazards considering regional seismicity as well as local site soils. In particular, this assessment can provide a more accurate representation of expected ground motion, including site specific response spectra and design ground motion time histories, and can also define the risk associated with ground failures such as liquefaction and settlement. An expertise in seismology and geotechnical engineering is usually required to perform this assessment.

5.3.2 Applicability

Site specific studies are required if the generalized approach can not adequately define the site hazards. If any of the conditions listed in Section 5.2.2 are applicable to the site, then a site specific study is required.

5.3.3 Methods

Ground Shaking Hazards — Ground shaking hazards are assessed considering regional and local sources of seismicity, probability of earthquake occurrence, local geology, and site soil characteristics determined by soil sampling. The development of site specific ground motion can be based on several sources of information. These include ground motion records obtained from past earthquakes at or adjacent to the site of interest as well as synthetic ground motion records generated using regional seismological models of fault movement. Records from past earthquakes can be obtained from the USGS, CDMG, as well as AT&T's network of seismic accelerometers located in selected facilities throughout active seismic zones (Figure 5-2). The latter source, however, may only provide ground motion data recorded since 1995.

Other Hazards — Site specific studies are generally required to more accurately define other earthquake-related hazards such as liquefaction, settlement, landsliding, and ground rupture. These studies are performed considering the expected ground shaking intensity, local geology, and soil characteristics determined by soil sampling. The outcome of this study can include such design parameters as the magnitude of expected settlement and the location of liquefaction-prone soils at the site.

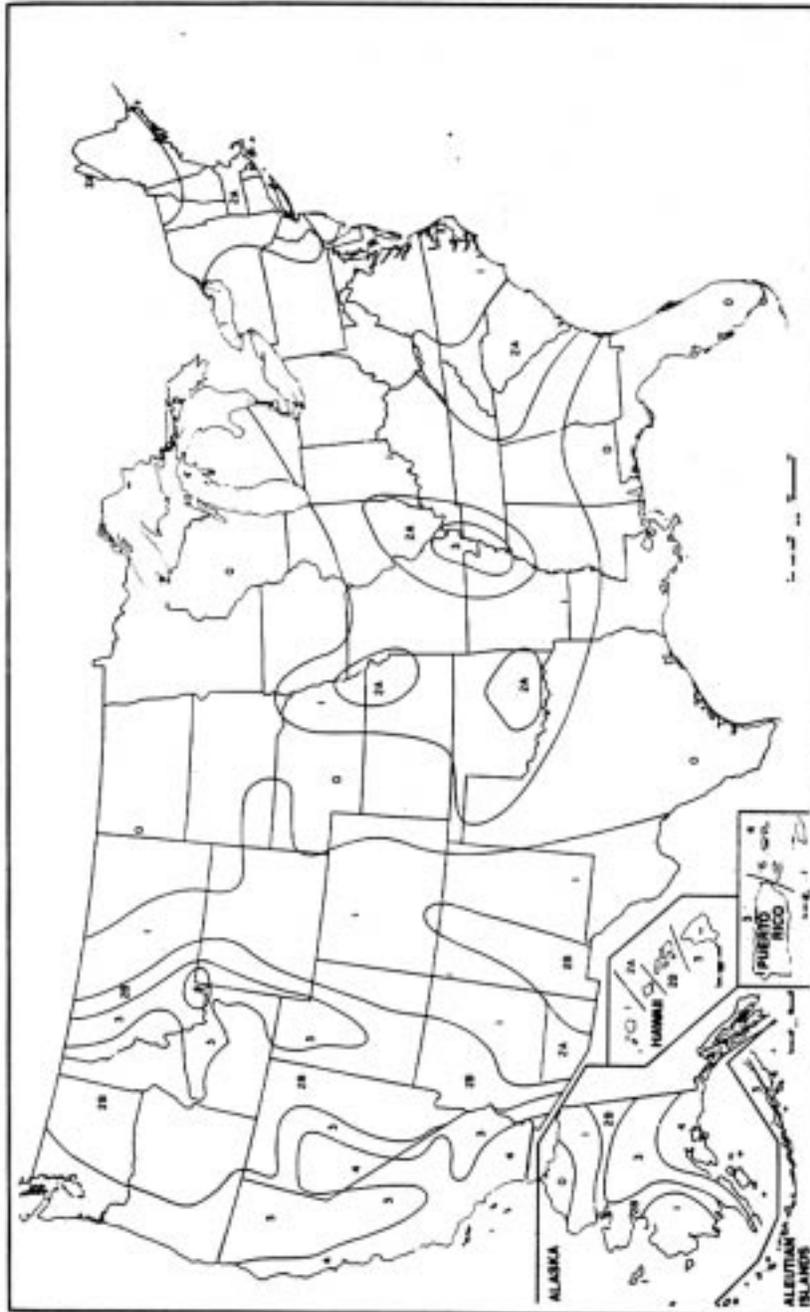


Figure 5-2. Map of the AT&T Seismic Accelerometer Network

AT&T — PROPRIETARY
Use pursuant to Company Instructions

Special Considerations

6

Contents	Page
6.1 Overview	6-1
6.2 Analysis Parameters	6-1
6.2.1 Effective Mass of Equipment	6-1
6.2.2 Soil-Structure Interaction	6-2
6.3 Energy Dissipation and Seismic Isolation	6-2
6.3.1 Overview	6-2
6.3.2 Passive Energy Dissipation	6-3
6.3.3 Seismic Isolation	6-6
6.4 Building Instrumentation	6-8
6.4.1 Overview	6-8
6.4.2 Deployment Requirements	6-8
6.4.3 Responsibilities	6-9
6.4.4 Hardware Selection	6-9
6.4.5 Instrument Positioning	6-9

Contents

Page

Special Considerations

6

6.1 Overview

This section presents selected topics in earthquake engineering, particularly as they relate to Central Office building design. This includes guidelines for the use of certain structural analysis parameters, description of the advance concepts of energy dissipation and seismic isolation, and requirements for building instrumentation.

6.2 Analysis Parameters

6.2.1 Effective Mass of Equipment

In performing a seismic analysis of a building, an allowance must be made for equipment weight rigidly connected to the structure. Refer to AT&T 760-200-020, *Design Loads for Telephone Buildings*, for requirements in determining effective equipment mass.

6.2.2 Soil-Structure Interaction

Description — It is commonly assumed in earthquake-resistant design that the motion experienced at the base of a structure is the same as the motion of the ground if the structure were not present. While this may be true for relatively short structures supported on rigid ground, it may not be true for structures supported on soft soil or for tall structures. Depending on the characteristics of the structure and the soil, soil-structure interaction (SSI) and soil flexibility may increase, decrease, or have no effect on the magnitudes of forces induced on the structure. While the effects of SSI may be considered for all buildings, such consideration is required only for those cases in which the structure motion response is likely to increase as determined by the project geotechnical engineer.

Simplified Approach — In cases where SSI is not expected to increase the structural response, an equivalent lateral force procedure may be used to account for the effects of SSI. In this approach, the total lateral force applied to the building may be reduced up to 30% by considering the increase in fundamental periods provided by the soil flexibility and system damping. [Reference 10] shall serve as a design guideline for implementation of this approach, and may only be used for buildings designed using the NEHRP method described in Section 4.2.5.

Detailed Approach — In cases where the simplified method may not be adequate, a detailed SSI assessment shall be performed. In general, two methods known as the direct and substructure methods are available. In the direct method, the soil and structure are modeled together and subjected to the site ground motion. In the substructure approach, “impedance” functions which represent the force-displacement characteristics of the soils are defined, and the site ground motion is modified to consider the geometric effects of the foundation system. These functions are applied to structure to determine the overall response. Appropriate analysis parameters shall be defined by a qualified geotechnical engineer.

6.3 Energy Dissipation and Seismic Isolation

6.3.1 Overview

Several devices are available to either absorb or reduce the kinetic energy introduced into a structure by an earthquake. These devices have been applied in both new and existing commercial buildings to meet stringent seismic performance requirements such as Immediate Occupancy or Operational levels. Although these devices may have limited applicability in Central Offices for structural and non-structural reasons, consideration should be given early in the design process for all new structures with Operational performance objectives to identify the feasibility and benefits of employing these concepts.

6.3.2 Passive Energy Dissipation

Description — Energy dissipation is a method of absorbing the kinetic energy introduced into a structure by an earthquake. All structures dissipate energy through deformation and damage. Passive energy dissipating devices are designed to concentrate deformation and energy dissipation in well behaved or sacrificial elements. Most passive energy dissipation devices are classified as either displacement-dependent or velocity-dependent, and are usually inserted in bracing systems or at other joints in a structural frame.

Displacement-Dependent Systems — The response of these systems is a function of the relative displacement between the ends of the dissipating devices. Displacement-dependent devices are typically based on yielding of metal or friction. An example of a yielding system is illustrated in Figure 6-1, where ductile steel inserts are designed to yield at a specific load and constructed into a concrete braced frame. An example of a friction system is illustrated in Figure 6-2, where a steel plate assembly in a bracing system is clamped together and designed to slip once a predetermined friction force is overcome.

Velocity-Dependent Systems — The response of these systems is a function of the relative velocity between the ends of the dissipating devices. An example of a velocity-dependent device includes a viscoelastic damper, which is inserted into a braced frame and operates by deforming a viscoelastic material (Figure 6-3). Viscous fluid dampers are also available, and operate by forcing a fluid through an orifice (Figure 6-4).

Considerations — The following considerations and requirements shall apply for all buildings which include passive energy dissipating systems:

- Passive energy dissipation shall only be considered for moment-resisting or braced frame buildings
- Appropriate linear and nonlinear analyses shall be performed as required by [Reference 2] to ensure adequate behavior of the system
- Energy dissipation devices shall be designed with consideration to environmental conditions including wind, aging effects, creep, fatigue, temperature, and exposure to moisture or damaging substances
- The mechanical properties of energy-dissipating devices shall be based on the results of physical testing
- An independent engineering review panel experienced in energy dissipation methods shall review the design of energy dissipation systems

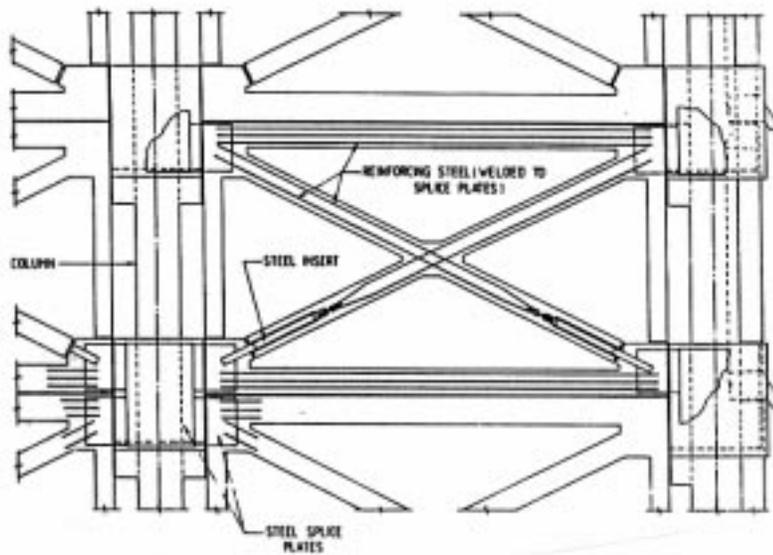


Figure 6-1. Concrete Braced Frame with Energy Dissipating Steel Inserts

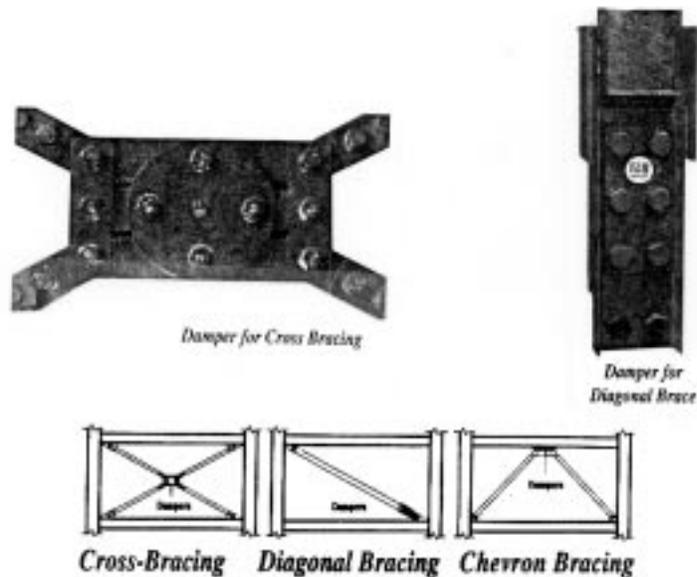


Figure 6-2. Examples of Friction Damping Devices for Energy Dissipation
(Illustrated Product Manufactured by Pall Dynamics, Montreal, QC,
Canada)

