STRUCTURAL FLOORS

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1. GENERAL

1.01 This section discusses and provides design standards for structural floors. These standards are provided for use in the design of new buildings or building additions that are intended to house telephone equipment that meets the requirements of Section 800-610-164, "New Equipment-Building System (NEBS), General Equipment Requirements."

1.02 This section supersedes Section 7.1 of Specification X-74300, "NEBS Building Engineering Standards (BES)." Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 Although the primary function of a floor is to support vertical live and dead loads, it also acts as a barrier between adjacent stories to prevent the spread of fire. Depending on the type of building superstructure, the floor may aid in resisting moments caused by wind or seismic loads, or it may act as a shear diaphragm which transmits these lateral loads to shear walls.

2. TYPES OF FLOORS

2.01 Although a variety of framing systems are in common use in equipment buildings, the vast majority of floor slabs are constructed of reinforced concrete. Concrete is easily formed, particularly in cable hole areas; has excellent fire resistant characteristics; and, if poured and finished properly, can have a level and uniform surface which can be drilled to install anchors for the mounting equipment. Concrete for the slab should be of sufficient quality to develop the pullout strength of the floor anchors as well as the pullout strength of the cast-in-place inserts on the underside. The floor surface should have a steel-troweled, nondusting finish.

2.02 Since telephone equipment must be leveled when it is installed, the floor should be finished to tolerances of levelness and flatness as noted in both GL 70-01-159 and in 8.02.

2.03 Aside from the commonly used concrete floor surface, the total floor structure in equipment buildings can be grouped into one of three different framing systems:

- Reinforced concrete framing
- Steel framing
- Precast concrete framing.

Most buildings have floors in the first category. The floor designs are called flat-slab, one-way beam and slab, two-way ribbed-slab, beam and two-way slab, and one-way joist. Steel frames are usually beam and girder construction, with some form of fire protection, and topped with one or two-way concrete slabs. One-story buildings framed in steel sometimes use a roof system of open web steel joists, but these are generally unsuitable for floor construction due to load carrying requirements and the necessity of a drop ceiling for fire protection. Precast floor framing, at this time, is rarely used for multistory equipment buildings. The construction typically consists of planks and joists or T-beams. It is generally used for single-story buildings with relatively long roof spans.

3. STANDARDIZED FLOOR DESIGNS

3.01 The forms of construction that best meet the requirements for telephone company use are flat slab for reinforced concrete buildings and one-way beam and slab for steel-framed buildings. Precast, prestressed concrete construction and open-web steel joist systems particularly lend themselves to the special case of small one-story dedicated buildings such as No. 2 and No. 3 ESS.

REINFORCED CONCRETE FLAT SLAB

3.02 Flat-slab construction is the most economical because of its low profile and ease of construction. The slab is supported directly by the columns without the aid of beams or girders, thus taking advantage of the two-way action of the concrete slab without the headroom penalties imposed by beams. The slab may be locally thickened in the form of drop panels at columns, and the columns may be enlarged in the form of column capitals to further strengthen the slab. The drop panels and column capitals both serve the double purpose of reducing shear stress in the slab near the column supports and of providing greater effective depth for negative bending moment. As an option to the drop panels, a flat plate may be used with steel shearhead reinforcement designed into the uniform depth slab. Flat-slab construction is considerably more economical than steel-frame construction for live loads above 100 psf and for spans up to about 30 feet. The cost of this type of floor construction as a function of superimposed load is given in Section 760-200-021, Floor Load, Fig. 2.

3.03 Figure 1 illustrates the dimensional standards that result from a design trade-off study following the 1971 code of the American Concrete Institute. The major standards shown in the illustration are:

- 8-inch thick slab for the floor system
- 6-foot 8-inch square drop panels at the columns.

