

FLOOR DESIGN LOAD

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1. GENERAL

1.01 This section discusses and provides standards for floor loads. 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 5.1 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 The loading on floors can be broken into two categories: dead load and live load. Dead load is the weight of all permanent construction including structural framing and walls, ceilings, roofs, air ducts, permanent partitions, and stairways of a building. Live load includes the weight of equipment, cable, materials, occupants, and other elements (supported by the building) that may be moved or relocated during the life of the building. For structural strength, the magnitude of the dead load is determined to a large extent by the specified live load that it must support.

1.04 The live-load requirements of a building affect the structure with respect to foundations, columns, beams, and floor slabs. The relative magnitude of costs for the structural frame of a 2-story reinforced concrete telephone equipment

building as a function of floor live load to which it is designed is shown in Fig. 1. The model used for this analysis is a vertical core* section of a building. It is assumed that the model is subjected only to gravity loads and that wind and earthquake loads are carried by additional bracing. Similar information for a lo-story reinforced-concrete building is shown in Fig. 2. This information is summarized and presented with cost data on a 5-story steel frame building in Fig. 3. However, since either the reinforced concrete or steel frame is only a portion of the total cost of a building (about 30 percent), the data is replotted in Fig. 4 to show the relationship to total building costs. Taking the information given in Fig. 4 in relation to the types of construction (steel or reinforced concrete) in the Bell System, it can be estimated that the overall effect on the cost of the building program is 4 percent for an incremental change of 100 psf in the floor live load to which buildings are designed. The cost curves show that it is beneficial to keep the floor live load as low as possible and still provide usable building space.

*A core is a building section that includes an interior column the full height of the building, all of the floor and roof beams and/or slabs tributary to it, and the supporting footing.

1.05 Analysis of all existing and planned electronic switching, transmission, and power systems with regard to equipment weight and aisle spacing, and utilization of information gained from past experience, have established the minimum acceptable floor live-load capacities. Table A shows the floor capacity requirements by the types of load that are found to be adequate for standard use. Because it is desirable to have flexibility in placing supported equipment at any location in the building, 150 psf is the floor live-load standard throughout the building.

1.06 In certain cases, however, it may be desirable to deviate from this standard. The batteries associated with the reserve power areas may be spaced more closely together and often more economically when they are located on floors stronger than those designed for 150-psf live load. Power areas comprise about 10 percent of the total building area, and the floor area required by batteries

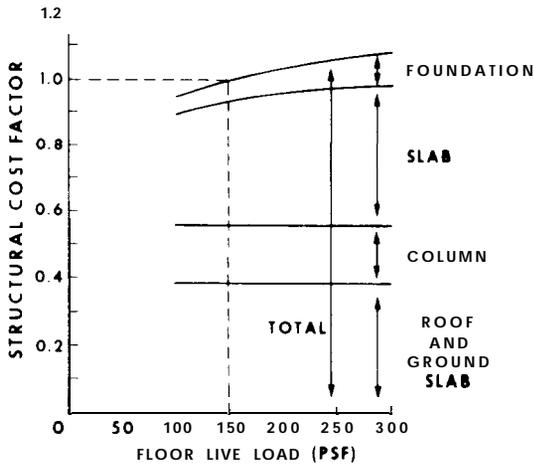


Fig. 1 -Structural Cost--P-Story Reinforced-Concrete Building

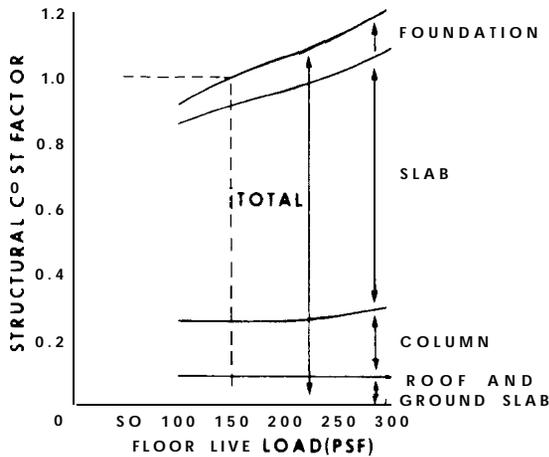


Fig. 2-Structural Cost- 10-Story Reinforced-Concrete Building

spaced so as not to exceed 150-psf loading is about one-third greater than that required where stronger floors are used. Because of this, the price of complete flexibility with respect to where the power area is located in the building through the use of 150-psf power layouts amounts to 3-1/3 percent of the total building cost. Complete flexibility in equipment placement may be achieved

