Live loads on floors of libraries and newspaper archive buildings

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Abstract

A detailed live load survey was carried out on floors of the library and newspaper archive at a public library in Mexico City. The study included furniture, racks and shelves, as well as books, journals, papers and other items used in libraries. Considering temporal concentration, an additional survey of people was estimated separately. Those loads were used to estimate distribution functions of the maximum total live loads for different areas. The results were compared with the values specified by the Mexico City Building Code and ASCE 7-16. The paper provides some detailed background behind the normative methodology of the current specialized codes to define the basic value of design live load intensity by considering the maximum load effect as a function of the building uses and the definition of influence area by structural element. The results of the survey corresponding to typical public libraries have shown that the probabilities of occurrence of the design loads recommended in the local code might be a proper representation of the mean values. Based on the results, basic values of design load intensity were proposed.

Keywords Live load · Libraries · Newspaper archives · Probability distribution · Design loads

Introduction

The live loads on floors in buildings are caused by the weights of people, furniture, supplies, stores, equipment, stored objects and persons, among others weights borne by the structure during its use and occupancy. Live loads are movable and variable and sometimes cause dynamic effects.

In codes, live loads are specified as the weight per unit area corresponding to the use of the floor. The design load shall be calculated by considering the maximum load effect for the particular use caused by the specific disposition of people and supplies. Live loads are composed of two stochastic processes corresponding to sustained loads (weight of users and furniture) and extraordinary loads as parties, meetings, etc. (Ruíz and Sampayo-Trujillo 1997).

However, the live load definition is linked with two main problems (AIJC-2006):

- (a) It is impossible to survey all possible uses of a floor, because future human activity cannot be predicted. So, design live loads for unspecified uses should be estimated from normative loads by similar uses.
- (b) Spatial scatter may be comprehended with enough data, but temporal scatter, especially that resulting from the concentration of people and furniture occurring only once in several years or even once in more than a period of time, cannot be determined with few data. It is considered that the current sustained live loads in practice could be referred without serious danger or loss of serviceability and, therefore, the basic value of live load is estimated on the basis of the sustained load data surveyed.

In addition, in some cases, the normative design loads values had been increased without account a formal survey, because it is intended to expect that buildings might be used for other purposes than those for which they were originally designed. For example, the design loads for offices proposed in the Mexico City Building Code (MCBC) were increased for areas larger than 37.2 m² to the values that appeared in

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the new version in 1993 (Fig. 1a), as a result of that many of the buildings damaged during the 1985 earthquake in Mexico City were overloaded. In fact, several buildings in the downtown zone that were designed as office buildings were used as sewing shops and fabric storage areas instead (Ruiz and Soriano 1997). The evolution for the typical uses, according to MCBCs, over time is shown in Fig. 1a.

The general features of a type of loads are fairly similar within a group of structures. In fact, several researches have focused attention in the study of the design live loads for structures with different specified uses (e.g., CIB 1989; Choi 1991; Ruiz and Sampayo-Trujillo 1997; Wen and Yeo 2001; Tapia-Hernández et al. 2017; Saberi et al. 2017). However, since there are not enough data for the current condition of live loads on floors of libraries, their normative demands are estimated from other building uses. For example, according to the MCBC-17 (Fig. 1a), the design live load at libraries has been classified as a gathering place (with or without fixed seats), which includes temples, churches, theaters, auditoria, gymnasias, dance floors, restaurants, games rooms, arcades and similar, despite the fact that different conditions and load demands might be expected between them.

The normative live loads on floor of libraries according to some international codes are compared in Fig. 1b. Four international regulations were considered: North-America ASCE/SEI 7-10 (2010), Japan AIJ-06 (2006), Canada CNBC-15 (2015) and Mexico MCBC-17 (2017). A single magnitude of live load is established in the MCBC-17, which applies equally to reading rooms and stack rooms. It is worth noting that the design live load for stack rooms,

according to the MCBC-17, is the lower limit, and in fact, it is equivalent to the load specified by the CNBC-15 for reading rooms. No information is included between the compared codes to define the design load for newspaper archive buildings; thus, the load should be estimated from normative loads of libraries.

