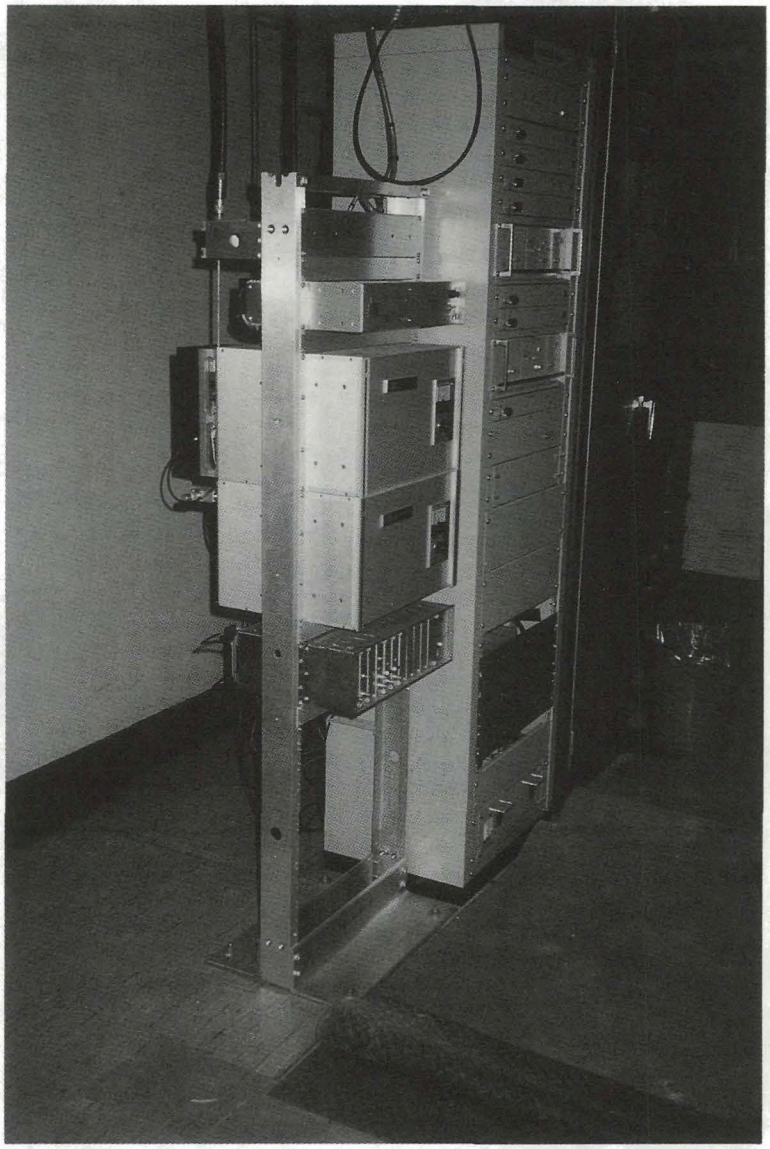

Figure 14.14 Typical equipment found at a cell site.

MOBILE TELEPHONE EXCHANGE

The MTX is the counterpart of a CO in the PSN. Several cell sites are connected to the MTX and it will be connected to a CO so that it serves as a link between the wireless network and the PSN. The MTX equipment is essentially the same as that found in a CO. The equipment racks, switch and transmission equipment, battery plant and engine-generator look the same and perform the same functions.

Figure 14.15 Wireless cell antenna mounted on lattice-type structure.

SUBSCRIBER EQUIPMENT

Subscriber equipment has rapidly evolved in the last few years. Early units weighed as much as 10 pounds and they could almost fill a lunch box. Today units weigh 10 oz. and can be carried in a shirt pocket. Units operate on batteries and can operate four to six hours on a single charge. These units require special battery packs, so that flashlight batteries cannot be used in the units. Spare battery packs are available. In general, subscribers can use the automobile cigarette lighter outlet with a special cable and adapter to recharge their batteries. As the units are designed to be carried around, they are physically rugged.