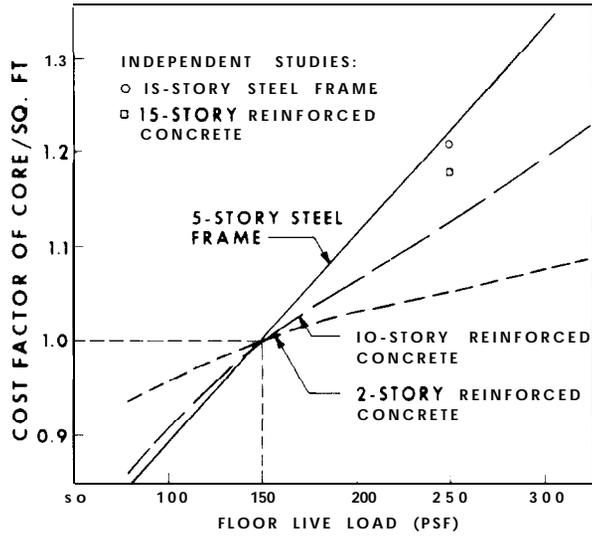


Fig. 3-Core Cost

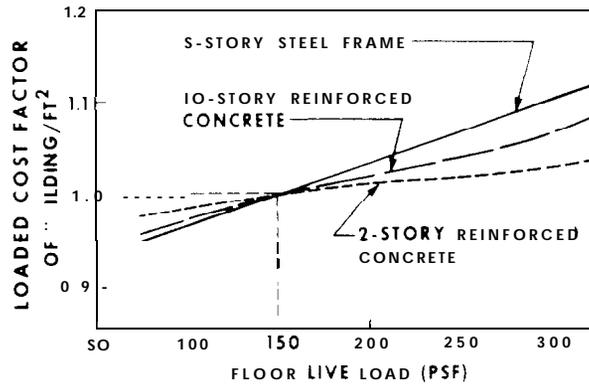


Fig. 4-Building Cost

also if the entire building is designed with floors capable of supporting the most dense equipment packing; however, when 300-psf floors are used, a penalty of from 6 to 10 percent of total building cost is incurred. (See Fig. 4.) More economical designs often may be obtained when only parts of the building are designed for heavier loadings. Heavy design-load areas may be established during building planning if it is known where power equipment will be located at anytime during the life of the building. Designing a minimum of 10 percent of the building's floor area for heavy loading results in a 1/2 to 1 percent increase in

TABLE A

FLOOR LIVE-LOAD ALLOTMENTS BY BUILDING AREA
(Total Capacity is 150 psf Uniformly Distributed)

BUILDING AREA	WEIGHT (PSF)
Equipment Frame Area	
Frames**	115
Cable	25
Transient Load	10
	} 150
Distributing Frame Area	
Frames and Cable	140
Transient Load	10
	} 150
Power Area	
Equipment and Cable	140
Transient Load	10
	} 150†

*When the Modular Cooling System is used, the floor load allocation includes the weight of process coolers, the support work and raised floor.

†This equipment may be compacted and located on floors designed for greater loads.

cost above that for a building uniformly designed with 150-psf floors. This approach allows for a number of alternative power-plant locations where future building use is not firmly established. A summary of these alternatives is given in Table B. However, in any decision concerning increased building flexibility, the annual carrying charges of "high-quality" building space not being used to capacity must be evaluated along with first-cost expense. This penalty cost is not included in Table B.

2. LIVE LOADS ON FLOORS

2.01 Building floors are designed on the basis of uniformly distributed live loads; in reality, telephone equipment produces a set of concentrated loads separated by maintenance and wiring aisles, work spaces, etc. It is obvious, therefore, that

TABLE B

COST INCREASE* FOR MULTISTORY EQUIPMENT BUILDINGS

ALTERNATIVE	STEEL-FRAME-BLDG (PERCENT)	REINFORCED-CONCRETE BLDG (PERCENT)
Spread out power apparatus to maintain 150-psf floor live load	3-1/3	3-1/3
Design building for 300-psf floor load throughout	10	6
Design N percent of stories for 300-psf floor load	N/10	N/20

*First cost only.