Additionally, current codes provide somewhat deliberate guidance in regard to treatment of live loads in the seismic analysis. For example, ASCE 7-16 requires consideration of 25% of the live load as inertia. These normative percentages are typically not questioned because live loads may not be so significant in relation to the dead load and because of the perception that only a minor portion of the live load is likely to be present at the time of occurrence of an intense earthquake. However, for storage structure such as libraries, live loads are nearly permanent (Smith-Pardo et al. 2015).

Book shelves that collapsed at a public library during the earthquake that struck Mexico City on September 2017 are shown in Fig. 2. Although light damage was found at structural elements, the inertial forces of the storage racks destroyed the library facilities. Therefore, an improved assessment of the actual load in stack rooms is desirable in order to get better estimates of the hazard level of the building and the structural elements.

With this panorama, this research aims to evaluate the design live loads on floors of libraries and newspaper archives buildings, according to the typical conditions in buildings of Mexico. Pursuant to this goal, a detailed live load survey was carried out, which included furniture, people and other items typical used in libraries. The study

Fig. 1 Design live loads in codes ($0.5 \text{ kN/m}^2 = 10.44 \text{ psf}$)

Fig. 2 Facilities of a library destroyed during the September 19, 2017 earthquake

pretends to improve the acquired knowledge and explores a more realistic assessment of the live load demands on the actual conditions of these particular floors uses.

Basic value of design live load

According to some specialized recommendations (e.g., AIJ-2006), the basic value of live load Q_0 is defined as sustained load by Eq. 1.

$$Q_0 = k_e k_a k_n Q \quad (1)$$

where Q is the basic live load intensity, which is obtained statistically; k_e is a conversion factor for equivalent uniformly distributed load; k_a is an area reduction factor; and k_n is a multi-story reduction factor.

Conversion factor for equivalent uniformly distributed load k_e

The conversion factor for equivalent uniformly distributed load k_e is used for converting the nominal live load intensity of a survey to the equivalent uniformly distributed load of a specific area. The conversion factor k_e is estimated differently for structural elements such as slabs, beams, columns and foundations, because the influence of their disposition state on load effect is quite different.

The structural elements are analyzed elastically to investigate the influence on structure based on the furniture disposition obtained from a survey. k_e is the ratio of the 99-percentile value of the equivalent uniformly distributed load to that of the averaging weight over the influence area.

According to AIJ-06, the conversion factor for uniformly distributed load of slab in stack rooms is equal to $k_e = 1.6$ and is equal to $k_e = 1.2$ for beams, columns and foundations.

Area reduction factor k_a

Moreover, since the live load obtained from a survey is averaged over the area, as the area increases, the variation of live loads becomes smaller. This variation is accounted by the area reduction factor k_a (Eq. 2).

$$L_1 = a + \frac{b}{\sqrt{A_l/A_{\text{ref}}}} \quad (2)$$

where L_1 indicates the reduced live load intensity, A_l is the influence area, and A_{ref} indicates the reference area. Parameters a and b are estimated using the method of least squares in the relation of the 99-percentile load to the unit area. The statistical data of square units with an area or more are used for the parameter estimation. Parameters a and b are normalized by dividing Eq. 2 by the basic live load intensity. Thus, the normalized formula for the reduction factor k_a is defined by Eq. 3.

$$k_a = a' + \frac{b'}{\sqrt{A_l/A_{\text{ref}}}} \quad (3)$$

The area reduction factor k_a shall be formulated using statistical data of the uniformly distributed load. According to the MCBC-17, members for which a value of A_l is 36 m² or more are permitted to be designed for a reduced live load in accordance with Eq. 4.

$$k_a = a' + \frac{b'}{\sqrt{A_t}}. \quad (4)$$

For residential flats, the parameters are equal to $a' = 0.6$ and $b' = 7.8$ in N/m^2 , which include dwellings, hotels rooms, multifamily houses, apartments, houses, boarding schools, military headquarters, fire stations, jails, reformatories, hospitals. For office buildings and laboratories, the parameters are equal to $a' = 1.1$ and $b' = 8.5$ in N/m^2 . No reductions are proposed for other floor uses; namely, the full intensity of the live load shall be applied.