RADIO SYSTEM COMPONENTS AND SUBSYSTEMS

The radio system can be considered as an extremely small scale and simplified wireless network. It consists of base stations (similar to cell sites), antenna (including tower), and handsets. The handsets communicate with the base station and with each other through the base station or directly to each other. The base station is usually co-located with the tower. Equipment is operated on commercial power. Battery backup and/or emergency power generator backup may be used by

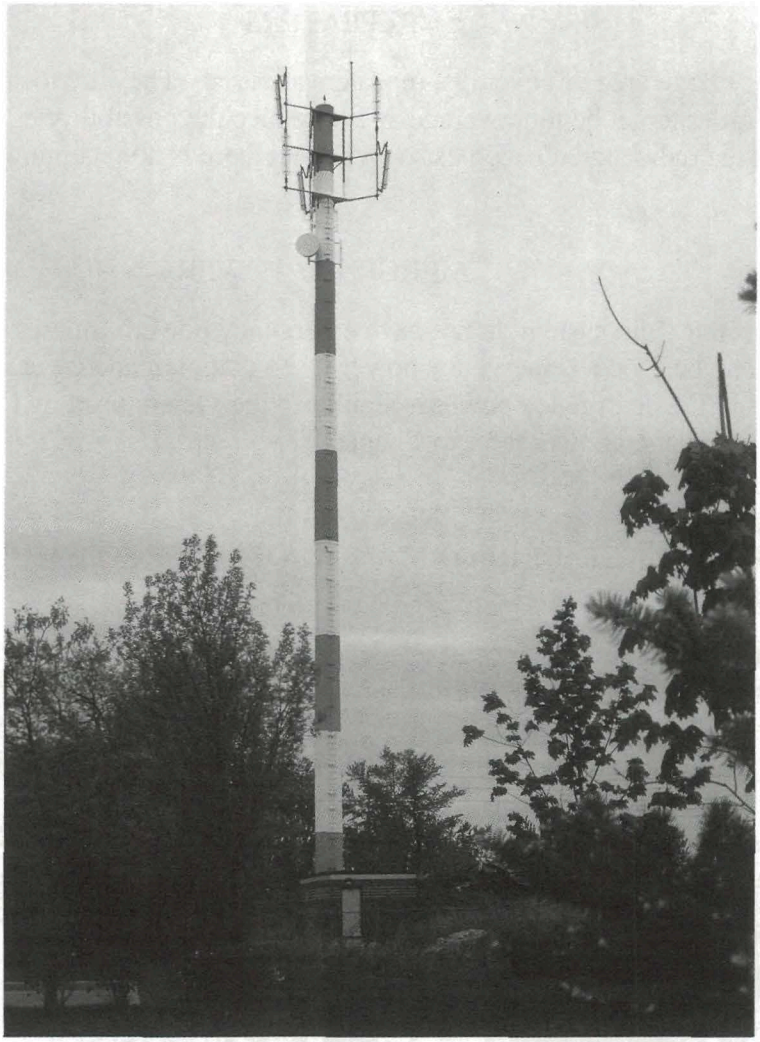

Figure 14.16 Wireless cell antenna mounted on steel mast.

critical operations such as police, fire station, and hospitals. In large service areas or in areas with hilly terrain, repeaters are typically used.

BASE STATION

The size of the equipment used in a base station depends on the area of coverage and the frequency band. Normally a base station will not have more than two cabinets of transmission and receiving units. There is no specific requirement in terms of power supply. Most of the equipment used can run on normal residential power sources.

ANTENNA

The antenna is usually a single mast mounted on a steel pole on roof top. Only very large system has its own tower.

REPEATERS

For very large area of coverage, repeaters are used. They are located on higher ground in order to get better coverage and to reduce the possibility of blind spots (areas that the radio signal becomes so weak that there is no reception).

EMERGENCY POWER

Most of the radio system do not have emergency power. Small gas powered generator can be used as emergency power when commercial power is out. For the large system, the emergency power is similar to the system used by COs. For details of emergency power refer to Chapter 17.

EARTHQUAKE PERFORMANCE OF TELECOMMUNICATION SYSTEMS

The earthquake performance of telecommunication equipment has been very good. Modern equipment has performed well if it was properly anchored. The main problem has been with circuit packs (circuit boards), which are not positively locked in to their card cages, coming loose. There have been many failures of cable trays. While overloading has contributed to these problems, there have been failures associated with cast-iron, cast-in-place rod hanger supports. Movement of suspended cable trays have also damaged cables entering or leading the tray when inadequate slack was provided. There have been a large number of different problems with emergency power, both battery and engine-generator systems. There have been a number of problems with roof-mounted HVAC systems. In addition to the loss of function, water leaks have cause secondary problems.

Additional information regarding earthquake performance of telecommunication systems is provided in Reference 1.

