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Dynamical response of composite steel deck floors

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Abstract

Structural engineers are nowadays facing a significant challenge related to the development of lighter and economical composite steel-concrete floor structures. A direct consequence of this new design trend is a considerable increase in the problems related to unwanted floor vibrations. This phenomenon is becoming very frequent in a wide range of structures subjected to rhythmic dynamical actions. The proper consideration of all the above-mentioned aspects pointed out the development of a properly calibrated finite element model that could accurately represent its structural response. The model was used to investigate a real composite floor dynamic behaviour based on the determination of its natural frequencies and vibration modes later to be compared to available experimental evidence. The investigated composite floor has 18m x 31m and is used for dancing activities. Preliminary results indicated that, for every studied computational model, the values of the structure natural frequencies could be significantly affected. However, the vibration modes remained very similar despite of the adopted computational model.

Keywords: vibration, composite floor, composite floor structural dynamics, composite structures, serviceability, human walking, dynamic loading factor and dynamic structural design.

1 Introduction

Structural designers have long been trying to develop minimum cost solutions, as well as to increase the construction speed. This procedure has produced slender structural solutions, modifying the ultimate and serviceability limit states that govern their structural behaviour. A direct consequence of this new design trend is a considerable increase in the problems related to unwanted floor vibrations. This phenomenon is becoming very frequent in a wide range of structures subjected to rhythmic dynamical actions. These actions are generally caused by human activities such as: people walking, sporting events, dance or even gymnastics.

Composite floors supported by columns are widely used for floors in offices, shopping centres and airport terminals. The use of this type of structure can lead to a serviceability problem due

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to vibrations produced by people walking indicating that this should be considered in design. However, the dynamic behaviour of composite floors is not well understood. Considering all aspects mentioned before, the main objective of this study is to identify an appropriate finite element model for this type of composite floor that could be used to study its dynamic behaviour.

The investigated structural model was based on an existing composite floor at the city of Belo Horizonte, Brazil. The structure dimensions are 18m by 31m. The structural system, used for the floor, is composed of a composite (steel/concrete) solution made of a “I” steel beam section and a reinforced concrete deck and is currently used for dancing in rock concerts.

Dynamic tests on the analysed composite floor were conducted by Ref. [11]. The tests involved monitoring the acceleration at the centre of each floor area. The structure was excited through a person of a height of approximately half meter, jumping on the floor [11]. The response was then converted to an auto spectrum using an FFT procedure and the dominant natural frequency identified (i.e. many spectra showed several modes although one mode would dominate the response at any one position).

The numerical and experimental studies on the floor have been conducted independently. The improvement of the numerical models is based on the comparison between the predictions, measurements and engineering judgement. Similar work, where both numerical and experiment studies are concerned, can be found in Refs. [1, 3–7, 9, 12–14].

This type of testing was undertaken as it is both simple, quick and provides data for comparing the various bays. The measurements provided a basis for evaluating the quality of different finite element models. Consequently, finite element analysis of several commonly used models were conducted, and numerical and experimental results were compared. This led to the development of refined finite element models and indicated that a floor-column model can be used for studying a long-span flat composite floor, supported by columns, dynamic behaviour.

2 Floor vibrations due to human activities

Although the design criteria for evaluation of the vibration levels induced by human rhythmic activities have been known for many years, only recently it was possible to apply it to the design of floor structures. The main reason was related to the considerable problem complexity. The load is also extremely complex while the structural system dynamic response, generally involves a high number of vibration modes. Over the past few years, a lot of studies have indicated that the problem can be simplified to be properly applied to the design practice [3, 6, 8, 10].

Most floor vibration problems generally involve dynamic actions related to repeated forces caused by machines, equipments or for human activities, such as: dancing, jumping, running, aerobics (gymnastics) or walking. The problem associated to people walking is a little more complicated than the others because the forces change location within each step. In some cases, the applied force is sinusoidal or similar.

In order to control the problem of excessive vibrations on the structural systems subjected to this type of dynamic loading, it is usually recommended to increase the structural system stiffness or damping, installation of dampers or even to limit the use of the structure to avoid critical loadings induced by people.

The type of dynamic loading considered in this investigation is induced by human activities such as walking, running, jumping, dance, sport events or even gymnastics. This type of dynamic action basically occurs in structures like floors, footbridges and gymnasiums when submitted to rhythmic human activities.

Generally, the dynamic excitations induced by human activities can be represented through a combination of harmonic forces, whose frequency, f, are multiples or harmonics of the basic frequency of the dynamic solicitation. A typical example is the step frequency, f_s, for human activities. These harmonic forces or time-dependent repeated forces could be represented by the Fourier series, as presented in the Eq. (1).

$$F(t) = P\left[1 + \sum \alpha_i \cos\left(2\pi i f_s t + \Phi_i\right)\right] \tag{1}$$

Where:

P: person's weight, taken as 700N-800N [1, 3, 6];

α_i: dynamic coefficient for the i^{th} harmonic force component;

i: harmonic multiple of the step frequency (i = 1,2,3...,n);

f_s: step frequency of the activity (dancing, jumping, aerobics or walking);

t: time in seconds;

Φ_i: phase angle for the harmonic.