AT&T — PROPRIETARY
Use pursuant to Company Instructions

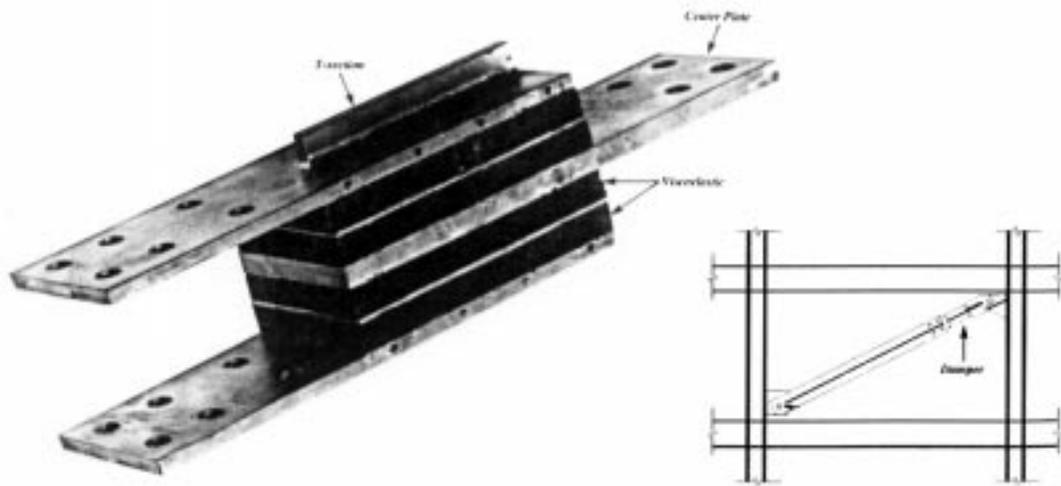


Figure 6-3. Example of Viscoelastic Damper for Energy Dissipation (Illustrated Product Manufactured by 3M, St. Paul, MN)

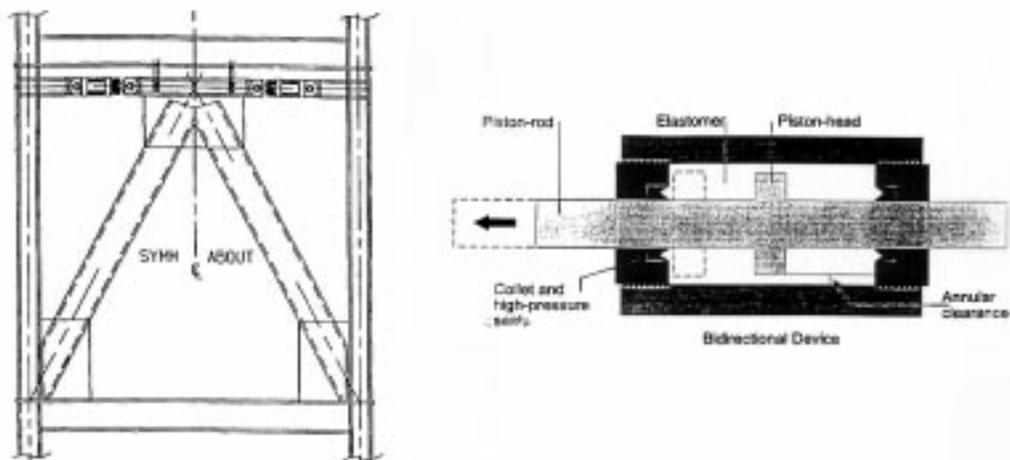


Figure 6-4. Example of Viscous Fluid Damper for Energy Dissipation (Illustrated Products Manufactured by Enidine Inc., Irvine, CA and Dynamic Isolation Systems, Lafayette, CA)

AT&T — PROPRIETARY
Use pursuant to Company Instructions

6.3.3 Seismic Isolation

Description — Seismic isolation is a method of limiting the kinetic energy introduced into a structure by an earthquake. This is achieved by decoupling the structure from the ground through the use of isolator devices installed between the superstructure and its foundation. Isolation significantly increases the fundamental period of the structure, thereby reducing resonance effects between the ground and building shaking. In so doing, the seismic forces generated in the building are reduced while the displacements across the plane of isolation are increased. Isolator devices are typically classified as either elastomeric or sliding, and are usually installed beneath columns and walls at the basement or first floor of a building (Figure 6-5).

Elastomeric Systems — Elastomeric isolators are typically made of layers of natural rubber separated by steel shims (Figure 6-6). In some cases, a lead core is installed to stiffen the isolator and absorb energy as the isolator displaces horizontally. The behavior of these devices is dependent on the properties of the materials which make up the isolator.

Sliding Systems — Sliding isolators are typically composed of bearings which slide on flat or curved steel surfaces. An illustration of a curved sliding system is provided in Figure 6-7, in which an articulated slider moves within a concave steel surface to create small pendulum motions of the supported structure. The movement of the slider generates a friction force which absorbs the energy of applied lateral loads. The behavior of these devices is dependent on the materials and geometry of the isolator.

Considerations — The following considerations and requirements shall apply for all seismically isolated buildings:

- Seismic isolation may be best suited for low-rise rigid structures on hard ground
- A rigid diaphragm is usually required immediately above the plane of isolation to ensure that all of the isolators in a building move in unison. Supports for the isolators must also be sufficiently rigid and strong. Accordingly, space requirements for the isolators and diaphragm may be significant and must be considered in the building design.
- The large relative movement which can occur across the plane of isolation must be considered in the design of all systems which intersect this plane.
- Appropriate linear and nonlinear analyses shall be performed as required by the UBC and [Reference 2] to ensure adequate behavior of the system
- Seismic isolation devices shall be designed with consideration to environmental conditions including wind, aging effects, creep, fatigue, temperature, and exposure to moisture or damaging substances
- The mechanical properties of seismic isolation devices shall be based on the results of physical testing

- An independent engineering panel experienced in seismic isolation shall review the design of the isolation system
-

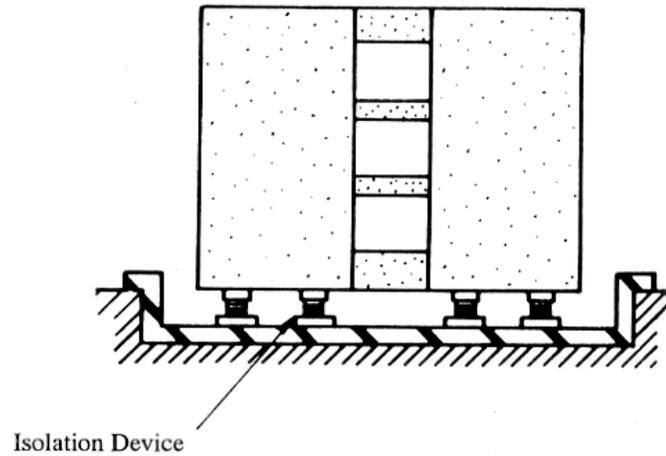


Figure 6-5. Idealized Elevation of a Base Isolated Building

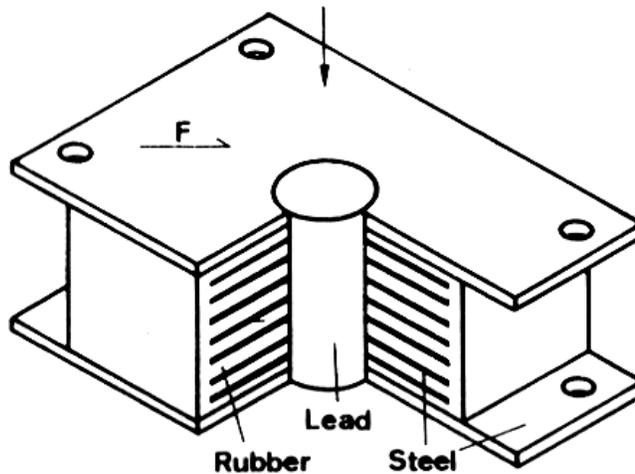


Figure 6-6. Elastomeric Lead-Rubber Isolation Device

AT&T — PROPRIETARY
Use pursuant to Company Instructions

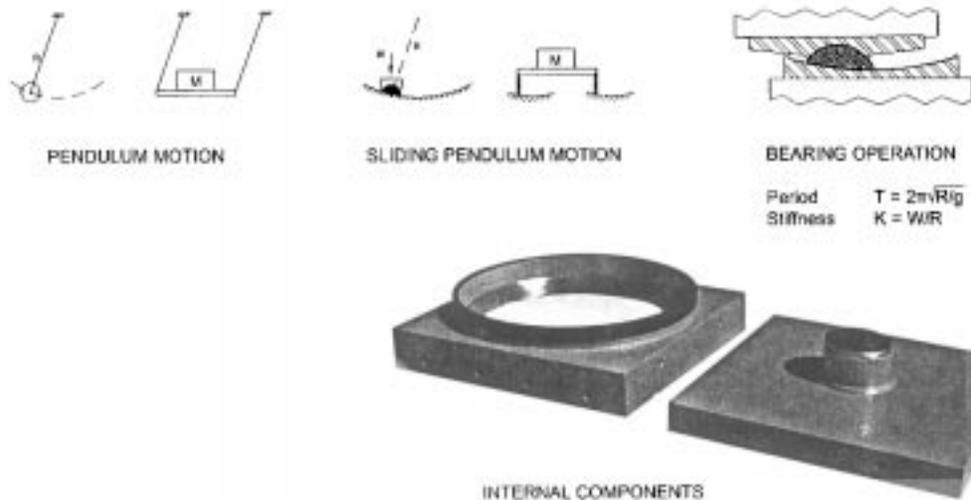


Figure 6-7. Friction-Pendulum[®] Sliding Isolator (Illustrated Product Manufactured by Earthquake Protection Systems, Inc., San Francisco, CA)

6.4 Building Instrumentation

6.4.1 Overview

Accelerometers are motion detecting and recording devices which measure the extent of ground and building shaking during strong earthquakes (Figure 6-8). These records are used by engineers and others to study the dynamic behavior of buildings and their contents when subjected to strong motion earthquakes. AT&T buildings in which accelerometers were deployed are shown in Figure 5-2. To augment this network, and to meet the requirements of the UBC, new buildings meeting certain criteria shall be instrumented as described in this section.

6.4.2 Deployment Requirements

In accordance with building code requirements, all new buildings in seismic zones 3 and 4 which are over six stories in height with an aggregate floor area of 60,000 square feet or more, or are over ten stories in height regardless of the floor area,

shall be provided with at least three earthquake motion recording accelerometers. These criteria shall apply to each independent structure at a site regardless of functional interdependence.

6.4.3 Responsibilities

The AT&T Building Engineer is responsible for coordinating the deployment and periodic maintenance of accelerometers in new buildings. This includes coordinating the involvement of other AT&T organizations, vendors, and specialty consultants as required.

6.4.4 Hardware Selection

The following description of the hardware presently deployed in AT&T buildings is provided as a guideline for future accelerometer hardware selection in new buildings:

- *Supplier:* Kinemetrics, Inc., 222 Vista Avenue, Pasadena, CA 91107 (818) 795-2220
- *Model:* SSA-2, which digitally records motion in three orthogonal directions
- *Triggering Sensitivity:* 0.01g
- *Recording Memory:* 10 minutes
- *Power Source:* 110/220 Vac
- *Remote Interrogation:* An external "smart" modem enables connection to designated telephone lines for remote interrogation of the instrument.
- *Unit Interconnection:* Cables which interconnect the instruments in a building provide simultaneous triggering during an earthquake. This feature is desirable but not necessary for adequate performance.
- *Protection:* Protection of the instrument is provided by steel cages anchored to the floor slab.

6.4.5 Instrument Positioning

Accelerometers shall be located in the basement, midportion, and near the top of each instrumented building. Each unit shall be positioned as close as possible to the center of mass of the building, which is typically near the geometric center of the floor area. To avoid recording local building vibrations, the instruments shall be mounted to the floor immediately adjacent to a building column, and shall not be located near oscillating equipment such as fans.

If possible, consideration should be given to providing an exterior instrument in lieu of the basement instrument to record the earthquake "free-field" motion of the ground surface. This unit must be located sufficiently far from structures and roads to avoid recording secondary vibrations, and must be mounted on a concrete pad with adequate weather protection.