EMERGENCY RESPONSE PROCEDURES

Every company has the responsibility to develop its own emergency response program. These plans should include personnel protection, restoration procedures, emergency response drills, officer notification, central planning center, and coordinated efforts with other companies and emergency agencies. The plans must be shared with all company personnel and each person must understand their roles in case of disaster. Companies normally have services available 24 hours a day.

If the company has an established program in place and is responding to an emergency outside interference should not be tolerated. Disasters normally create enough confusion without having outside agencies attempting to assist with unplanned efforts. The company should have designated emergency response personnel with proper identification allowing their authorized presence.

Customers must understand that in case of service outage, a restoration plan is in place to control demand for service. Local emergency agencies, national security services, key local civic leaders have priority over many other customers. Some industries that rely on communications for economic survival, for example, banks, insurance, aerospace may find that they do not have the highest priority for restoration.

Most phones may experience busy signals immediately following a major disaster. The inability to get dial tone is not necessarily because of equipment failure. The dial tone may only be delayed due to very heavy traffic. How soon this situation resolves itself is dependent on customer activity. Emergency calls may have to be made at pay phones or by going directly to emergency service locations. Pay phones if owned by local telecommunications company are normally classified as critical service allowing access.

Contingency plans should address CO operation, network reliability, personnel preparation and corporate structure. Information related to these key items provides data for enhancement to the emergency response process.

GUIDE TO INVESTIGATING TELECOMMUNICATION SYSTEMS

As noted above, telephone systems can be divided into two parts: COs and outside plant. While in the field, some observations of damage to outside plant may be made, and conversations with field crews can provide a limited view of the types of damage sustain by outside plant. Information on the overall response of outside plant, COs, and the network will have to be obtained from telephone company management. If access can be gained to COs, information on their performance can be obtained. COs are secured facilities and historically gaining access has been difficult. One method that has been successful is to approach the CO during lunch break, when CO officers may be out of the office. Request to visit with the engineer currently in charge of the office. Calls to personal contacts can be useful. Once access has been obtained to any office, have someone at that office call and set up an appointment with other facilities. Statistics on damage and performance of COs, outside plant, and network operations, if it is provided, will only be available several weeks after the earthquake.

It may be very difficult to follow the network design of a particular office. Every company may have their own scheme for interconnecting equipment. Grounding schemes may be different, location of equipment may be different and can make the task of surveying an office challenging.

Most personnel working in the central offices may not have full understanding of the equipment layout. Therefore, their input is not always reliable. Personnel working in the toll area may have no idea what goes on in the switch room. Power is only understood by power maintenance people. Even then, the knowledge of the

field personnel would be restricted to their day to day function, not the design concepts.

The obvious discrepancies may be the only areas that can be reported. How those discrepancies affect the network will not be ascertained. There are many modes of failures that may not affect the reliability of the network. The recommendation is to report any failed mechanical part, any falling parts, any buckling of structures, loss of service of equipment, failed bracing or anchorage. Poor engineering design in support of equipment should also be noted. Look for any taut cables that may have been stretched by movement of equipment or cable racks.

Evidence of large displacement and stress should be sought. Markings on walls or floors or on equipment panels will give indication of the movement within the office. Buckled structural members may show loads experienced by the equipment.

Common Failures

Expected problems are mechanical failures to overhead ironwork, equipment racks or maybe overturned storage cabinets. Desk-top equipment such as personal computers, typewriters, calculators may end up on the floor. As mentioned earlier, the network is composed of miles of cables interconnecting frames and equipment. The cables are supported by ladder type cableracks that may be severely overloaded in some older and larger office. Depending on the intensity of the ground motion, these cableracks may collapse from failed ceiling anchors or failed rod supports. The experience has been that ironwork hardware will rain onto the floor. The hardware will consist of metal clips, corner brackets, nuts, bolts and splice pieces. Most companies use friction fittings to join the ironwork.

Embedded concrete anchors will most likely be a problem. Tall slender relay racks loaded with equipment shelves are the most common means to mount equipment. These racks are mounted as cantilevers from the floors applying high stress to the anchors when racks are rocked. While top support is provided for the racks, the bracing does not prevent rack top displacement. Anchors may creep or ultimately fail from the severe loads.

Sheet metal or plastic trim on equipment bays will fall. Most manufacturers use snap on or quick release features to secure panels. They will not withstand much ground motion.