In particular, the live loads in stack rooms might be regarded as less random. The location of book shelves is systematic to some extent as a result of the use, without changes or remodeling over the years. Thus, the load caused by stored objects may consist of a number of loads sustained and distributed over areas with few and smooth fluctuations over a long period of time. In any case, they might tend to increase over the time, because of the acquisition of new editions or new copies.

Multi-story reduction factor k_n

Finally, the axial compression stress in building columns caused by live loads is the cumulative stress of the live loads on every floor. Therefore, the variation of axial compression in a multi-story column becomes smaller as the number of floors supported increases, because the variation on every floor is averaged. Thus, in calculating the axial compression caused by live loads, the design live load can be reduced according to the number of stories supported by the column, throughout the multi-story reduction factor k_n .

However, this load reduction does not apply where loads are produced mainly by people for two reasons (AIJC-06). One is that the temporary concentration of human load can easily occur, and the other is that the load distribution over different floors cannot be clearly described. When the multi-story reduction factor k_n is used, the influence area of a single-story column is used as the influence area to calculate the reduction factor k_n (Eq. 5).

$$k_n = \frac{1 + \beta \delta_i \sqrt{\frac{\rho(1-\rho)+1}{n}}}{1 + \beta \delta_i} \quad (5)$$

where n is the number of stories, δ_i is the tributary area of the column, β is the reliability index based on the second moment method, and ρ is the correlation coefficient of live loads between two different floors. According to AIJ-06, $\beta = 2.33$ for a 99% limit value based on the second moment method and the correlation coefficient is equal to $\rho = 0.119$ based on survey results for office buildings. Substituting these values, removing the square and rounding the

coefficients, the multi-story reduction factor is derived as follows for office buildings (Eq. 6).

$$k_n = 0.6 + \frac{0.4}{\sqrt{n}}. \quad (6)$$

Since, in this study, the live load on floor of libraries is discussed from the mean influence area for each slab, instead the axial compression in columns, the multi-story reduction factor was accounted equal to $k_n = 1$.

Statistical data

A detailed survey of 1603 m^2 of library floor and 362 m^2 of newspaper archive was performed. The type of live load considered was limited to loads resulting from the intended use of the library and newspaper archive building at a public University at the Metropolitan area of Mexico City (Fig. 3). The building was built in 1974, and it is structured with moment resisting reinforced concrete frames. This paper discusses the results of a detailed survey of live loads on typical floor of libraries and newspaper archives. In spite of the fact that the type of live load considered was limited to loads resulting from the intended use of the library and newspaper archive building in a public University in Mexico City, the results may be cautiously extrapolated for similar settings around the world. The study included furniture, racks and shelves, as well as books, journals, papers and other items used in libraries. Considering temporal concentration, an additional survey of people was estimated separately, in reading rooms during 2 months and more than 3 months at the corridors of the stack rooms.

The building is located near the boundary between hill and transition zones of Mexico City, according to the seismic zonification of the MCBC-17. The distribution of the collections by floor is depicted in Table 1. Further information can be found in Martínez-Ruiz (2017).

The library section is organized following the classification system of the Library of Congress Classification (LCC), which was developed in the late nineteenth and early twentieth century to organize and arrange the book collections of the Library of Congress of United States of America, whereas the newspaper archive collection is made up by publications (journals and newspapers): (1) 1200 printed journals, which represent 180,000 fascicles and (2) eight national newspapers and two international newspapers, which represent 900 copies. Further information might be found in Domínguez-Palacios (2016).