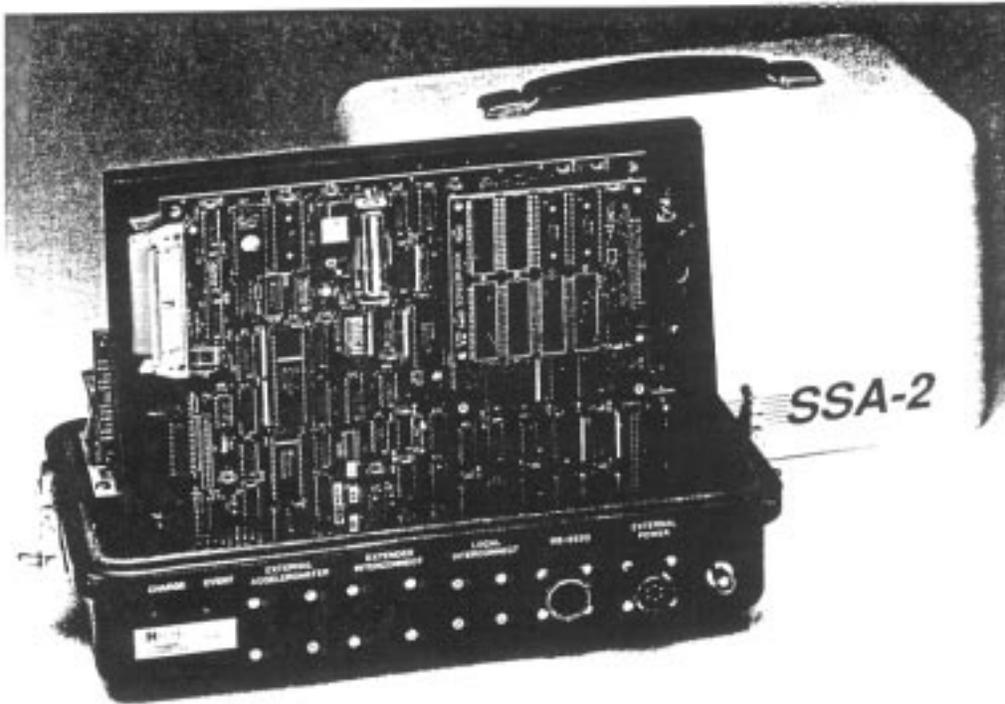


Figure 6-8. Instrument Deployed for AT&T's Existing Accelerometer Network

Foundations

7

Contents	Page
7.1 Overview	7-1
7.2 Foundation Types	7-1
7.2.1 Shallow Foundations	7-1
7.2.2 Deep Foundations	7-2
7.3 Design Considerations	7-4

Contents

Page

Foundations

7

7.1 Overview

Foundations must be adequately designed to ensure that forces can be safely transmitted between the structure and the soil during an earthquake. These forces include horizontal base shear, vertical overturning forces, and gravity loads. Inadequate foundation design can result in excessive settlements and significant building damage, especially to heavy rigid structures that cannot accommodate these movements. This section presents information concerning earthquake-resistant design of building foundations.

7.2 Foundation Types

7.2.1 Shallow Foundations

Description — Foundations which rely on near-surface soils for support are generally classified as shallow foundations. Shallow foundations, which include spread footings and mats (Figure 7-1 and Figure 7-2) resist vertical loads by bearing directly on the soil. Lateral resistance is provided by friction between the foundation and the soil, as well as passive pressure created when the foundation element pushes against surrounding soil.

Application — Concrete spread footings are often used to support columns which have light to moderate loads where the soil has adequate bearing capacity. Mat foundations are sometimes necessary, however, when the column loads are large and/or the soil has limited bearing capacity. Mats are also used to reduce the detrimental effects of differential settlement between columns.

7.2.2 Deep Foundations

Description — Deep foundations usually consist of piles or drilled piers which support a concrete pile cap beneath the columns of a building (Figure 7-3). Vertical loads are resisted by point bearing of the piles on competent soil and/or skin friction between the piles and the soil. Lateral resistance is usually provided by passive pressure created when the piles push against the soil.

Application — Earthquake vibrations can cause consolidation or liquefaction of soil (Section 1.2.3), resulting in building settlement. While stabilization of soil prior to construction can reduce the expected settlement, deep foundations can also provide adequate protection against settlement damage. Deep foundations are also used when near surface soils have inadequate bearing capacity to resist the applied loads, or when structural uplift anchorage is required.

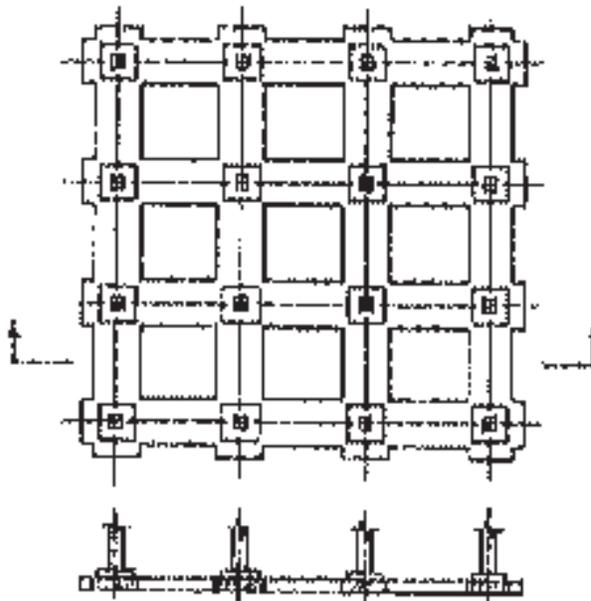


Figure 7-1. Spread Footing Foundation

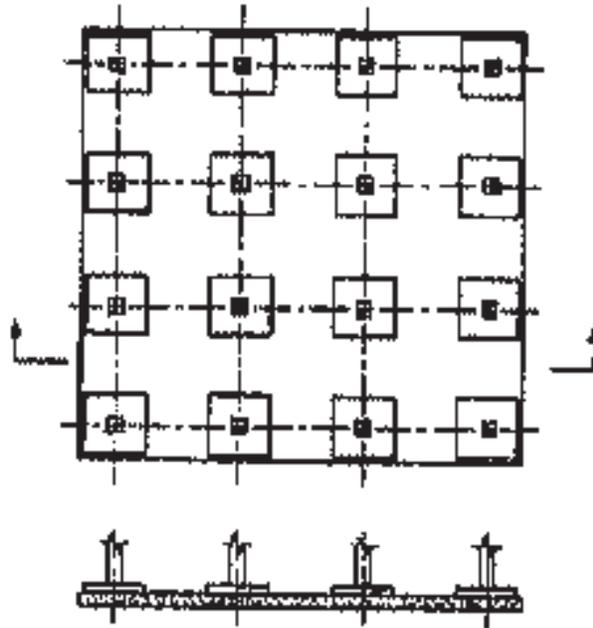


Figure 7-2. Mat Foundation with Grade Beams

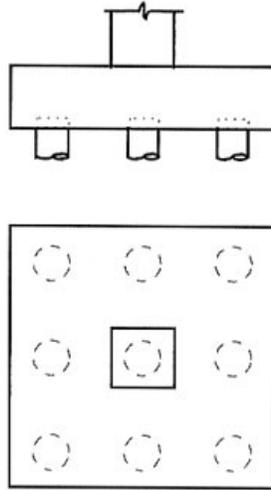


Figure 7-3. Typical Single Column Pile Cap

7.3 Design Considerations

Foundations shall be adequately analyzed and designed to satisfy strength requirements and to ensure that foundation deformation and settlement are consistent with the specified seismic performance objectives. Designs shall be in accordance with building codes enforced by the jurisdiction at the time of construction. Specific earthquake-resistant design considerations include the following:

Soil Bearing Pressures — Soil bearing pressures must be evaluated considering gravity loads as well as vertical seismic loads including overturning.

Liquefaction — The potential for liquefaction and the effect on the building foundation must be considered in the design (Section 2.1.4).

Grade Beams — Spread footings shall be interconnected with grade beams or slabs to limit differential movement between columns, unless deemed unnecessary by the project geotechnical engineer.

Pile and Pile Cap Reinforcement — Concrete piles shall have sufficient vertical and transverse reinforcement to ensure ductile behavior under axial, bending, and shear demands. Piles shall be well tied to pile caps through the use of steel reinforcement

Soil-Structure Interaction — In situations where the explicit consideration of soil-structure interaction is warranted, it should be performed in accordance with guidelines set forth in Section 6.2.2.

Concrete Structures

8

Contents	Page
8.1 Overview	8-1
8.2 Floor Diaphragms	8-1
8.2.1 Description	8-1
8.2.2 Design Considerations	8-2
8.3 Shear Walls	8-3
8.3.1 Description	8-3
8.3.2 Application	8-4
8.3.3 Design Considerations	8-4
8.4 Moment Frames	8-5
8.4.1 Description	8-5
8.4.2 Application	8-6
8.4.3 Design Considerations	8-6

Contents	Page
8.5 Precast Concrete	8-7
8.5.1 Description	8-7
8.5.2 Application	8-8
8.5.3 Design Considerations	8-8
8.6 Quality Assurance	8-8

Concrete Structures

8

8.1 Overview

Concrete has frequently been used in Central Office building construction for gravity support and lateral load resistance. This section describes important attributes for the seismic resistant design of concrete structural elements as they apply to Central Office building construction. This is intended to serve as a design guideline only and is not a building code. All design and detailing for new AT&T buildings shall conform to the requirements of building codes enforced by the jurisdiction at the time of permit application unless more stringent requirements are specified below.

8.2 Floor Diaphragms

8.2.1 Description

During an earthquake, inertial loads generated in a building must be transferred to lateral load resisting elements such as shear walls, moment frames, or braced frames. Concrete floor and roof slabs typically provide this load transfer mechanism by acting as horizontal diaphragms spanning between the walls or frames. Concrete floors shall be designed in accordance with AT&T 760-200-100, *Structural Floors*, to resist gravity loads per AT&T 760-200-020, *Design Loads for Telephone Buildings*, as well as seismic loads required by this section.

8.2.2 Design Considerations

Slab Irregularities — Floor slab irregularities, such as openings for stairs and elevators as well as reentrant building corners, are sources of concentrated stresses resulting in damage during earthquakes. Irregularities which must be present shall be carefully located and properly designed to minimize detrimental effects on structural performance (Figure 8-1). If possible, irregularities should be located in areas of limited shear stress demand and away from major seismic load resisting elements such as shear walls.

Cable Openings — Cable openings are a common slab irregularity in Central Offices and shall be designed in accordance with AT&T 760-200-032, *Cable Openings*. If possible, cable openings should be located in areas of limited lateral shear demand and away from major seismic load-resisting elements such as shear walls. Local reinforcement of the slab adjacent to the openings may be necessary for gravity as well as seismic resistance.

Construction Joints — Floor construction joints and connections to walls or frames must be properly detailed to ensure adequate force transfer during earthquakes.

Advanced Planning — Future floor uses shall be considered in the structural design to accommodate designated space allocation. In particular, potential power floors or other heavily loaded spaces as defined in AT&T 760-200-020, *Design Loads for Telephone Buildings*, shall be identified early in the design process to ensure that the structure is adequate to support the additional loads. In situations where the building construction is intended to be carried out in phases, the effects of future vertical and horizontal building expansion shall be considered, including the ability to extend the slab and support additional gravity and seismic loads placed on the slab due to changes in space allocation. It is important to note that accommodating future changes in space allocation during the initial design is significantly less costly than subsequent retrofitting.

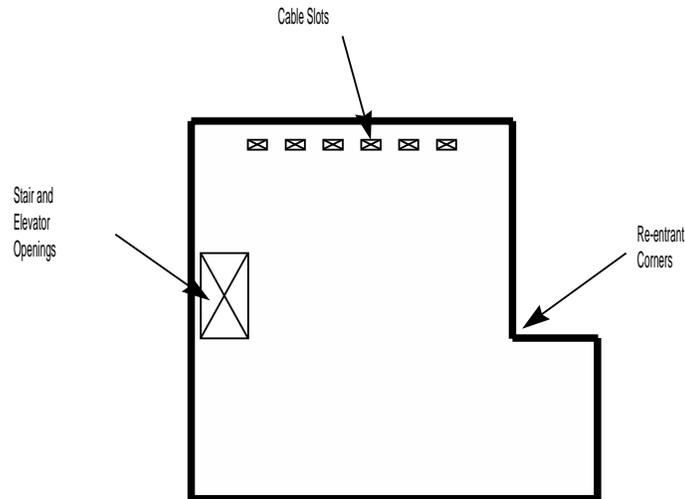


Figure 8-1. Typical Floor Diaphragm Irregularities

8.3 Shear Walls

8.3.1 Description

Reinforced concrete shear walls are often used to resist large lateral loads, and act as vertical cantilevers fixed at their base transferring forces down to the foundation. The performance of reinforced concrete shear wall buildings in earthquakes is highly dependent on the distribution and configuration of walls in the building, the size and number of wall openings, the steel reinforcing details, and the quality of construction.