Battery racks that are not provided with adequate cell restraints or not designed for earthquake loads may experience power loss. The cells on the racks may be thrown around breaking intercell connectors or posts or at worst fall off the rack. Jars could break spilling electrolyte if they impact rack uprights or adjoining cells.

Circuit board walkout is a very real problem. Older equipment were not provided with latches to prevent cards from coming loose. The clamping force of the electrical connector in most cases is not enough to prevent card walkout. A

circuit board decoupled from the connector would loose service. Critical cards could shut down the system.

The distributing frames in most offices are large structures made of channels and angles, Figure 14.4. Channels cantilever out from a center structure that is anchored and overhead braced. At the ends of the channels are terminal blocks with wiring pins. Cable is also supported by the arms of these channels. A lot of mass is supported by these frames with very little bracing to restrain displacement. Damage is expected to the frame, however, service should not be affected severely.

The overall expectation is that there will be failures of isolated equipment and some mechanical damage. Service is not going to be totally affected, however. Limited loss of service may affect some customers. Mechanical restoration of operating equipment may be necessary following the event. The immediate activity would be concentrated on restoration of service where affected, however. Limited loss of service may affect some customers. Many of the concerned failure modes such as downed lines or cut lines may turn out to be ill founded because of the protection built into the network.

The inspection procedures that follow assumes investigation personnel have some familiarity with central office equipment. The inspection process is usually a visual one, while in some cases cover removal is required for the inspection, this should only be done by telephone company personnel. The inspection of anchor tightness may involve the use of tools to check for nut or bolt torque, however, this must be done by telephone company personnel.

The earthquake investigator should not touch equipment much less attempt corrective actions of any kind. Checking should be limited to visual inspection. Circuit boards that may appear to be loose in shelves or card cages could be bad boards or incorrect boards that were stored there prior to the earthquake. Fuses may be pulled purposely prior to the earthquake.

Due to densely packaged integrated circuits in newer equipment, inspection personnel should not touch the cabinets or frames to avoid ESD (electrostatic discharge) which could cause damage to circuitry.

It is recommended that the earthquake investigator be accompanied by people that are familiar with that particular office or with the equipment. The Equipment Engineers, COE's, DEC Engineer or Maintenance Engineer would be good resources. It is a good practice to report to the staff accompanying you your findings before leaving the building.

Cable racks run through the CO as continuous systems. Though the inspection procedures are divided into specific equipment areas, the cable rack inspections must be followed through other equipment areas, and through wall or floor openings.

Power Room

Extra care must be exercised to avoid injury. Don't touch any object if you do not thoroughly understand its operation and function.

- Examine the battery rack verticals for buckling or bends. Fresh paint crack lines are good indication of bending.
- Inspect battery rack side and end cell rails for failure, bends or looseness.
- Examine battery rack joints for weld failures or loose fasteners. Weld failures could be hairline fractures so the use of magnifying glass may be needed.
- Inspect battery cell tray or rail supports for bends or buckling as well as acid spill. Inform engineer(s) when acid spill is found.
- If there is overhead bracing, check for bends, loose or failure of ironwork.
- Examine anchors for looseness.
- Examine cell jar for cracks or separation of top from jar. Cracks could be hairline in size. Look especially at areas where jar may have impacted rack and at bottom of jar.
- Examine cell post seal area for bent or broken posts. Inspect for bent, loose or shorted intercell straps on batteries. Look for cell posts that may have been broken by intercell straps. Look into jar, which are usually transparent, and check for post separation from plates.
- Inspect plates inside cell jar for broken plates , dislocated, and mis-aligned plate supports. Plates should be evenly supported across the jar.
- Inspect inter-row and inter-tier cables for looseness or bent post connector plates. Cables to busbar may be separated or be chafed.
- Verify ground cable to rack is secure.

Rectifiers and Distribution Panels

- Inspect for operation by looking at output meters. Some rectifiers may not be carrying load with output meters reading zero.
- Inspect cabinet condition for open doors, bent or buckled cabinet panels, bent structural frame, and loose equipment within panel. Check transformer mounts for damage or looseness.
- Visually inspect cable connections for tightness, broken cables, and damaged cable insulation. Review AC input cables, DC output cables and ground connections.
- Inspect for busbar connection tightness and slippage. Check for possible shorts or opens.
- Inspect cabinet anchors and/or overhead bracing.
- Check for loose circuit boards.
- Check for meter operation and loose panel instruments. Check for loose fuses or broken fuse holders. Ask craftsperson if circuit breakers had to be reset and how many.