The survey included furniture, racks and shelves, as well as books, journals, papers and other items used in libraries (Fig. 4). The loads acting on the floors underwent an initial

(a) Front entrance

(b) Interior view at the second floor

Fig. 3 Studied building**Table 1** Organization of the library building

Level	Facilities	Extension (m ²)
Ground floor	Newspaper archive Electronic resources Specialized collection	362.0
First floor	General collection Q–Z Audiovisual collection	725.0
Mezzanine	Rare books Collection of reference works	168.0
Second floor	General collection A–P	710.0

inspection, then some typical areas were selected, and data were processed in order to ensure that samples were a fair representation of the actual load.

In this study, it is assumed that the live load on a library can be treated as stationary homogeneous random field in space and time. This means that the statistical distribution does not change with time, which is an assumption that is desirable to make it possible to use the results of this survey to other similar buildings.

Sampling results

Two platform scales were used to estimate the sustained loads of the book shelves per unit area, each with a capacity of 4.9 kN (1.1 kips). In the process, books of engineering, drawing and architecture were selected as typical loads of the library area. And journals of engineering and social sciences were selected for the newspaper archive area. Then,

(a) Representative view at the Library (Second floor)

(b) View at the newspaper archive (ground floor)

(c) Typical rack at the library and newspaper archive

Fig. 4 Characteristics of the stack rooms

a typical shelf was weighted (Fig. 4c), and subsequently, the publications were carefully weighted by each ledge until complete the set of book shelves (Fig. 5). In this process, a strict control of the weights per ledges and shelves were conducted in order to perform the statistical analysis of the actual loads as discussed below.

Representative results of double-faced book stacks (shelves and publications) are shown in Fig. 6. It is worth noting that some book shelves apply more than 4.50 kN (9.92 kips) on the slab, which may represent the design condition. In fact, according to ASCE 7-16, floors of stack rooms in libraries shall be designed to support safely a concentrated load equal to 4.45 kN (9.81 kips) at the most unfavorable position. This recommendation agrees with the results on the floor of the library (Fig. 6a), but it is necessary to increase in 20 percent the value (5.3 kN; 11.7 kips) in order to achieve a better representation of the actual effects on the floor of the newspapers archive (Fig. 6b).

Influence of the area

The design live loads are the maximum loads expected by the intended use or occupancy and shall not be less than the minimum uniformly distributed unit loads established in codes (e.g., ASCE 7-16; MCBC-17). The scatter of the averaged load (live loads divided by the area on which they act) becomes smaller as the area becomes larger. This is because live loads are averaged over the area. Therefore, the basic live load intensity should be determined considering the influence of area.

For the above, in calculating statistic values, the surveyed data were divided into square unit areas, such as 1 m², 4 m² (2 m × 2 m) and 9 m² (3 m × 3 m) as far as 100 m² (10 m × 10 m) and the averaged loads were calculated for

each case. In codes, this tendency is evaluated by the area reduction factor k_a discussed above. The obtained results for the library and newspaper archive are depicted in Fig. 7, which also includes the normative area reduction factor for residential flats and office buildings according to the MCBC-17 (Eq. 4).

The results in Fig. 6 are called the analysis of averaged live load intensities for square unit areas. Load models are area dependent (Choi 1991). In general, it is expected that load values are small for large areas and grow for small areas. However, the variation of live loads on floors of libraries and newspaper archives is such less sensitive to the area of influence in comparison with the factor for residential flats or office buildings. In fact, the live loads are practically constant from 25 m², equal to 2.6 kN/m² (54.3 psf) for the library and 3.0 kN/m² (62.7 psf) for the newspaper archive. This means that the magnitude might be established in regardless of the influence area in practice, because the load caused by book shelves consists of loads sustained and distributed over areas with few and smooth fluctuations. This tendency supports the recommendation of ASCE 7-16 and MCBC-17, where a reduction in uniform live loads in stack areas as a function of the area supported by the element or by the tributary area under any condition is not permitted.