8.3.2 Application

Shear walls are often used for seismic resistance in Central Office buildings for the following reasons:

- Shear walls can be efficiently designed to resist the large inertial forces induced by heavy building weights.
- High rigidity of shear walls can lead to reduced displacement and inter-story drift demands on conduits and ducts.

8.3.3 Design Considerations

Wall Location and Redundancy — Shear walls shall be located to maximize the symmetry and torsional resistance of the lateral load resisting system (Figure 2-4). The total area of wall at each floor should be maximized as much as is reasonable to ensure redundant capacity.

Irregularities — Shear walls shall be as uniform and continuous as possible between the building roof and foundation. Weak stories, soft stories, in-plane offsets, and out-of-plane offsets **shall not** be incorporated into shear wall designs (Figures 2-5 and 2-6).

Wall Openings — Wall openings for windows, doors, and equipment shall be positioned and designed to minimize their effect on the wall performance. It is preferable to minimize the number and size of openings, distribute openings as uniformly as possible, and reduce the horizontal and vertical alignment of openings which can lead to local stress concentration and damage in an earthquake (Figure 2-7).

Lightweight Concrete — Based on poor performance in past earthquakes, lightweight-aggregate concrete **shall not** be used for shear wall construction.

Aspect Ratio — Shear walls shall not have aspect (height to width) ratios which exceed 4.

Boundary Members — Vertical boundary reinforcement is generally required in areas of high compressive stress, usually near the base of the extreme ends of the wall, to improve the flexural resistance and overall seismic performance of the wall. Appropriate detailing and transverse confinement reinforcement is typically necessary to prevent concrete crushing and enhance wall ductility (Figure 8-2).

Construction Joints — Wall construction joints shall be properly detailed and adequately roughened and cleaned to ensure monolithic behavior under seismic loading.

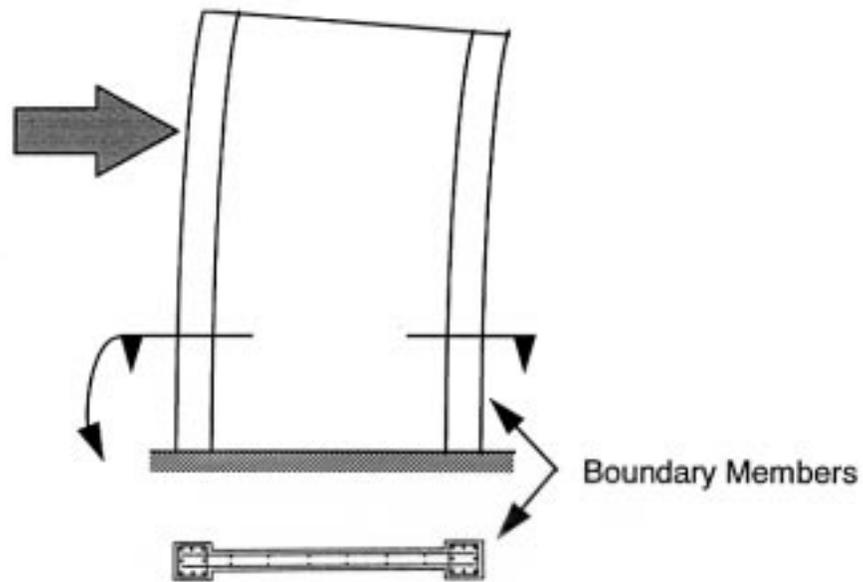


Figure 8-2. Shear Wall Boundary Members

8.4 Moment Frames

8.4.1 Description

Reinforced concrete moment frames consist of rigidly interconnected and specially designed beams and columns which resist lateral load through bending. Their performance is highly dependent on the detailing of the reinforcing steel in the members and joints, as well as the positioning and number of frames used in a building. Of particular importance is the transverse reinforcing or ties which are wrapped around the primary reinforcing steel to “confine” the concrete members and joints.

8.4.2 Application

Concrete moment frames have not been widely used as the primary lateral load resisting system in Central Office buildings located in active seismic zones since their relative flexibility can lead to increased displacement demands on equipment. Moment frames have been more commonly used in conjunction with shear walls to provide backup lateral load resistance in dual system buildings. Nevertheless, concrete moment frames may be used for primary or secondary lateral load resistance as long as all structural and nonstructural performance issues are addressed.

8.4.3 Design Considerations

Frame Location and Redundancy — Moment frames shall be located to maximize the symmetry and torsional resistance of the lateral load resisting system (Figure 2-4). Moment frames should also be designed and arranged to incorporate as many moment resisting connections as is reasonable to ensure redundant capacity.

Irregularities — Moment frames shall be as uniform and continuous as possible between the building roof and foundation. Weak stories, soft stories, in-plane offsets, and out-of-plane offsets **shall not** be incorporated into moment frame designs (Figures 2-5 and 2-6).

Failure Mode Control — Suppression of undesirable failure modes is critical to ensure moment frame ductility and reliable seismic performance. In particular, members and connections shall be properly detailed and confined in accordance with prevailing building codes to ensure ductile performance (Figure 8-3). Columns shall be designed to be stronger than beams in order to minimize the effect of earthquake damage on structural stability.

Splices — Particular attention should be paid to the location and length of longitudinal reinforcement splices in columns. Splices shall be staggered and located away from areas of high stresses such as at the base and top of columns. When reinforcement must be spliced in areas of high stresses, mechanical or welded splices shall be used.

Displacements — Due to their inherent flexibility, concrete moment frame buildings can undergo significant lateral displacements and inter-story drifts during earthquakes. The effect of these movements on structural and nonstructural components including equipment must be considered in the design.

Dual Systems — Concrete moment frames may be used in conjunction with shear walls to provide secondary resistance to lateral loads. The frame and shear wall shall resist the total lateral demand considering interaction and relative rigidity of the walls and frames. Additionally, the backup moment frame must be able to resist at least 25% of the total lateral load demand on the building.

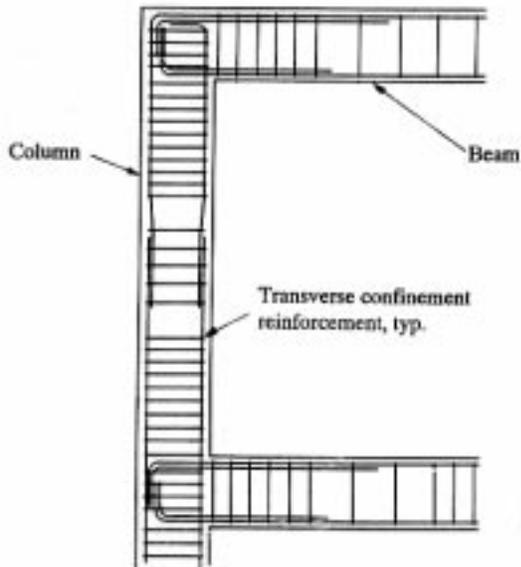


Figure 8-3. Typical Reinforcement of Concrete Moment Frame

8.5 Precast Concrete

8.5.1 Description

The performance of precast concrete elements is highly dependent on the detailing of the connections between members. These connections are usually made at the site and sometimes lack adequate strength and ductility to resist earthquake loads. To construct earthquake-resistant precast concrete elements, the design of the member must follow the rules of reinforced concrete construction and connections must be designed with care to provide adequate strength and ductility.

8.5.2 Application

Precast concrete has historically been used in Central Office buildings primarily for removable wall panels to facilitate future expansion. Until the building addition is constructed, however, these panels usually act as primary shear wall elements in the lateral load resisting system.

8.5.3 Design Considerations

Wall Panels — Removable wall panels shall be designed for seismic resistance if they act as primary shear wall elements at any time during the life of the building. Panel connections to floor slabs and adjacent panels should be designed to ensure adequate lateral load transfer. All wall panels, whether part of the lateral load resisting system or not, shall be designed for out-of-plane inertial forces induced during an earthquake.

Floor Systems — Buildings incorporating precast concrete floor systems shall be topped with a reinforced concrete topping slab to bond the precast units together and ensure monolithic behavior under earthquake loading.

8.6 Quality Assurance

Verification inspection and testing are essential to assuring good quality construction, and all inspection and reporting requirements of the local jurisdiction shall be adhered to. For concrete construction, the quality assurance program **shall include** the following:

- Review of reinforcement steel mill certificates.
- Visual inspection of the placement of reinforcement and concrete.
- Visual inspection of construction joint roughening and cleanliness.
- Physical tests including slump tests during concrete placement and cylinder tests to verify concrete compressive strength.
- Visual inspection of reinforcing steel welding.

Masonry Structures

9

Contents	Page
9.1 Overview	9-1
9.2 Shear Walls	9-2
9.2.1 Description	9-2
9.2.2 Application	9-2
9.2.3 Design Considerations	9-2
9.3 Infill Walls	9-3
9.3.1 Description	9-3
9.3.2 Application	9-3
9.3.3 Design Considerations	9-3
9.4 Quality Assurance	9-4

Contents

Page

Masonry Structures

9

9.1 Overview

Good seismic design and construction practice limits the use of concrete block and clay brick masonry only to walls rather than other structural elements. Masonry shall be used only in combination with reinforcement steel. Caution must be exercised when used in seismic load resisting members for the following reasons:

- Masonry is inherently brittle
- Masonry is relatively heavy and rigid, yet may possess limited strength to resist large inertial earthquake forces
- Construction quality may be difficult to control
- Less favorable performance during past earthquakes has been noted in masonry construction.

Proper design and construction quality control of masonry are essential to ensure adequate earthquake performance. This section describes important attributes for the seismic resistant design of masonry structural elements as they apply to Central Office building construction. This is intended to serve as a design guideline only and is not a building code. All design and detailing for new AT&T buildings shall conform to the requirements of building codes enforced by the jurisdiction at the time of permit application unless more stringent requirements are specified below.

9.2 Shear Walls

9.2.1 Description

Reinforced masonry shear walls are often used for low to mid-rise buildings for lateral resistance. The performance of masonry shear wall buildings in earthquakes is highly dependent on the distribution and configuration of walls in the building, the size and configuration of wall openings, the steel reinforcing details, and the quality of construction.

9.2.2 Application

Seismic resistance in AT&T buildings may be provided by adequately designed and detailed reinforced masonry shear walls. The high rigidity of shear wall construction generally provides reduced displacements and interstory drifts resulting in reduced demands on conduits and ducts relative to other lateral load resisting systems such as moment frames.

9.2.3 Design Considerations

Wall Location and Redundancy — Shear walls shall be located to maximize the symmetry and torsional resistance of the lateral load-resisting system (Figure 2-4). The total area of wall at each floor should be maximized as much as is reasonable to ensure redundant capacity.

Irregularities — Shear walls shall be as uniform and continuous as possible between the building roof and foundation. Weak stories, soft stories, in-plane offsets, and out-of-plane offsets **shall not** be incorporated into shear wall designs (Figures 2-5 and 2-6).

Wall Openings — Wall openings for windows, doors, and equipment shall be positioned and designed to minimize their effect on wall performance. It is preferable to minimize the number and size of openings, distribute openings as uniformly as possible, and reduce the horizontal and vertical alignment of openings which can lead to local stress concentration and damage in an earthquake (Figure 2-7).

Materials — Reinforced hollow concrete blocks shall be used in lieu of clay bricks in lateral load resisting systems.

Aspect Ratio — Reinforced masonry shear walls shall not have aspect (height to width) ratios which exceed 3.

Boundary Members — Vertical boundary reinforcement is generally required in areas of high compressive stress, usually near the base of the extreme ends of the wall, to improve the flexural resistance and overall seismic performance of the wall. Appropriate detailing and transverse confinement reinforcement is typically necessary to prevent masonry crushing and enhance wall ductility (Figure 9-1).

Construction Joints — Construction joints shall be properly detailed and adequately roughened and cleaned to ensure monolithic behavior under seismic loading.

9.3 Infill Walls

9.3.1 Description

Masonry walls are sometimes used to infill reinforced concrete or steel frames to create exterior walls or interior partitions. Infill walls must either be completely separated from the frame or fully integrated with the frame (Figure 9-1). A separated infill does not participate in lateral load resistance, but is instead isolated from the frame with a gap sufficient to allow frame deformation. An integrated infill participates in lateral load resistance by limiting the deformation of the frame and increasing the stiffness, strength, and energy-dissipation capacity of the building. Adequate seismic performance depends not only on the proper design and detailing of the structural frame (Section 8.4 and Section 10.2), but also on the proper detailing of the masonry infill.