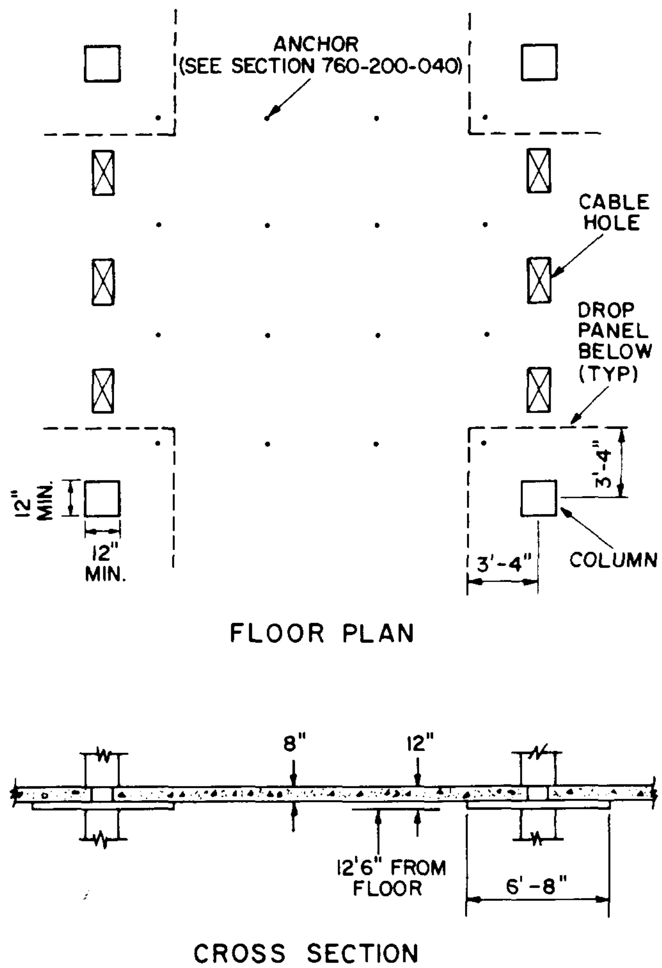

Fig. 1—Flat-Slab Floor Standard

3.04 Among the considerations upon which this conclusion is based is the use of high-strength reinforcing steel and concrete with a 28-day compressive strength of 3000 psi. The use of higher strength concrete opens the possibility of deflection problems caused by thinner slabs. However, 4000-psi concrete may be preferable for other reasons—contractor logistics, temperature, quality control, and building size. One disadvantage of this type of floor system is the absence of framing members around the cable holes. However, the slab system can be designed taking into account the holes and the resulting increase in slab flexibility. Section 13.6 of the ACI code gives specific guidelines for slab design with respect to the percentage of cross-sectional area lost at openings. If the openings in any region of the slab exceed the percentage allowed by the code, the empirical methods of slab design are not acceptable. In such cases, the code requires an analysis of the entire perforated slab system.

BEAM AND SLAB CONSTRUCTION

3.05 Steel framing, encased in concrete for fire protection, is well suited for very large buildings. The proposed beam configuration is shown in Fig. 2.

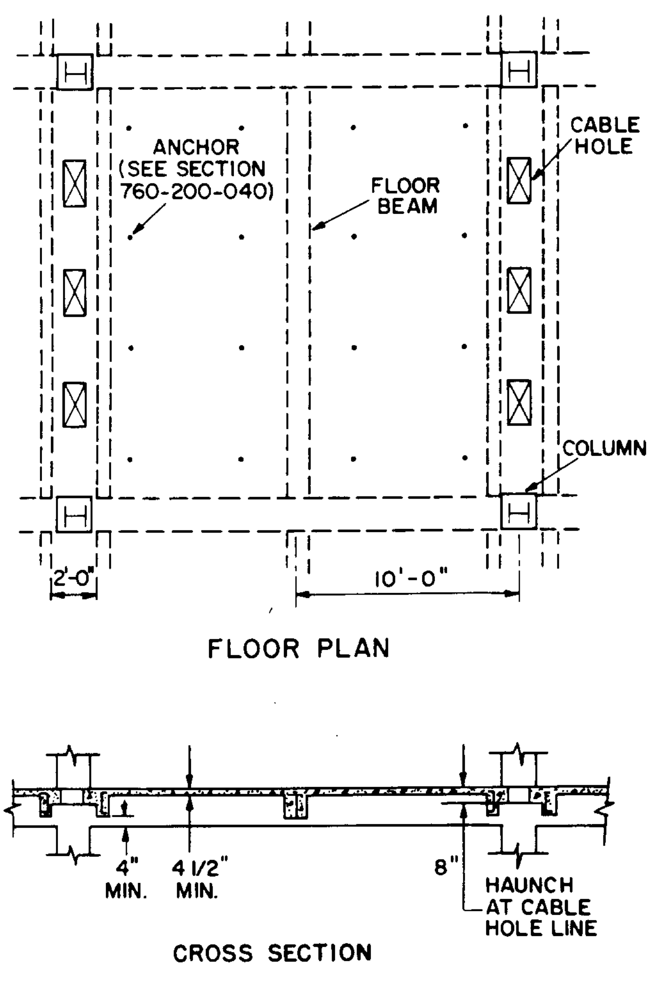

Fig. 2—Steel-Frame Floor Standard

3.06 In a steel beam and slab floor, the girder is the major element and, therefore, the deepest with respect to overhead obstruction. It spans between columns and supports the beams. The girders not only carry floor loads but are very often designed to carry lateral loads on the building, such as wind, by moment connections to the columns.