care must be taken to ensure that the individual beam or slab elements within a building bay supporting an average live load of 150 psf do not experience localized stresses exceeding those derived from a uniformly distributed load. If inspection of the equipment layouts indicates areas where the floor will be overloaded, the possibility of relocating some of the equipment should be explored. Minor adjustments in the position of heavy pieces of equipment may possibly be permitted without violating equipment requirements while gaining structural advantage. Changes of this type must be negotiated between the areas responsible for the building and the equipment. In general, building bays containing four or more lineups of equipment whose weight averages out to meet the 150-psf floor live-load requirement will not overload any portion of the floor. However, bays with fewer than four lineups, whose weight averaged over the bay approaches 150 psf, may overload individual members of the floor structure because of load concentration. Benefits in floor loading may sometimes be obtained if concentrated loads are located nearer to columns and/or girders; these being the strongest portions of the floor.

UNIFORMLY DISTRIBUTED LOADS

2.02 In the majority of telephone equipment building space, there is a relatively uniform

distribution of the equipment. This condition is apparent in the typical switching or transmission equipment layout where each building bay contains six lineups, including the lineup that may be in the column line location. In this situation, the uniform load equivalent to the actual load can be reliably estimated by either of two methods:

- (1) The weight of equipment in the space bounded by columns can be summed and then divided by the area. This has the effect of averaging, or smoothing, the distribution of weight over each building bay.
- (2) The weight of each bay, or module, of equipment can be divided by the sum of the footprint area and the floor area tributary to the bay defined by the centerline of the front and back aisles. In effect, this process averages the weight of each piece of equipment over the floor area assigned to it.

CONCENTRATED LOADS

2.03 Some equipment arrangements produce distinctly nonuniform floor loading patterns. Battery plants, engine-alternators, and other large, heavy items of equipment generally fall into this category. For such cases, some structural members tend to be loaded more heavily than others. Therefore, average equipment weight cannot be used as the criterion for determining the required live-load capacity of the floor on which this equipment is to be placed.

2.04 An example of the effects of concentrated loads on required floor live-load capacity is given in 2.05. Also, guidelines for determining when concentrated loading must be considered are covered.

2.05 Example—200-kW 415A Power Plant:

A layout of 200-kW 415A power plant using plastic battery stands meets the NEBS requirements. In compliance, the layout is suitable for a floor designed to a 150-psf live load, 10 psf of which is reserved for transient loads. The layout, shown in Fig. 3, averages to 134 psf exclusive of the transient load. However, since it is a general layout and not one designed for any particular building, several typical framing systems and configurations must be considered to accurately determine its suitability. Figure 6 (6a through 6d) shows beam configurations that might be used with

the proposed layout, and each sketch includes some of the critical loading diagrams determining the equivalent uniform loading. Both the number of beams and their orientation with respect to the axis of the battery lineups have a significant effect on the floor requirements. In the specific cases studied, the structure with one central beam parallel to the battery lineups (Fig. 6a) illustrates a floor that would be inadequate if designed for a live load of 150 psf, while the other floors (Fig. 6b, 6c, and 6d) supporting the same layout have sufficient strength when designed to 150 psf. The indication is that, if given the specific layout, the designer in this case can produce a 150-psf floor that will support it.

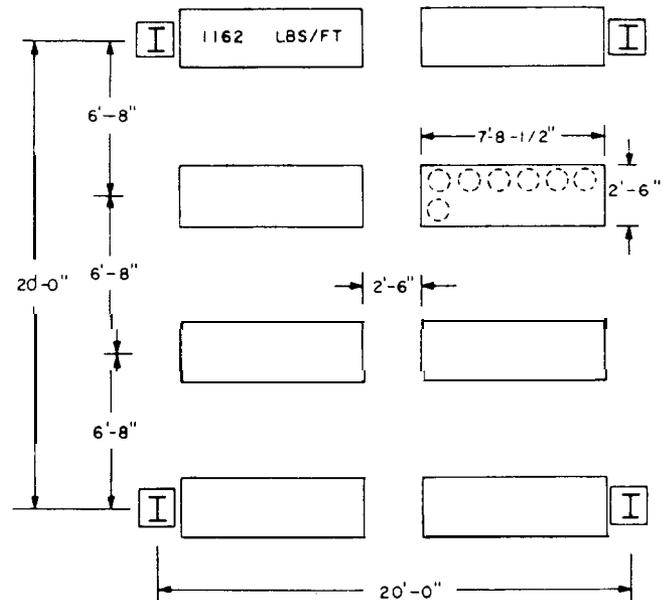


Fig. 5-Battery Floor Plan (150#/7' Floor Loading)

2.06 This example, given in 2.05, shows that equipment density alone does not determine floor load requirements. Of equal importance is the configuration of the equipment loads relative to the supporting structure.