Busbar

- Inspect all bolted oints for tightness and slippage. Follow busbar from one end to the other.

- Check all insulators for cracks, breakage or misalignment.
- Look for ironwork, electrical conduit, water pipes, lighting fixtures, ventilation ducts that have fallen over or near busbar or battery racks.

Engine-Generators

- Inspect all fuel, water and air lines for broken joints and leaks. Bent pipes may exist at floor or wall openings. Pipe integrity must be checked along length of pipe.
- Intake air and exhaust piping should be inspected for collapse or bends. Flexible joints may be crushed or loose. Check integrity of pipe supports.
- Inspect outside radiator for structural damage. Check all legs of radiator for bends or buckling. Check fan motor mounts for tears, looseness or failure. Check heat exchanger tubes and header for coolant leaks. Inspect anchors for looseness or failure.
- Inspect engine skid mounts and anchors for damage. Skids may have isolators that are steel springs or rubber. Check for broken springs or metal parts in isolators. Inspect anchors for looseness or broken concrete. Check snubber for signs of engine displacement.
- Check generator housing for mechanical problems. Inspect bearing supports for damage. Check coupling to engine for damage. Verify cables to generator are intact and not shorted.
- Inspect starting battery racks and cells. Inspect charger for operation. Wall mounted chargers may have come loose.
- Inspect air storage tanks and compressors for anchorage and leakage. All pipe joints must be checked for looseness. Check pressure gauges for pressure.
- Inquire about start up problems.

Main Distributing Frame (MDF) and Distribution Frames

- Inspect distributing frame for displacement and out of plumb. Check for sheared frame bolts.
- Check for bent or buckled uprights, horizontals for block mounting strips.
- Inspect anchors for looseness and bent base angles.
- Verify ground strap is intact with ground bar. Check cable rack and Auxiliary Framing (overhead ironwork) above for signs of damage such as loosen friction clips.
- Inspect cable rack above frame for failed mounts or joints.
- Check wiring to blocks for broken leads or tautness of wires.
- Check for loose or fallen connector blocks, protectors, and protector mounts.

Cable Vault

CAUTION: Inspections in the cable vault should be conducted only after the vault has been checked for toxic and flammable gases by qualified personnel, and should always be accompanied by qualified/personnel or person responsible for the cable vault.

- Verify that cable entry wall seals are still good. Check for cracked sealing material or cracked concrete around entry openings.
- Check for signs of cable pull or chafing of cable insulation.
- Check cable splice cases that may have fallen off rack. Splice cases may have cracks or opened.
- Check support structure for wall anchor condition, loose fasteners, or bent ironwork.
- Visually check for operation of pressurizing equipment by looking for pressure at gauges.
- Inspect pressurization equipment cabinet condition for bent panels or loose parts. Inspect anchorage of cabinets for looseness.
- Inspect pressure tubing connections for pulled or broken joints.

Switching Equipment

- Inspect equipment frame for buckled uprights, shifted base plate, loose doors, covers and unsupported equipment shelves. Examine card cages for distorted frames and cracked back-plane and connectors.
- Check for loose side panel covers, cable tray panels, cross aisle cable trays, frame joining hardware.
- Examine anchor for looseness or broken concrete. Some frames may have hidden anchors requiring opening of covers. Random inspection is required where there are obvious signs of equipment frame movement. The movement can be traced by auxiliary framing hitting walls, columns or buckled framing. Fresh crack paint lines can be a clue.
- Check overhead bracing, if used, for buckled or slipped bracing. All fasteners should be tight.
- Check cable strain reliefs.

Equipment Performance

- Inquire with Operations Personnel of any service problems that resulted from the earthquake, such as loose circuit boards, system re-sets, open fuses, loose connectors.
- Check for loose plug in circuit boards in equipment cages and loose wires in backplane. Look for taut cables and wires in cable tray.
- Check for loose fuses or blown fuses in fuse panels.
- For equipment with cooling fans, check for proper fan operation and verify filters have not come out of housing.
- Inspect tape drive or disk drive units for proper operation. Tape drive unit may have lost tape spool. Inquire of operations personnel.
- Check for cooling fans operation.

Overhead Auxiliary Framing for Cableways

- Inspect framing for loose channels, ladder rack or braces. Follow cable racks through wall and floor openings. Look for clips, support brackets, hangers, splices that may have come loose. Heavily loaded cable racks are especially vulnerable to failure.