3.07 The beam configuration that is transverse to the girders must be established with reference to the cable holes that also run transverse to the girders. Because the holes are centered on a line between columns, the beam that would normally be on the same centerline must be offset. For the sake of symmetry, a split-beam type of construction is recommended. This involves using two smaller beams, each offset to opposite sides of the column centerline and framed into the ends of the girders. To allow adequate air flow in the drop ceiling plenum when the Modular Cooling System (MCS) is used, these two beams should be at least 4 inches shallower than the girder (Section 760-230-100). The remainder of each building bay is then framed with one or two beams spanning between girders, dividing the building bays into two or three one-way slabs. The depth of these beams is not particularly important because they are seldom as deep as the girders that support them. The width of the floor beams have little effect on the equipment interrelationships, but the width should not cause the beams to coincide with planned ceiling insert locations.

3.08 The position of the floor beams also should be such that they do not interfere with the grid of ceiling inserts. It is desirable to have the inserts all on the underside of the slab, in the same plane, rather than some on the underside of the beams. The split-beam construction avoids the grid of inserts specified in Section 760-200-040. However, if two central beams are used, there is interference with both center rows of inserts. Thus, the preferred configuration is one central beam that divides the building bay into two slabs and is located between rows of inserts. Other considerations of one central beam versus two (increased beam load and slab span with one beam, extra forming of two beams) essentially balance each other.

3.09 Generally, the depth of the slabs depends on the distance they must span between beams. However, in the cable hole area (between the split beams), the span is very short. Because

8-inch deep cable plugs are recommended as standard for flat-slab floors, there are advantages to having the same dimension for beam and slab floors. Therefore, the small portion of floor slab between the split beams shall conform to the 8-inch depth as shown in Fig. 2. The depth of the remainder of the floor follows conventional design procedures with a minimum depth of 4-1/2 inches acceptable for deflection requirements and fire rating requirements.

4. DEFLECTIONS

4.01 Telephone equipment is likely to be damaged by large floor deflections; therefore, the floors should be designed to meet a maximum allowable deflection. Individual elements of a floor, such as a beam or girder, should prevent a total live and dead-load deflection that is greater than 1/480 of the element's span. However, where beams are supported by girders, individual deflections can accumulate significantly and produce large deflections at the center of building bays. For floors with multiple-element one-way construction, the sum of individual element deflections should be limited so that the center of bay deflection is less than 1/360 of the column spacing.

5. FLOOR JOINTS

5.01 Construction joints occur between portions of a slab whose concrete is placed at different times. Proper design and construction techniques provide for continuity of the reinforcing steel and keying of the concrete when a floor is large enough to require more than one pour during initial construction. When a building is extended, and there is no need for an expansion joint, particular attention should be given to the interface of the old and new grade slabs to be sure they are properly keyed to prevent differential settlement.

5.02 Expansion joints are provided in large buildings (lengths greater than 200 to 300 feet) to prevent excessive stresses in the building structure as a result of thermal motion. Where practical, expansion joints should be planned so that they do not traverse equipment rooms. A newly constructed telephone building is rarely large enough to require expansion joints. However, large building additions often require expansion joints between the existing building and the new building to permit thermal expansion and minimize stresses that might be induced by differential settling of the foundation. In either new buildings or building additions, expansion joints can generally be planned so that they are in the core area and do not interfere with equipment rooms. This planning will obviate the need for special engineering or installation measures for equipment frame lineups, bus bars, raised floors, or other noncompliant elements spanning a joint.

6. FLOOR SUPPORT OF EQUIPMENT FRAMES

6.01 Equipment frames conforming to the requirements of the new Equipment Design Standards will be self-supporting at the base connection. The floor connection must normally resist overturning and shear forces exerted by lateral loads such as craftspersons leaning on the frames or pulling cable in overhead cable racks. These forces become maximum under the lateral motion caused by earthquakes, as described in Section 760-200-023. The floor must be designed to resist these loads in addition to the live and dead loads. Specific information on both floor anchors and ceiling anchors is contained in Sections 760-200-040 and 760-200-041.

6.02 Concrete floors should be designed to permit subsequent installation of drilled anchors. Self-drilling anchors, recommended for use as floor anchors to fasten equipment frameworks, must be relocated if steel reinforcing rods are encountered during drilling. This requires redrilling and possibly repositioning the entire equipment frame lineup, which is a very costly operation and should be avoided.