Sampling of people

The uniformly distributed live loads established in codes also include the weight of users normally present. The ratio of the magnitudes of the load caused by persons in ordinary load situations and the load caused by furniture may vary considerably depending on the type of structure and the occupancy along the day.

Fig. 5 Field work (weighing process)

Fig. 6 Location of the measured loads ($0.5 \text{ kN/m}^2 = 10.44 \text{ psf}$)

(a) Typical results on floor of library

(b) Typical results on floor of newspaper archive

Fig. 7 Live load intensities for square unit areas ($1.0 \text{ kN/m}^2 = 20.89 \text{ psf}$)

In residential flats and office buildings for example, it is expected that only a minor portion of the live load is likely to be present at the time of occurrence of an extraordinary event, in relation to the dead load; nevertheless, this perception might not be suitable for stack rooms. With this in mind, parallel to the weighing of the book shelves, a sampling of the people was carried out in the reading room (Fig. 8a) and on the corridors of the stack rooms at the library (Fig. 8b). The sampling of people was not considered at the newspaper archives, since it is a restricted access area. The weight of persons was here regarded as constant in time (in the same way as the fluctuating part of the weight of book shelves).

A sampling of users was performed from 7:00 am to 21:00 pm within working days in areas from approximately 100 m^2 . In reading room, the measurements were carried out during 32 working days (almost 2 months), whereas the sampling was conducted over 66 working days at the aisles of stack rooms (more than 3 months). The academic year at this university is divided upon a trimester-based

system. The trimester consists of 12 intensive teaching weeks including some exams periods. For this reason, the sampling at the aisles of stack rooms was carried out during 13.2 weeks (66 days), in order to cover the ordinary teaching weeks, exam seasons and the break weeks. The number of users, depending on the time of day, is shown in Fig. 9.

According to the results, the maximum number of users at reading room happened around noon with a maximum of 35 people (Fig. 9a). In contrast, six was the maximum number of users at aisles of stack rooms (Fig. 9b). Assuming 0.70 kN (0.16 kips) per person, based on similar studies (Ruiz and Soriano 1997; Ruiz and Sampayo-Trujillo 1997), the weight per unit area linked to the users would be 0.042 kN/m^2 in the worst-case scenario ($6 \times 0.7 \text{ kN}/100 \text{ m}^2$). This implies that most of the live load in stack rooms is closely related to the weight of shelves and publications. And in fact, in newspaper archives, the live load depends only on the furniture, since the amount of users tends to zero.

This result is relevant in regard to the treatment of live loads in the seismic analysis, being that the weight would not be reduced or removed during an earthquake in libraries or newspaper archives. In other building uses, the normative percentages might typically not be questioned since live loads may not be so significant. In storage structures, dynamic amplifications of live loads have been previously identified and investigated in cars parking garages (Wen and Yeo 2001) or containers stacks (Smith-Pardo et al. 2015). According to the obtained results for stack rooms, live loads (1) could exceed the dead load (Fig. 6) and (2) are nearly permanent for practical purposes (Fig. 9). For this reason, some codes require consideration of 25 percent of the live load as inertia in storage floors (e.g., ASCE/SEI 7-10), but might not be enough conservative and need to be studied further in order to develop a normative proposal.

(a) View of the reading room

(b) View of a typical stack room

Fig. 8 Areas of the sampling of people

Fig. 9 Users sampling results

In spite of this negative panorama, during an earthquake, storage slabs may slide or rock and this action affects the way in which the building responds to the excitation. Because such movement is accompanied by energy dissipation associated with friction or impact, only a portion of live load effectively contributes to the inertial forces action on the structure (Smith-Pardo et al. 2015). In anyway, further analyses to evaluate the energy dissipation under lateral seismic demands are desirable in order to calibrate the live load reduction in codes.