9.3.2 Application

Masonry infill walls have been used in some older Central Office buildings to provide lateral load resistance. Infill walls which participate in lateral load resistance in new buildings shall be designed as shear walls in accordance with applicable codes.

9.3.3 Design Considerations

Wall Isolation — Infill walls which are not intended to participate in lateral load resistance must be adequately separated from the frame with a gap sufficient to allow frame deformation.

Wall Location — Infill walls intended to participate in lateral load resistance shall be located to maximize the symmetry and torsional resistance of the lateral load-resisting system (Figure 2-4). Infill walls shall not introduce structural irregularities as described in Section 9.2.3.

Failure Mode Control — Infill walls intended to participate in lateral load resistance must be adequately designed to preclude premature shear, crushing, or sliding failure. The frame must also be designed considering any supplemental loads placed on the beams, columns, or connections by the action of the infill.

Out-of-Plane Wall Support — All masonry infill walls, whether integrated with or separated from the lateral load resisting system, shall be adequately connected to the floor slabs and frames to preclude out-of-plane collapse of the infill panel during an earthquake.

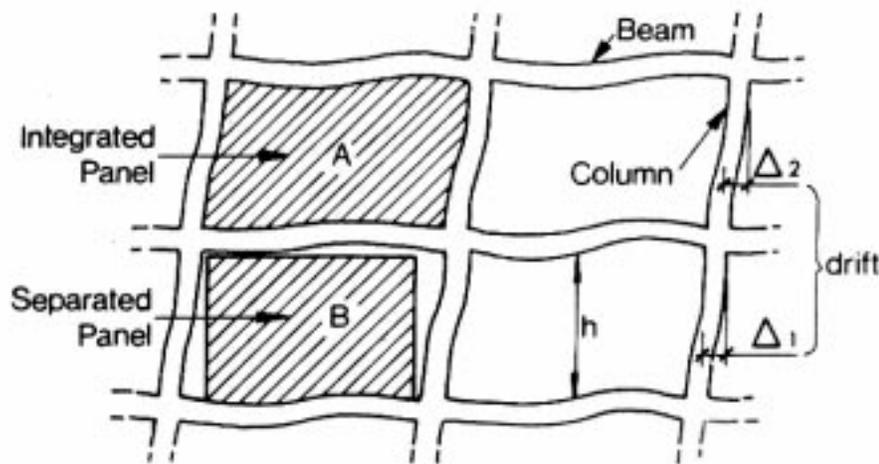


Figure 9-1. Integrated and Separated Infill Wall Panels

9.4 Quality Assurance

In order to ensure adequate quality of construction, more supervision is generally required for reinforced masonry than for other materials. The quality assurance program shall meet all inspection and reporting requirements of the local jurisdiction, and **shall include** the following:

- Review of reinforcement steel mill certificates.
- Visual inspection of masonry unit, reinforcement, and grout placement. Proper consolidation of grout is particularly important.

- Visual inspection of grout spaces and construction joints to ensure adequate treatment and cleanliness.
- Physical testing of grout specimens.

Steel Structures

10

Contents	Page
10.1 Overview	10-1
10.2 Moment Frames	10-2
10.2.1 Description	10-2
10.2.2 Application	10-2
10.2.3 Design Considerations	10-2
10.3 Braced Frames	10-5
10.3.1 Description	10-5
10.3.2 Application	10-5
10.3.3 Design Considerations	10-5
10.4 Quality Assurance	10-7

Contents

Page

Steel Structures

10

10.1 Overview

While steel has been frequently used in Central Office building construction for gravity support, its use as the primary lateral load resisting system has been historically limited. This is primarily due to the inherent flexibility of steel frame systems, resulting in larger lateral displacements and interstory drift demand on conduits and ducts relative to concrete or masonry shear wall systems. Nevertheless, steel may be used for primary lateral load resistance depending on the function, size, and location of the building. This section describes important attributes for the seismic resistant design of steel elements as they apply to Central Office building construction. This is intended to serve as a design guideline only and is not a building code. All design and detailing for new AT&T buildings shall conform to the requirements of building codes enforced by the jurisdiction at the time of construction unless more stringent requirements are specified below.

10.2 Moment Frames

10.2.1 Description

Steel moment frames consist of rigidly interconnected beams and columns which resist lateral load through bending. The interconnection between beams and columns has typically been accomplished by directly welding and/or bolting the elements together.

Prior to the 1994 Northridge, California, Earthquake, welded steel moment frame structures were considered to be among the most reliable type of construction for earthquake resistance. Following this earthquake, however, fractures were discovered in welded connections of several hundred buildings in the Los Angeles area (Figure 10-1). To date, a number of factors have been identified as potential causes of the damage, including poor quality control, the use of welding materials with low toughness, wide variations in steel strength, and basic problems with the configuration of the welded joint. In response, design and construction practice for steel moment frames have been revised to improve seismic performance. Current practice includes moving inelastic action away from the column face through local reinforcement of the beam-column joint (Figure 10-2).

10.2.2 Application

As described in Section 10.1, steel frames have not often been used for primary lateral load resistance in Central Office buildings. Moment frames have more commonly been used in conjunction with shear walls to provide backup lateral load resistance in dual system buildings. Nevertheless, steel moment frames may be used for primary or secondary lateral load resistance as long as all structural and nonstructural performance issues are addressed.

10.2.3 Design Considerations

Frame Location and Redundancy — Moment frames shall be located to maximize the symmetry and torsional resistance of the lateral load resisting system (Figure 2-4). The moment frames should also be designed and arranged to incorporate as many moment-resisting connections as is reasonable to ensure redundant capacity.

Irregularities — Moment frames shall be as uniform and continuous as possible between the building roof and foundation. Weak stories, soft stories, in-plane offsets, and out-of-plane offsets **shall not** be incorporated into moment frame designs (Figures 2-5 and 2-6).

Failure Mode Control — Suppression of undesirable failure modes is critical to ensure moment frame ductility and reliable seismic performance. In particular, moment frames should be designed to preclude rupture of connections, and columns shall be designed to be stronger than beams in order to minimize the effect of earthquake damage on structural stability.

Connections — Moment frame connections must be carefully designed and constructed to ensure adequate seismic performance. Guidelines specified in [Reference 24] shall be followed for welded connections unless more current design information and guidelines are available. Bolted moment-resisting connections may be warranted in light of the problems encountered with welded connections.

Displacements — Due to their inherent flexibility, steel moment frame buildings can undergo significant lateral displacements and interstory drifts during an earthquake. The effect of these movements on structural and nonstructural components including equipment must be considered in the design.

Dual Systems — Steel moment frames may be used in conjunction with shear walls or braced frames to provide secondary resistance to lateral loads. The frame and shear walls or braced frames shall resist the total lateral load demand considering interaction and relative rigidity of the walls and frames. Additionally, the backup moment frame must be able to resist at least 25% of the total lateral load demand on the building.

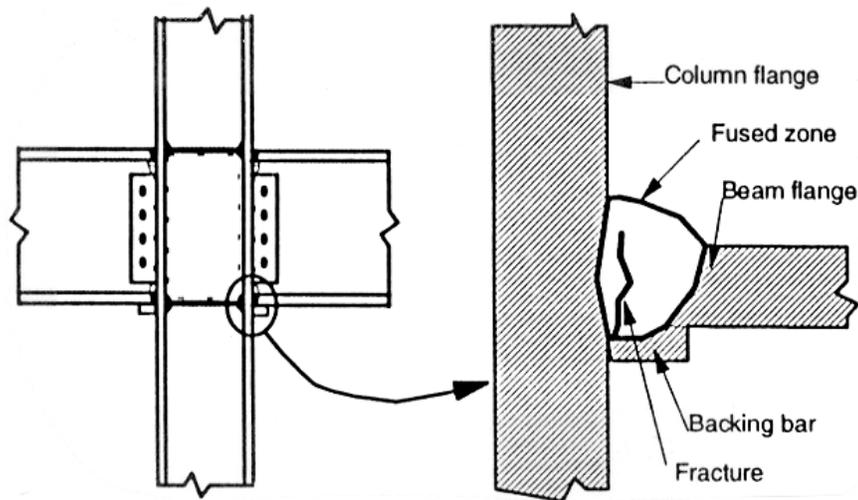


Figure 10-1. Typical Fracture of Welded Beam-column Joint During the 1994 Northridge Earthquake

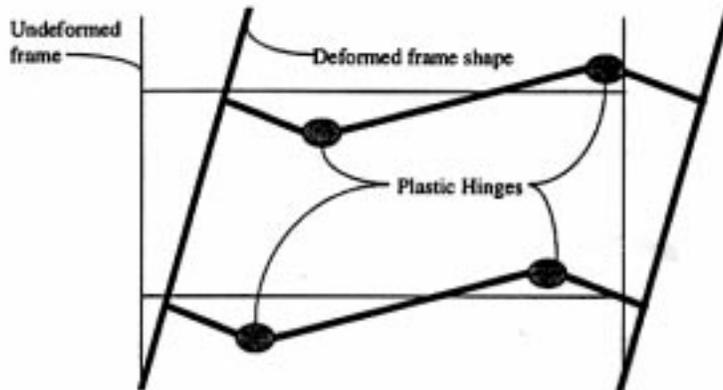
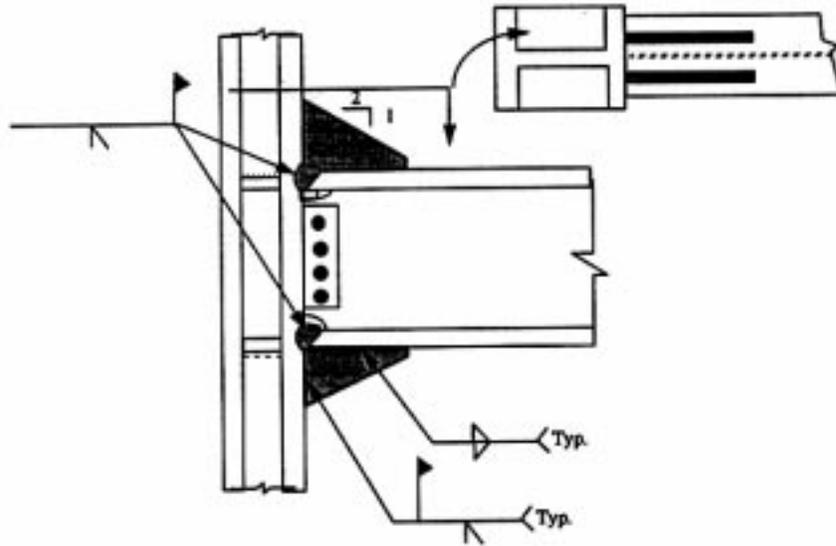


Figure 10-2. Connection Reinforcement is Necessary for Welded Beam-column Moment Frame Connections to Move Inelastic Action (plastic hinges) Away from the Face of the Column.

AT&T — PROPRIETARY
Use pursuant to Company Instructions

10.3 Braced Frames

10.3.1 Description

Diagonally braced frames are generally classified as either concentrically or eccentrically braced depending on the triangulation of the braces. Concentrically braced frames are composed of braces which intersect beam-column joints or a single point on a beam, and resist lateral loads through tension and compression of the braces (Figure 10-3). Eccentrically braced frames incorporate eccentricities in the brace configuration which induce small controlled amounts of bending into the framing. The framing and braces are designed to perform without failure, and the resulting behavior provides enhanced stiffness and energy dissipation capacity (Figure 10-4).

10.3.2 Application

Steel braced frames may provide adequate lateral resistance in Central Office buildings, particularly for low to mid-rise structures, due to their increased rigidity relative to moment frames, as well as their adequate past record of seismic performance.

10.3.3 Design Considerations

Frame Location and Redundancy — Braced frames shall be located to maximize the symmetry and torsional resistance of the lateral load resisting system (Figure 2-4). The arrangement of braced frames shall incorporate as much redundant capacity as is reasonable into the lateral load resisting system.

Irregularities — Braced frames shall be as uniform and continuous as possible between the building roof and foundation. Weak stories, soft stories, in-plane offsets, and out-of-plane offsets **shall not** be incorporated into braced frame designs (Figures 2-5 and 2-6).

Failure Mode Control — Suppression of undesirable failure modes is critical to ensure reliable seismic performance. In particular, braced frames should be designed to preclude rupture of connections and premature buckling of braces.