6.03 One solution to this problem is to design the concrete floor so as to have steel reinforcing rods no closer to the surface of the concrete than the depth of the floor anchor. This approach requires one or two inches of concrete covering the steel in addition to the 3/4-inch minimum clear distance specified by the ACI or local building code. For an additional cover of concrete ranging from one to three inches, the increased total loaded cost of the building amounts to about 1.2 percent per inch of concrete added to the floor.

6.04 An alternative is to place the reinforcement in the concrete so as not to interfere with the floor anchors. Reinforcing rods parallel to the direction of the frame lineup can be located so as not to coincide with the centerline of floor anchors (Fig. 3). Since the location of the floor insert varies along the centerlines shown, the exact location of rods perpendicular to the frame lineup cannot be specified. At the intersection of column strips, placing these rods below the level of the parallel rods may place them below the depth of the insert. If, however, the rods are still encountered during drilling, the framework base is designed to allow redrilling without repositioning lineups.

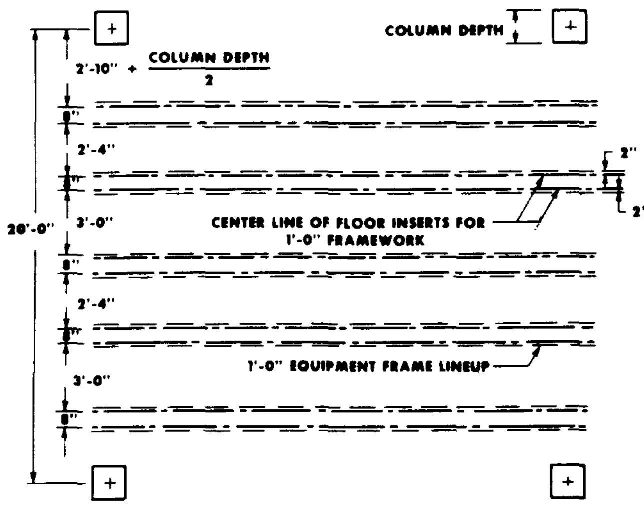

Fig. 3—Centerline of Floor Anchors in Standard Floor Plan

7. RAISED FLOORS

7.01 The MCS described in Section 760-230-100 requires a raised floor above the structural concrete floor. The decision to use raised or nonraised floors should be made before designing is begun. Provision must be made so that raised areas and nonraised areas, such as the building core, are all the same level when the building is in service. Depending on whether the raised floor will conceal chilled water pipes and/or an air plenum, attention should be given to the building floor slab with respect to a drainage system, waterproofing, and dustproofing.

7.02 In specifying a particular raised-floor system, consideration should be given to the following points:

(a) The space provided under the raised floor for chilled water may also be used for distribution of cabling and air.

(b) The floor should be structually adequate to support floor-mounted equipment under standard loads and earthquake loads, if required.

(c) The floor should be dimensionally coordinated with the building bays, aisle spaces, and floor panels.

(d) The floor should be level and the equipment layout planned for ready installation and attachment of equipment.

(e) Floor construction should comply with applicable fire codes.

(f) All metallic portions of the floor should be grounded.

7.03 Bell Laboratories has developed a raised-floor system for use in equipment buildings. This system is described in Section 760-200-110.

8. REFERENCES

GL 70-01-159—Buildings: Floor Levelness in Equipment Areas, Jan. 19, 1970

George Winter et al, ***Design of Concrete Structures,*** McGraw-Hill, 1964

Building Code Requirements for Reinforced Concrete, American Concrete Institute, ACI 318-71

9. STRUCTURAL FLOOR STANDARDS

9.01 All floors should be designed to support the live loads specified in Section 760-200-021 over the 20-foot 0-inch spans.

9.02 The maximum deviation from the elevation established for the floor should be ±1 inch over the entire floor area and the maximum difference in elevation between the high and low points in any building bay should be 3/4 inch. The maximum deviation from a true straightedge 8 feet in length placed anywhere on the floor should be 1/4 inch.

9.03 In active seismic areas, concrete of sufficient quality should be used to hold floor anchors under pullout loads of 6000 pounds per anchor.

9.04 The underside of the slab must resist the rated loads imposed on cast-in-place ceiling inserts.

9.05 Select size and location of steel reinforcement so as to minimize interference during installation of drilled floor anchors.

9.06 Construct floors in equipment areas with cable holes and slots as described in Section 760-200-032.

9.07 Finish concrete floors so that they have a steel-troweled, dust-free surface.