In contrast, the situation may be quite different for reading rooms where the weight of users is a large part of the total live load. So, a reduction in the gravitational load during an intense earthquake is expected as established in current codes (Fig. 1b).

Finally, considering temporal concentration, people and furniture should be estimated separately because of their different dispositions. For this reason and accounting that the weight of users is small, the following discussion that pretends a better understanding of live loads in libraries focuses the attention on the book shelves loads mainly.

Statistical study

Four types of probability distributions are usually applied in engineering issues: normal, lognormal, Gumbel and Gamma. In fact, sometimes other distributions are also applied, but have not significantly influenced the results (Ang and Tang 2007). In particular, both normal and lognormal distributions are used to establish the probability of occurrence, where the normal distribution is symmetrical and a lognormal one is not. Here, a lognormal distribution was considered, because it is useful in decision making as a

description of natural phenomena. The frequency distributions into class intervals on the basis of the lower value are shown in Fig. 10.

The coefficient of variation for the load data on floors of the library was equal to $CV = 0.167$, whereas that for the newspaper archive was equal to $CV = 0.162$. And then, the lognormal density functions are shown in Fig. 11, including the normative design value of 3.43 kN/m^2 (71.64 psf), according to the MCBC-17. The averages values per unit area resulted as follows: $\mu_{\text{Library}} = 3.5 \text{ kN/m}^2$; and $\mu_{\text{Newspaper archive}} = 3.9 \text{ kN/m}^2$.

According to the results, for practical purposes, the normative magnitude (3.43 kN/m^2 ; 71.6 psf) is an adequate representation of the mean value of the actual load on the floor of the library; however, for the newspaper archive, it is 11% less than the mean value. In contrast, the magnitude of the live load for stack rooms according to the ASCE/7-16 (7.18 kN/m^2 ; 150.0 psf) is not an adequate representation of the local conditions.

It is worth noting that the normative load is not conservative, since it implies a relevant percentage of measured loads that are not covered. Thus, in order to evaluate the suitability of the normative live load according to the MCBC-17, the cumulative probability distribution was obtained (Ang and Tang 2007) as shown in Fig. 12. In this study, an index of probability equal to unity would represent the case in which the load proposal envelops the obtained data in the survey, whereas an index equal to zero represents a proposal where all data exceeded that load magnitude.

Based on the results (Fig. 12), the normative value (3.43 kN/m^2 ; 71.6 psf) is related to a probability of occurrence of 0.47 for the library and 0.24 for the newspaper archive. This indicates that the local design load for stack rooms might not enough conservative and it would

Fig. 10 Frequency distribution ($1.0 \text{ kN/m}^2 = 20.89 \text{ psf}$)

Fig. 11 Density distributions of loads ($0.5 \text{ kN/m}^2 = 10.44 \text{ psf}$)

be desirable to define a live load for each case (libraries and newspaper archives), since the data and probabilities are not equivalent between them. Thus, it is necessary to increase the basic live load for purposes of design of newspaper archive buildings in relationship to the one defined for libraries.

For design purposes, the probability of occurrence of 0.84 might be appropriate. This is related to a live load equal to 4.1 kN/m^2 (85.6 psf) for the library (Fig. 12a) and 4.8 kN/m^2 (100.3 psf) for newspaper archive. These results apply to stack room floors that support non-mobile, double-faced library book stacks, where the shelf depth is around 27.5 cm (10.8 in) for each face and parallel rows of double-face book stack is separated by aisles around 80.0 cm (31.5 in) wide as depicted in Fig. 6. Finally, it is worth noting that the basic live load magnitude must be defined according to

each code's philosophy, since the appropriate magnitude of the probability of occurrence and the magnitude of basic live load are linked to the load factors applied in the load combinations.