2.07 In the structure that has been analyzed, the assumed framing neglects cable holes. Although their presence would modify the framing to shorten the slab spans, the effect on a comparative analysis of this type would be negligible. Flat slab types of construction have not been discussed,

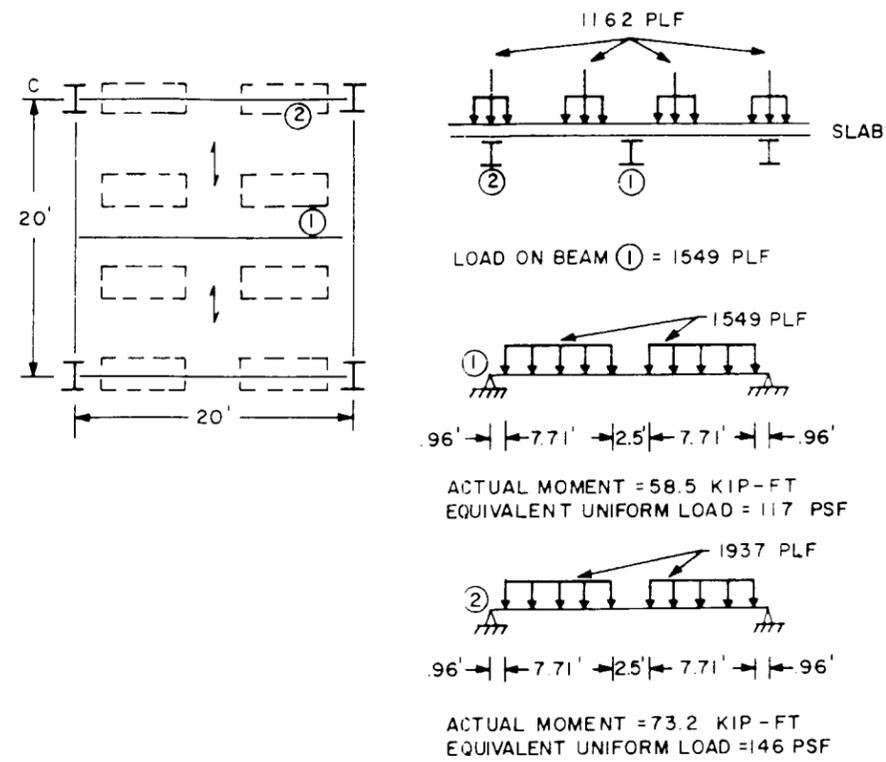


Fig. 6a—The uniform load equivalent to the concentrated loads is 146 psf (more than the uniform design load of 140 psf)

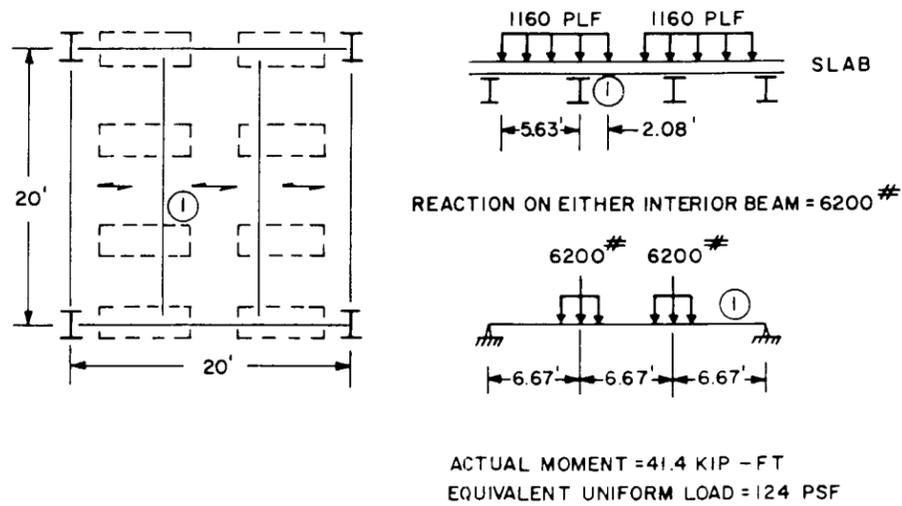


Fig. 6b—The uniform load equivalent to the concentrated loads is 124 psf (less than the uniform design load of 140 psf)