Brace Configuration — Several patterns of concentric braced frames are common (Figure 10-3). These include diagonal “X” or “Z” bracing, which intersect opposite beam-column joints in a frame, as well as chevron “V” or “^” bracing, which intersect the middle of beams. Of these systems, the diagonal “X” or “Z” systems are preferred for seismic resistance. Knee or “K” bracing, which intersects the middle of columns, is not allowed for seismic resistance since they can induce large stresses in the columns and thus affect structural stability.

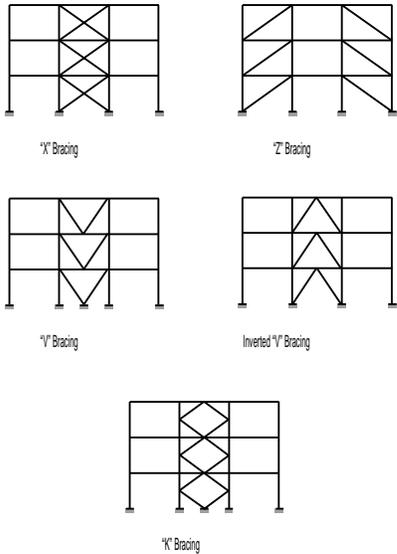


Figure 10-3. Concentric Braced Frame Configurations

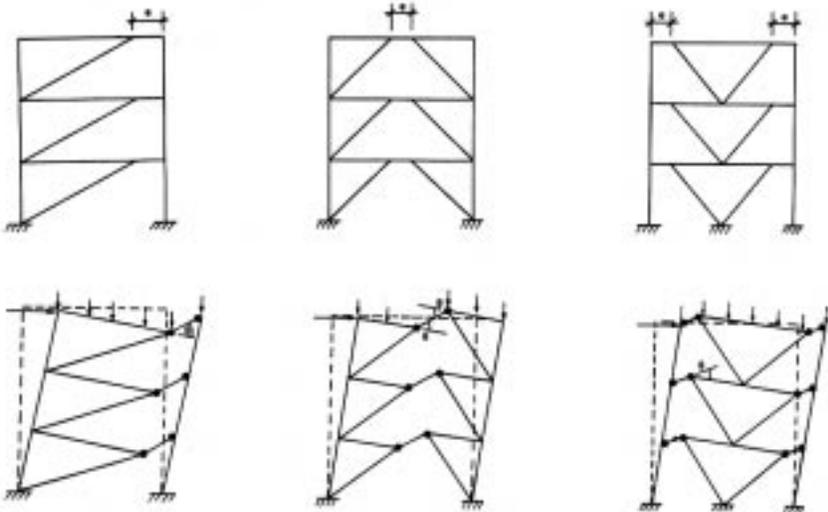


Figure 10-4. Eccentric Braced Frame Configurations and Deformation Under Lateral Load

AT&T — PROPRIETARY
Use pursuant to Company Instructions

10.4 Quality Assurance

Verification inspection and testing are essential to assuring good quality construction, and all inspection and reporting requirements of the local jurisdiction shall be followed. For steel construction, the welding quality assurance program **shall include** the following:

- Welding inspectors and welders shall be certified by The American Welding Society (AWS) and, if required, by the local jurisdiction.
- Welding Procedure Specifications, as required by AWS, shall be submitted by the contractor for review by the engineer. The procedures shall be available at the site for use by the welders and inspectors to ensure that welding is performed in accordance with approved parameters (i.e. amperage, voltage, travel speed, pre- and post-heat temperature, etc.).
- Welds shall be inspected visually as required by the local jurisdiction
- All complete and partial joint penetration welds shall be inspected ultrasonically
- Magnetic particle testing of each weld layer is required for particularly critical welds, or for welds which are not suitable for ultrasonic testing.

Architectural Components

11

Contents	Page
11.1 Overview	11-1
11.2 Design Considerations	11-1
11.2.1 Ceilings	11-1
11.2.2 Partitions	11-2
11.2.3 Fenestrations	11-3
11.2.4 Cladding and Veneers	11-3
11.2.5 Elevators	11-3
11.2.6 Stairs	11-3
11.2.7 Light Fixtures	11-4

Contents

Page

Architectural Components

11

11.1 Overview

Damage to architectural components during an earthquake can present significant hazards due to falling debris. Accordingly, the use of unnecessary ornamental features **shall be** minimized in building design, particularly in equipment environments, in order to minimize the associated seismic risk. Architectural components which are deemed necessary in new buildings must be adequately designed to resist seismic forces and displacements. In general, ensuring that components remain intact and attached to the structure will minimize hazards associated with falling debris. Design considerations for common architectural items found in Central Office buildings are provided below. All architectural items installed in active seismic zones shall be designed in accordance with applicable building codes and standards of practice.

11.2 Design Considerations

11.2.1 Ceilings

Ceiling systems, including those directly attached to the structure as well as those suspended below the structure by wires or other means, require adequate bracing, attachments, and edge details to resist the accelerations and displacements induced by an earthquake [Reference 11] and [Reference 12]. Surface applied

ceiling finishes generally perform well as long as the supporting structure does not excessively crack or adhesive does not fail. Suspended ceiling systems are generally more susceptible to damage, and must be well braced to minimize horizontal and vertical movement (Figure 11-1). Additionally, adequate clearance around ceiling penetrations such as smoke detection heads, light fixtures, and air distribution vents is necessary to accommodate movements.

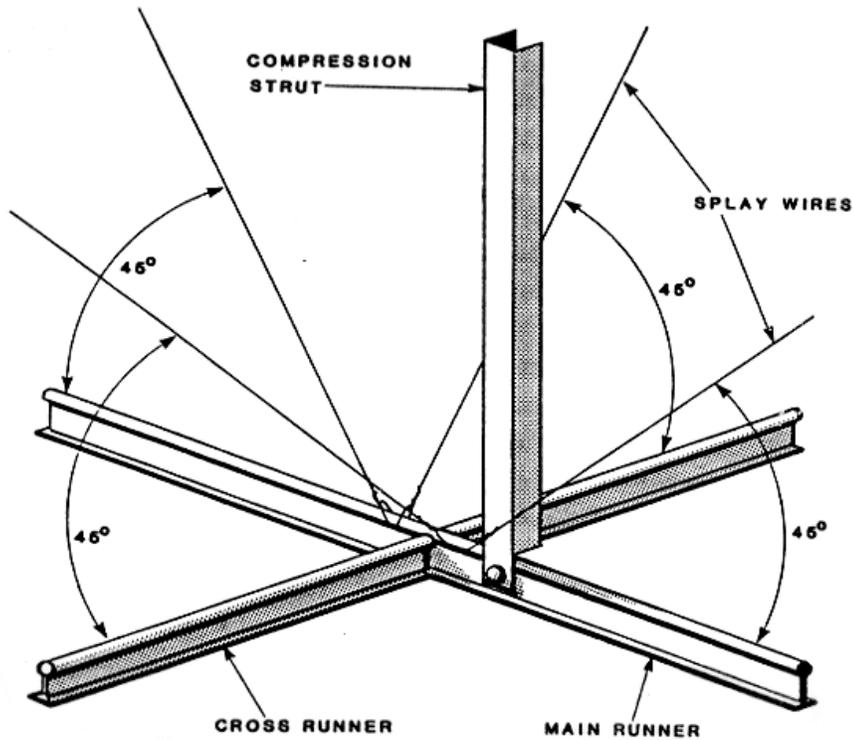


Figure 11-1. Seismic Bracing of a Suspended Ceiling

11.2.2 Partitions

Partitions which are attached to a ceiling system and all partitions greater than 6 feet in height shall be designed to resist forces generated by an earthquake, including out-of-plane bracing between the top of the wall and the building structure. This bracing shall be independent of bracing required for ceiling systems. Partitions constructed of masonry or concrete shall be reinforced as required to resist seismic loads, and shall be adequately separated from the building structure to prevent unintended interaction with the structural response (See Section 9.3).

11.2.3 Fenestrations

Breakage of glass in an earthquake can present a significant life safety hazard. Accordingly, appropriate clearance around glass or window sashes is necessary to minimize the potential for glass breakage. Laminated glass or plexiglass shall be used in any fenestrations located along emergency egress routes.

11.2.4 Cladding and Veneers

To minimize potential hazards due to falling objects, non-structural precast concrete cladding and curtain walls shall be adequately anchored to the structure. Specially designed flexible connections shall be used to accommodate the structural response. Brittle or heavy veneers, such as tile, glass, and stone, shall not be applied on any lateral load resisting walls unless adequate mechanical connectors are provided. In any case, brittle or heavy veneers shall not be used along emergency egress routes.

11.2.5 Elevators

Typical elevator damage in an earthquake includes counterweight or cab derailment, equipment sliding, and damage to the elevator shaft. All elevators and elevator shafts in active seismic zones shall be designed to preclude significant damage. Particular attention should be paid to the anchorage of counterweight and elevator cab rails, as well as the anchorage of elevator equipment.

Additionally, seismic controls shall be provided in all elevators in seismic zones 3 and 4 [Reference 1].

11.2.6 Stairs

To enable safe egress from a building following an earthquake, it is of particular importance to minimize earthquake damage to stairs and stair enclosures. Stair shafts which may participate in lateral load resistance must be considered in the overall structural evaluation and analysis and adequately designed to resist tributary seismic loads. Stair shafts which are independent of the building must have independent lateral support to resist induced seismic loads as well as adequate separation to reduce or eliminate structural interaction between the stair and the building. Stair enclosure materials shall be carefully selected and designed to minimize falling debris which could inhibit emergency egress. For example, the use of Fibermesh fibers in concrete for stair walls has the beneficial effect of minimizing falling hazards due to spalled concrete.

11.2.7 Light Fixtures

Light fixtures, including those which are recessed in ceilings, surface mounted to ceilings and walls, supported within a suspended ceiling system, or suspended from ceilings or a structure, shall be adequately anchored to prevent loss of support during an earthquake. Consideration must be given not only to the anchorage and bracing of the fixture itself, but also to the seismic integrity of the wall or ceiling which provides the support. Particular attention must be paid to the anchorage of emergency light fixtures to preclude failure during an earthquake due to loss of support or impact from falling debris.

Equipment Protection

12

Contents	Page
12.1 Overview	12-1
12.2 Seismic Loading	12-1
12.2.1 Basic Principals	12-1
12.2.2 General Design Method	12-2
12.2.3 Site-Specific Design Method	12-5
12.3 Design Considerations	12-5
12.3.1 Factors of Safety	12-5
12.3.2 Equipment Location	12-5
12.3.3 Rigidly Mounted Equipment	12-5
12.3.4 Base Isolated Equipment	12-6
12.3.5 Ducts, Pipes, and Conduits	12-7
12.3.6 Equipment Support Pads	12-8
12.3.7 Concrete Anchorage	12-9
12.3.8 Wall Penetrations	12-9
12.3.9 Equipment Certification	12-10

Contents

Page

Equipment Protection

12

12.1 Overview

Adequate seismic protection of equipment is of primary importance in meeting the performance objectives described in Section 3. Survival of fire and life safety systems is necessary for all buildings to meet Life Safety performance objectives. Adequate seismic protection of other critical infrastructure equipment is necessary to enhance network reliability in accordance with the Operational performance objectives and the AT&T hazard management strategy. This section addresses seismic load requirements for mechanical and electrical infrastructure equipment, and presents considerations for equipment protection design. It is important to note that detailed design guidelines for earthquake bracing of various critical mechanical and electrical infrastructure equipment items are not provided in this section. Equipment protection methods shall be designed by qualified structural or systems engineers in accordance with the provisions of this section.

12.2 Seismic Loading

12.2.1 Basic Principals

Equipment response during an earthquake depends not only on the weight and dynamic properties of the equipment, but also on the location of the equipment within the building and the building's response to the earthquake ground motion.

The magnitude of horizontal acceleration and corresponding lateral force demand generally increases as equipment is located higher up the building. Additionally, lateral forces imposed on equipment with natural vibrational frequencies similar to the building's natural vibrational frequencies will tend to be amplified due to resonant response. Equipment seismic performance depends on the ability of internal equipment components, support framework, and anchorage to resist seismic loads. Fortunately, most infrastructure equipment items are inherently rugged and can survive earthquake motions as long as they are adequately anchored.

12.2.2 General Design Method

Design Basis — The design accelerations presented in this section are based on the approach described in [Reference 10] and [Reference 21]. The following parameters have been considered in the development of the presentation format:

- The variation in design accelerations between seismic zones is based on a median hazard expected for each zone, assuming a site composed of stiff soil.
- A nominal level of energy absorption capacity is assumed.
- Design accelerations are appropriate for critical mechanical and electrical infrastructure equipment which is essential to life safety and network systems.