Conclusions

This paper discusses the results of a detailed survey of live loads on typical floor of libraries and newspaper archives. In spite of the fact that the type of live load considered was limited to loads resulting from the intended use of the library and newspaper archive building in a public University in Mexico City, the results may be cautiously extrapolated for similar settings around the world. The study included furniture, racks and shelves, as well as books, journals, papers

Fig. 12 Cumulative total loads ($0.5 \text{ kN/m}^2 = 10.44 \text{ psf}$)

and other items used in libraries. Considering temporal concentration, an additional survey of people was estimated separately, in reading rooms during 2 months and more than 3 months at the corridors of the stack rooms.

Based on the results, density distribution and fragility curves were performed in order to evaluate the suitability of the live load for gathering rooms, according to the Mexico's City Building Code (MCBC-17) in relation to the actual condition. The paper provides some detailed background behind the basic value of design live load of the current specialized codes and its relationships with the results of this study.

The main contributions of this research are as follows:

- According to the results, the actual live loads in stack room floors of libraries and newspaper archives are not equivalent, when the weight of shelves and publications is accounted for. The general features of this type of loads might not be fairly similar between different gathering rooms (temples, churches, theaters, auditoriums, gyms, dance floors, restaurants, game rooms, galleries and similar) as it is currently proposed at the Mexico City Building Code (MCBC-17). In fact, when the normative load is compared with other international regulations, it is noted that a more detailed definition is required by the Mexican Code.
- The measured loads of double-faced book stacks (shelves and publications) noted that floors of stack rooms in libraries shall be designed to support a concentrated load around 4.45 kN (9.81 kips) at the most unfavorable position such as recommended by ASCE 7-16. But it is necessary to increase in 20% that value of the concentrated load, in order to achieve an appropriate representation of the actual effects on the floor of the newspaper archive.
- The analysis of averaged live load intensities for square unit areas concludes that the variation of live loads on floors of libraries and newspaper archives is less sensitive to the area of influence compared to the reduction factor for residential flats and office buildings. In fact, the live loads are practically constant from 25 m^2 ; therefore, live loads in stack rooms might be regarded as less random in practice. The location of racks is systematic to some extent as a result of the uses, without changes over the years. The load caused by stored objects may consist of a number of loads sustained and distributed over areas with few and smooth fluctuations a long period of time. In any case, they have a tendency to increase uniformly over the time of occupancy, because of the acquisition of new editions or new copies.
- The sampling of the users noted that the number of users at aisles of stack rooms is negligible even in the maximum sampled value. Thus, the live load is closely related to the weight of shelves and publications. This result is relevant in regard to the treatment of live loads in the seismic analysis for purposes of design and practical implementation, being that the weight would not be reduced or removed during a strong earthquake.
- Through a statistical study, density distributions and fragility curves were obtained accounting the actual conditions in a typical public library. It was concluded that the current proposal in the local code (MCBC-17) is adequate to estimate just mean values of the live loads, which corresponds to an associated probability of exceedance of 0.53 and 0.76 for the library and newspaper archives, respectively. Based on a probability of occurrence of 0.84, proposals of the basic value of design load intensity were developed, equal to 4.1 kN/m^2 for the library and 4.8 kN/m^2 for newspaper archive. This dis-

cussion is relevant to define an appropriate magnitude of the live load, since in current codes, the issue of whether nominal design loads are intended to be means or upper bound values is linked to the load factors applied in the load combinations. Because of this, the proper basic value of design load shall be defined according to each code's philosophy.

- According to the results, the live load proposed at ASCE 7-16 of 7.18 kN/m^2 is conservative for the local actual conditions.

Additional samples of libraries and newspaper archives could complement and potentially help for the calibration in the design codes. Caution should be exercised by designers, before the generalized application of the above statements as they correspond to finding for the specific cases analyzed here.

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