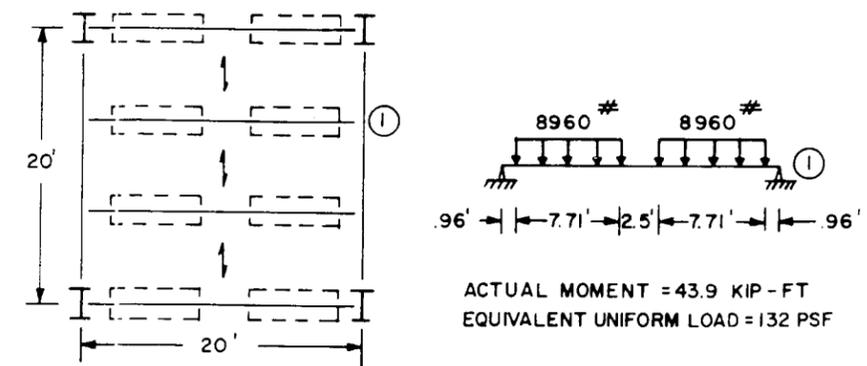


Fig. 6c—The uniform load equivalent to the concentrated loads is 132 psf (less than the uniform design load of 140 psf)

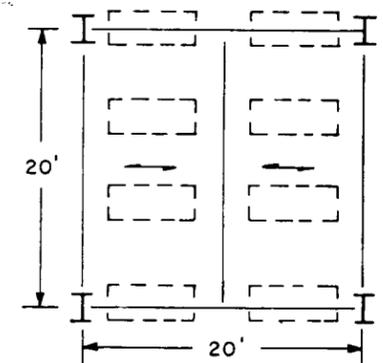


Fig. 6d—The uniform load equivalent to the concentrated loads is approximately 134 psf (less than the uniform design load of 140 psf)

Fig. 6—Beam Configuration for Proposed Battery Floor Plan

mainly because there are no clearly defined members to carry the loads back to the columns. But, by their nonarticulated nature, flat slabs are better able to distribute load concentrations to prevent overload situations. The economics of flat-slab construction are most attractive, but such a structure should not be used as an alternative to a frame structure as justification for neglecting a load concentration problem.

2.08 This discussion has not noted safety factors.

Because of building code requirements, building construction normally is overdesigned by a factor from 50 to 100 percent, or more, to account for various factors such as: construction inaccuracies, material weakness, and overloading. Although the example cited in 2.05 does not involve overloading beyond the ultimate load, it is not considered good engineering practice to rely on the factors of safety to carry known loads. Any existing installation that, upon reexamination, does not meet the criteria for adequate design may very well be safe as a result of the safety factors. In these situations, if there is no evidence of structural overload such as excessive deflection or cracking, there is likely no need to modify existing installations.

3. FLOOR LOAD STANDARDS

3.01 Design structural floors, except as noted in 3.04 and 3.05, to support a dead load and a uniformly distributed live load of 150 pounds per square foot.

3.02 Identify all floors and portion of floors where there will be less than four lineups of equipment per building bay, including the column line lineup and extremely concentrated loads.

3.03 Supply the architect-engineer with equipment layouts and weights of all building bays

identified as having uneven live loads so that he may verify that no portion of the floor is overstressed.

3.04 Construct all slabs on grade to a minimum live-load capacity of 300 psf-no maximum load capacity is here specified. Such higher strength floors are particularly suited for some types of power equipment such as the large engine-generator set or battery plants.

3.05 Particular floors may be designed to support loads greater or less than those specified in 3.01 at the discretion of the Operating Company. These are floors dedicated to nontelephone use for the life of the building, or where the anticipated load will be greater than that specified in 3.01.

4. REFERENCES

Section 760-200-151—Design Loads for Telephone Buildings

GL 70-01-159—Buildings: Floor Levelness in Telephone Equipment Areas

GL 70-08-155—“Buildings: Costs of New Equipment Buildings and Additions-1969 and 1970,” AT&T, August 25, 1970

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