For sites located in close proximity to active faults (i.e. less than 5 miles) or sites composed of vulnerable or weak soils, design accelerations for equipment anchorage shall be developed based on a site specific hazard assessment per Section 5.3.

Equipment Frequency — Equipment design loads are determined considering the rigidity of the equipment and equipment supports. In general, equipment with a fundamental frequency greater than about 15 Hz is considered to be rigid and have limited dynamic amplification during an earthquake. Equipment with a fundamental frequency less than 15 Hz is considered to be flexible, and subject to response amplification due to resonance with the structure. Natural vibration frequencies for various equipment items should be established by appropriate tests and obtained from the equipment manufacturers. In the absence of this information, equipment shall be deemed rigid or flexible in accordance with Table 12-1.

Table 12-1. Equipment Rigidity

Rigid or Rigidly Attached Equipment	Flexible or Flexibly Attached Equipment
Nonvibration isolated equipment (HVAC, generators, etc.)	Vibration isolated equipment (HVAC, generators, etc.)
Electrical cabinets (MCC, switchgear, etc.)	Cooling towers
Elevator components	Piping systems
Storage tanks	Bus ducts, conduits, cable trays
Light fixtures	Stacks

Horizontal Acceleration — The horizontal acceleration which shall be considered for equipment protection design depends on the seismic zone (Section 1.1.2), equipment rigidity, and location within the building. Design horizontal accelerations are provided in Figure 12-1 and Figure 12-2 for rigid and flexible equipment, respectively. The specified accelerations shall be applied at the equipment center of gravity and assumed to act in any horizontal direction.

Vertical Acceleration — In addition to the horizontal acceleration, equipment at all elevations shall be designed to resist a simultaneously applied vertical acceleration equal to one half of the horizontal acceleration for similar equipment at grade level.

Relative Displacements — Systems which traverse across structural separations between adjacent buildings or have points of attachment which are subject to relative movement shall be designed to accommodate this movement. The magnitude of relative horizontal displacements between adjacent buildings can be determined by means of appropriate relative displacement analyses [Reference 9]. In the event such analyses are not available, the minimum magnitudes of the relative horizontal displacements between adjacent buildings, in both directions, shall be assumed to be equal to 4% of the height above grade.

Modification Factors — The design accelerations presented above may be modified as appropriate in the following manner:

- Accelerations **shall be doubled** if brittle or buckling failure modes are expected.
- If materials and detailing are sufficiently ductile, design accelerations may be reduced only if substantiated by physical testing performed in accordance with Bellcore NEBS requirements [Reference 9].
- Accelerations **shall be doubled** for lighting fixtures.
- Accelerations may be reduced to 70% of the specified values only if the equipment is not essential to life safety or network systems
- Accelerations may be reduced to 50% of the specified values for bus ducts, conduits, and cable trays.
- Accelerations at grade level are appropriate for below grade equipment.

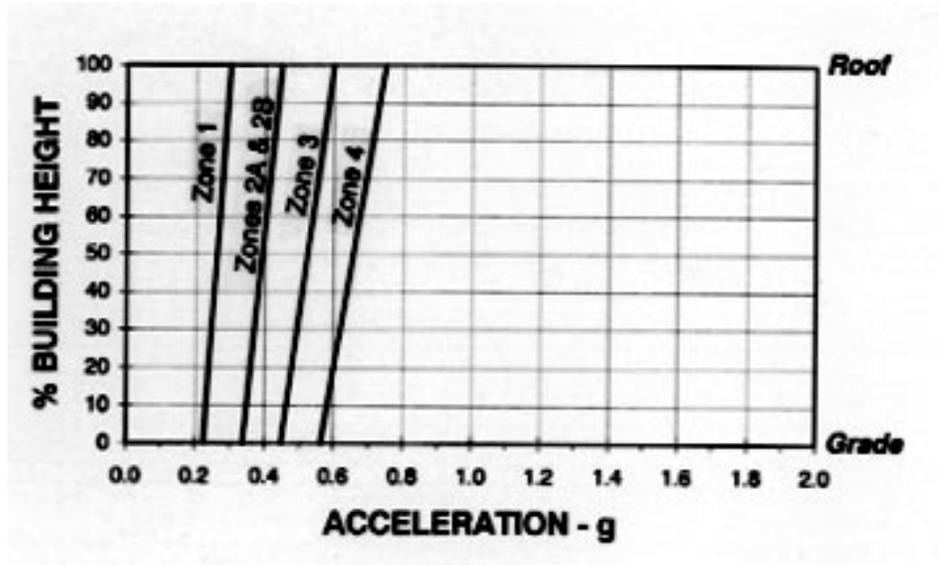


Figure 12-1. Horizontal Design Accelerations for Rigid or Rigidly Attached Equipment (first fundamental frequency > 15 Hz)

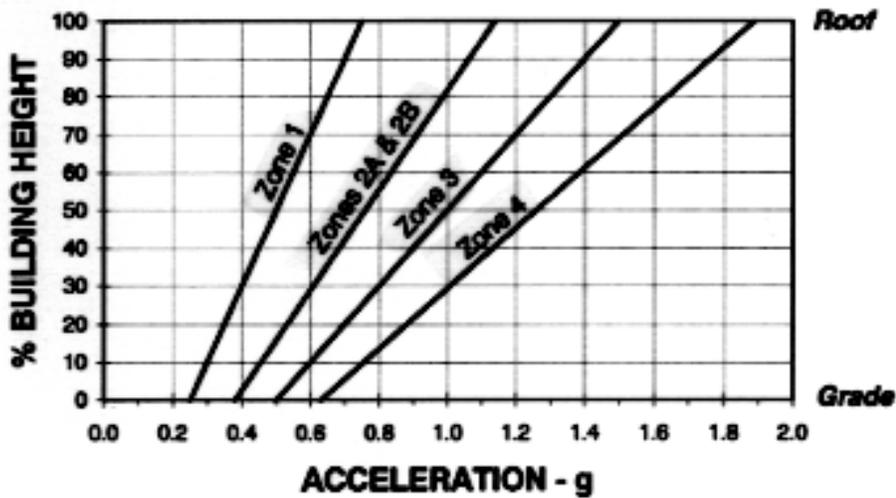


Figure 12-2. Horizontal Design Accelerations for Flexible or Flexibly Attached Equipment (15Hz)

12.2.3 Site-Specific Design Method

Floor response spectra developed for the building may be used in lieu of the general approach described in Section 12.2.2 if the properties of the building and equipment, as well as the characteristics of the earthquake ground motion, are appropriately considered in determining the amplification at the point where the equipment is located (see Section 5.3). In this case, equipment ductility and overstrength may be considered through the use of appropriate factors in accordance with [Reference 10].

12.3 Design Considerations

12.3.1 Factors of Safety

Equipment, supports, and anchorage must be designed to resist the loads specified in Section 12.2 assuming adequate load and resistance factors of safety. For example, in designing drilled expansion or epoxy anchors, the combined consideration of the appropriate load and resistance safety factors results in an effective allowable capacity equal to 25% of the anchors' ultimate capacity. Appropriate factors of safety for other materials shall be selected in accordance with UBC requirements.

12.3.2 Equipment Location

As illustrated in Figure 12-1 and Figure 12-2, the magnitude of horizontal acceleration and corresponding lateral force demand on equipment increases with height up the building. Accordingly, it is desirable from a future damage and cost benefit viewpoint to locate critical equipment below grade or at the lowest floor possible.

12.3.3 Rigidly Mounted Equipment

Rigidly mounted equipment generally has high natural frequencies of vibration, and need to be well anchored and braced to resist sliding and overturning forces. Consideration must be given not only to the support anchorage, but also to the ability of the equipment enclosures to resist the loads (Figure 12-3).



Figure 12-3. Typical Anchorage for Rigidly Mounted Equipment

12.3.4 Base Isolated Equipment

Equipment which vibrates under normal use is often supported by base isolation devices such as springs to minimize the transmission of vibration to the structure. Base isolated equipment generally has lower natural frequencies of vibration relative to rigidly mounted equipment, which may often be in the frequency range subject to amplification during earthquake motion. Accordingly, base isolation should be used primarily in situations where operational requirements make its use beneficial or necessary. In such situations, equipment protection shall be designed to resist the amplified seismic forces. Seismic “snubbers” are commonly used to resist seismic loads on base isolated equipment. Snubbers afford freedom of

movement under normal operations while restricting movements during an earthquake (Figure 12-4). Snubbers or restrained isolator devices shall be designed to resist the loads defined in Section 12.2.

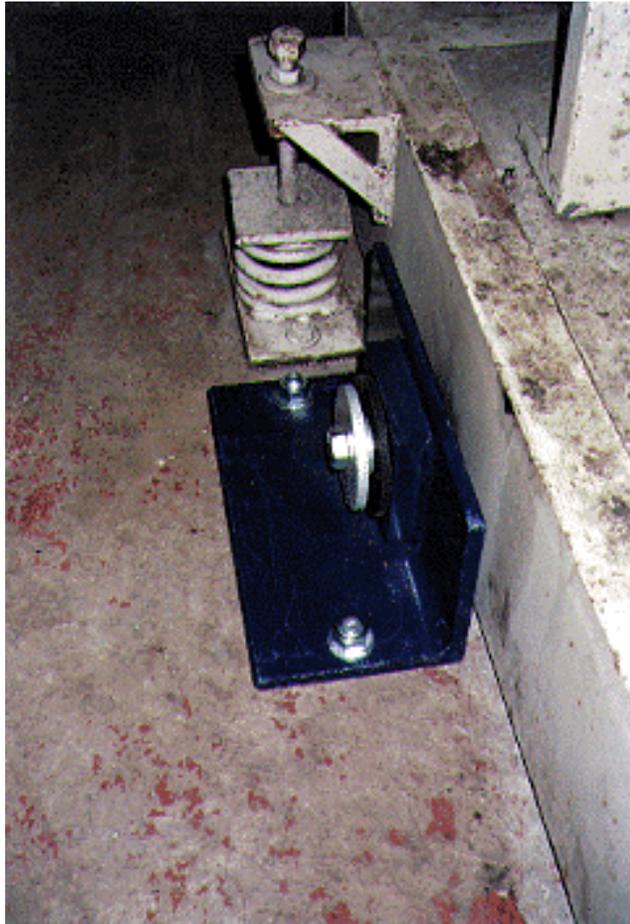


Figure 12-4. Typical Seismic Snubber for Base Isolated Equipment

12.3.5 Ducts, Pipes, and Conduits

Adequate seismic protection of ducts, pipes, and conduits includes the installation of appropriately spaced anchorage and braces for transverse, longitudinal, and vertical load resistance. Systems such as water pipes **shall not** be installed above critical equipment to preclude collateral damage due to pipe leakage or rupture. Ducts, pipes, and conduits **shall not** be routed in spaces between adja-

cent buildings unless sufficient separation is provided to prevent damage due to impact (Section 2.3). Systems **shall not** traverse across building separations unless adequate flexibility is incorporated to accommodate relative movement (Figure 12-5).



Figure 12-5. Fire Sprinkler Pipe Expansion Joint at a Structural Separation

12.3.6 Equipment Support Pads

Infrastructure equipment is often mounted on top of precast support pads. It is important to ensure that the support pads are designed to transfer the loads into the building structure. This includes doweling of concrete mechanical pads to the supporting floor slabs, as well as adequately designing steel support frames and bracing systems.

12.3.7 Concrete Anchorage

Anchorage into concrete is generally made through the use of embedded anchor bolts cast into the concrete, as well as expansion or epoxy anchors installed in holes drilled into hardened concrete. The use of concrete anchors may require consideration of the following:

- Floor slabs often have limited thickness which limits the embedment available for concrete anchorage. The available embedment shall be considered in the selection of concrete anchors to ensure that the loads are adequately resisted.
- Holes which are drilled in floor slabs or walls should generally not be drilled within about 2 inches of the concrete member opposite surface to avoid damaging the surface.
- When drilling holes in existing floor slabs or walls, care shall be taken to minimize damage to reinforcing steel. The use of a pachometer to determine the location of embedded reinforcing steel is recommended.
- Anchors installed in lightweight concrete elements may have a reduced strength relative to similar anchors installed in normal weight concrete. In the absence of test results, the capacity of anchors installed in lightweight concrete shall not be greater than 75% of the capacity of similar anchors installed in normal weight concrete.
- To verify construction quality, at least 25% of concrete expansion or epoxy anchors shall be tension tested to a proof load of twice the allowable tension capacity. The percentage of anchors to be tested may be increased or decreased at the discretion of the engineer depending on the quality of construction demonstrated through testing. Nevertheless, the percentage of anchors to be tested shall not be less than 10%.

12.3.8 Wall Penetrations

Wall penetrations for equipment, such air intake and exhaust, shall be carefully placed considering the effect of the opening on the seismic performance of the building. It is generally beneficial to position wall penetrations around the building's perimeter in a balanced manner. Likewise, it is beneficial to minimize the horizontal and vertical alignment of openings. The walls around openings shall incorporate appropriate local reinforcement to minimize damage.

12.3.9 Equipment Certification

Prior to acceptance of critical infrastructure equipment for installation in AT&T buildings, appropriate supporting documentation for the equipment seismic performance must be provided. Such documentation may consist of calculations and/or test results acceptable to AT&T. In all cases, documents submitted must meet or exceed requirements imposed by local jurisdictions.

Cost Considerations

B

Contents

Page

13.1 Overview

13-1

Contents

Page

Cost Considerations

13

13.1 Overview

Several variables influence the cost premium associated with earthquake resistant design, including the following:

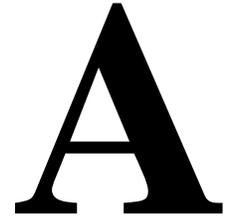
- **Regional seismicity** — Increased earthquake hazards are translated into higher design loads which in turn require the construction of stronger and more compliant buildings.
- **Desired building performance** — Higher performance standards are typically required for critical facilities as compared to standard buildings.
- **Structural complexity** — Complex building shapes typically require special framing patterns to achieve adequate performance.
- **Construction type** — The cost of achieving adequate seismic performance can be substantially affected by the choice of construction materials.
- **Building size** — Earthquake forces largely increase with building size, requiring a corresponding increase in the force resisting measures.
- **Phased construction** — Occasionally, new buildings must be constructed as additions to existing structures which may not meet adequate earthquake protection standards. In such situations the need to upgrade previously constructed buildings may have marked cost effects.

The actual cost premium for achieving adequate seismic resistance may vary depending upon the particulars at hand. However, the cost premium for providing earthquake protection is likely to range from 5% to 15% of the total nonseismic construction cost (excluding equipment). The upper end of this cost range is

associated with critical buildings in high seismic zones which have high Operational performance objectives. The lower end of this cost range is associated with buildings in low seismic zones which are required to meet Life Safety performance objectives.

It is important to note that the costs associated with providing earthquake protection in new buildings are in general significantly lower than the cost of rehabilitating existing buildings to achieve the same performance objectives.

Related Standards



This appendix lists the related standards referenced through out this document.

- AT&T 760-100-020, *Selection of Building Sites for Central Offices.*
- AT&T 760-200-020, *Design Loads for Telephone Buildings..*
- AT&T 760-200-024, *Enhancement of Earthquake Safety for Existing Buildings.*
- AT&T 760-200-032, *Cable Openings.*
- AT&T 760-200-040, *Floor and Ceiling Anchors.*
- AT&T 760-200-041, *Equipment Support.*
- AT&T 760-200-050, *Mechanical Design Standards.*
- AT&T 760-200-100, *Structural Floors.*
- AT&T 760-200-110, *Procurement Requirements for the Raised Seismic Access Floor (SAFloor) System for NSD Equipment Locations.*
- AT&T 800-610-155, *Earthquake and Disaster Bracing for Central Office Equipment General Equipment Requirements.*
- AT&T 801-900-160, *Network Equipment Development Standards (NEDS) Generic Requirements.*
- Bellcore GR-63-CORE, *Network Equipment - Building Systems (NEBS) Requirements: Physical Protection, Issue 1, October 1995.*

References

B

This appendix lists the related documents referenced through out this document.

1. American Society of Mechanical Engineers, *Safety Code for Elevators and Escalators*. ASME A17.1, 1993.
2. Applied Technology Council, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*. Federal Emergency Management Agency Report No. 273, Washington, D.C. 1996.
3. Applied Technology Council, *Rough Draft, Product 1.2, Recommended Methodology for Seismic Evaluation and Retrofit of Existing Buildings for the Seismic Safety Commission, Sacramento, California*, ATC Report No. 40, Redwood City, California, 1995.
4. AT&T 760-100-020, *Selection of Building Sites for Central Offices*.
5. AT&T 760-200-020, *Design Loads for Telephone Buildings*.
6. AT&T 760-200-032, *Cable Openings*.
7. AT&T 760-200-100, *Structural Floors*.
8. AT&T 801-900-160, *AT&T Network Equipment Development Standards (NEDS) Generic Requirements*.
9. Bellcore, *Network Equipment-Building System (NEBS) Equipment Requirements: Physical Protection*. Issue 1, Bellcore GR-63-CORE, October 1995.

10. Building Seismic Safety Council, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings*. Federal Emergency Management Agency, Report Nos. FEMA 222A (Provisions) and FEMA 223A (Commentary), Washington, D.C., 1995.
11. Ceilings and Interior Systems Construction Association (CISCA), *Recommendations for Direct-Hung Acoustical Tile and Lay-In Panel Ceilings. Seismic Zones 0-2*, 1991.
12. Ceilings and Interior Systems Construction Association (CISCA), *Recommendations for Direct-Hung Acoustical Tile and Lay-In Panel Ceilings. Seismic Zones 3-4*, 1990.
13. City of Riverside, California, *General Plan and Seismic Safety Element*. 1984.
14. Dowrick, D.J., *Earthquake Resistant Design for Engineers and Architects, 2nd Edition*. John Wiley & Sons, 1977.
15. Frankel, A., et al, *Interim National Seismic Hazard Maps*. U.S. Geological Survey, Denver, Colorado, January 1996.
16. Freeman, S.A., A Review of Practical Approximate Inelastic Seismic Design Procedures for New and Existing Buildings. *Proceedings of the 64th SEAOC Annual Convention*, pp. 311-331, Indian Wells, California, 1995.
17. Hamburger, R.O., et al. Vision 2000: A Framework for Performance Based Engineering of Buildings. *Proceedings of the 64th SEAOC Annual Convention*, pp. 127-145, Indian Wells, California, 1995.
18. Hamilton, R. M. et al. Tecumseh's Prophecy, *Preparing for the Next New Madrid Earthquake*. United States Geological Survey Circular 1066, 1990.
19. Harvey, S., *AT&T NCS Infrastructure Segmentation Strategy*, May 21, 1996.
20. Hyndman, R.D., Giant Earthquakes of the Pacific Northwest. *Scientific American*, pp. 68-75, December 1995.
21. International Conference of Building Officials, *Uniform Building Code*. Whittier, California, 1994.
22. NEHRP Provisions Update Committee, *Proposals 8-1 and 8-10 for Revisions to 1997 NEHRP Sections 3.1.3 and 3.3.2*. Building Seismic Safety Council, Washington, D.C., October 1996.
23. Nilson, A.H. and Winter, G.W., *Design of Concrete Structures, 11th Edition*. McGraw-Hill Book Company, 1991.
24. SAC Joint Venture, *Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment Frame Structures*. Federal Emergency Management Agency Report No. 267, August 1995.

25. Shedlock, K.M. and Pakiser, L.C., *Earthquakes*. U.S. Geological Survey - National Earthquake Information Center, Denver, Colorado, 1996.
26. Structural Engineers Association of California, Seismology Committee, *Recommended Lateral Force Requirements and Commentary, 6th Edition*. Sacramento, California, 1996.
27. Town of Los Gatos, California, *General Plan*. 1985.
28. Wakabayashi, M., *Design of Earthquake Resistant Buildings* McGraw-Hill Book Company, 1986.
29. Working Group on California Earthquake Probabilities, *Probabilities of Large Earthquakes Occurring in California on the San Andreas Fault*. United States Geological Survey Open File Report 88-398, 1988.
30. Working Group on California Earthquake Probabilities, *Probabilities of Large Earthquakes Occurring in the San Francisco Bay Region, California*. United States Geological Survey Circular 1053, 1990.

Glossary

A

Accelerometer

Device which measures and records the motion of the structural element to which it is mounted.

ATC

Applied Technology Council

Attenuation

Change in ground motion as it propagates away from the earthquake source.

AWS

American Welding Society

B

Base Shear

The total lateral force or shear at the base of a structure.

C

Capacity

The permissible strength or deformation of a structural member.

CDMG

California Division of Mines and Geology

Confinement

Closely spaced spiral, closed stirrup, or hoop reinforcement to restrain concrete in directions perpendicular to the applied load.

D

Damping

Forces which act to reduce structural vibrations. Structural damage is a source of damping in earthquakes.

Demand

The amount of force or deformation imposed on an element.

Diaphragm

A horizontal structural element used to distribute lateral forces to vertical elements of the lateral force resisting system.

Dynamic

Loading and structural response which varies with time.

E

Elastic

Ability of a structural member to return to its original size after an applied load is removed.

F

FEMA

Federal Emergency Management Agency

H

Hazard Level

Earthquake shaking demands of a specified severity, determined on either a probabilistic or deterministic basis.

I

Inelastic

Permanent deformation of a structural member resulting from an applied load.

Inter-story Drift

The relative horizontal displacement of two adjacent floors in a building.

L

Lateral Force Resisting System

Those elements of the structure that provide its basic lateral strength and stiffness, and without which the structure would be laterally unstable.

Liquefaction

An earthquake-induced process in which saturated, loose, granular soils lose a substantial amount of shear strength as a result of increased pore water pressure during earthquake shaking.

Linear

Linear relationship between an applied load and structural deformation. The load to displacement ratio (stiffness) is constant.

N

NEHRP

National Earthquake Hazards Reduction Program

Nonlinear

Nonlinear relationship between an applied load and structural deformation. The load to displacement ratio (stiffness) is not constant.

P

Peak Ground Acceleration

The maximum ground acceleration at a site during an earthquake, usually expressed as a percentage of gravity.

Performance Objectives

An expression of the desired building performance in the event that the building is subjected to earthquake demands of a specified severity.

R

Return Period

The average period of time, in years, between the expected occurrence of an earthquake of specified severity.

Redundancy

Quality of having alternative paths in the structure by which the lateral forces are resisted, allowing the structure to remain stable following the failure of an element.

Response Spectrum

A plot calculated from an earthquake ground motion record that gives values of peak structural response as a function of the structural natural period of vibration.

Rigidity

The ability of a structure or element to resist loads without deformation. Also referred to as *stiffness*.

S

Soft Story

Story which has a lateral rigidity significantly less than the story above.

Static

Loading and structural response which do not vary with time.

Strength

The maximum axial force, shear force, or moment that can be resisted by a structural element.

T

Time History

Plot of ground motion or structural response as a function of time.

U

UBC

Uniform Building Code

USGS

United States Geological Survey

Y

Yield Point

Maximum load which can be applied to an element without causing permanent deformation.

How Are We Doing?

Document Title: _____

Document Number: _____ Issue Number: _____ Issue Date: _____

AT&T welcomes your feedback on this document. Your comments can be of great value in helping us to improve our documentation.

1. Please rate the effectiveness of this document in the following areas:

	Excellent	Good	Fair	Poor	Not Applicable
Ease of Use					////////////////////
Clarity					////////////////////
Completeness					////////////////////
Accuracy					////////////////////
Organization					////////////////////
Appearance					////////////////////
Examples					////////////////////
Illustration					////////////////////
Overall Satisfaction					////////////////////

2. Please check the ways you feel we could improve this document:

- | | |
|--|---|
| <input type="checkbox"/> Improve the overview/introduction | <input type="checkbox"/> Make it more concise/brief |
| <input type="checkbox"/> Improve the table of contents | <input type="checkbox"/> Add more step-by-step procedures/tutorials |
| <input type="checkbox"/> Improve the organization | <input type="checkbox"/> Add more troubleshooting information |
| <input type="checkbox"/> Include more figures | <input type="checkbox"/> Make it less technical |
| <input type="checkbox"/> Add more examples | <input type="checkbox"/> Add more/better quick reference aids |
| <input type="checkbox"/> Add more detail | <input type="checkbox"/> Improve the index |

3. Please provide details for the suggested improvement. _____

4. What did you like most about this document?

5. Feel free to write any comments below or on an attached sheet.

If we may contact you concerning your comments, please complete the following:

Name: _____ Telephone Number: (____) _____

Company/Organization: _____ Date: _____

Address: _____

When you have completed this form, please fold, tape, and return to address on back or Fax to: (508) 960-6851.

----- Do Not Cut — Fold Here And Tape -----



Please
Place
Stamp
Here

AT&T
NM&PQ Documentation Management District
ATTN: Documentation Manager
30-MZB-40
1600 Osgood Street
N. Andover, MA 01845