As an example, Figs. 1 to 2 present time records of the dynamic loading functions for two different human activities such as: walking and dancing. These loading functions were generated through the equation (1).

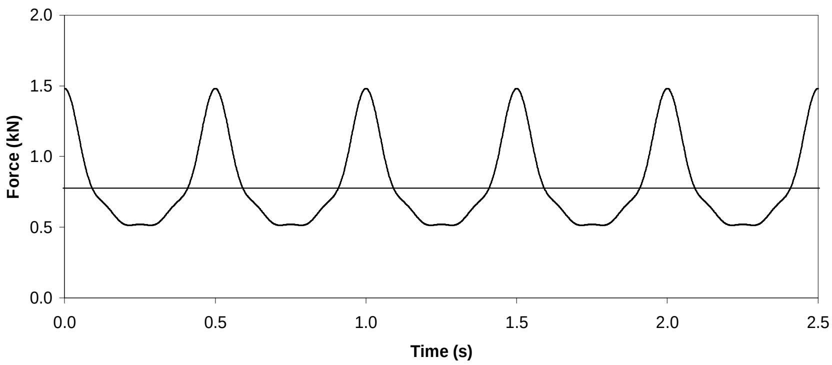

Figure 1: Dynamic loading function for one person walking at 2.0Hz.

As a general rule, the magnitude of the dynamic coefficient, α_i, decreases with an increase of the harmonic. For example, the dynamic coefficient regarding with the first four harmonics

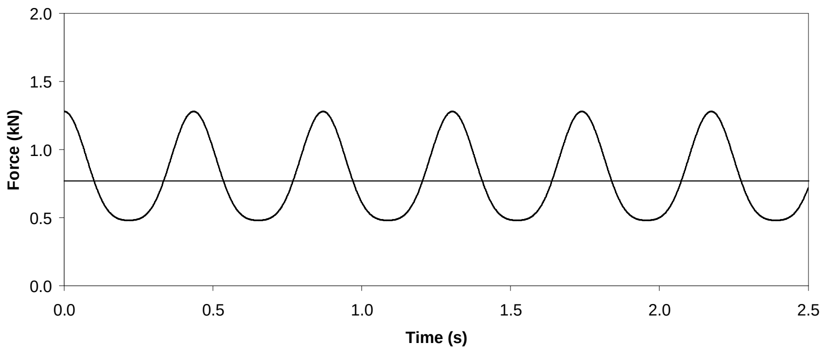

Figure 2: Dynamic loading function for one person dancing at 2.3Hz.

corresponding to the human activity of walking are 0.5, 0.2, 0.1 and 0.05, respectively. Another important point that should be considered in the floor vibration analysis is associated to the matching of any excitation frequency produced by the humans and the natural frequency of a structural system vibration mode, in which case the resonance phenomenon will occur, causing large amplifications in the system dynamic response.

In the floor vibration analysis the human activities of dancing, jumping or aerobics excite the first structural system vibration modes, since the higher modes are more difficult to excite. This is true because people are spread out over a relatively large area and tend to simultaneously force all the floor panels in the same direction, whereas adjacent panels must move in opposite directions for a higher modal response [6].

People walking generate a concentrated force in certain points of the structure and therefore may excite higher floor vibration modes. However, higher floor mode shapes are generally excited only by relatively small harmonic walking force components when compared to those related to the lowest floor vibration modes. Thus, in current design practice, only the lowest floor vibration mode is considered for human activities [6].

The control of the maximum acceleration of the structural system, associated to a resonance condition, tends to be more efficient when the sinusoidal forces are small, as in the case of people walking. This control can just be made increasing the structural system damping or mass. The system natural frequency also plays a role, because the intensity of the harmonic forces generally decreases with the increase of the harmonic, that is to say, the higher the harmonic frequency the lower will be the dynamic force intensity. Generally, the design criteria for floor vibration analysis due to people walking are based on these principles.

When the dynamic forces are significant, as in human activities like dancing, jumping or aerobics, the structure maximum acceleration is too great at resonance and is very difficult to be practically controlled by increasing the system damping or mass. In this case the floor natural frequency of any mode shape excited by the dynamic force must be kept away from the excitation frequency range. This generally means that the floor fundamental frequency must be made higher than the highest harmonic force excitation frequency. On the other hand, when the floor natural frequency is near or higher than 9Hz-10Hz, the resonance phenomenon becomes less important for human induced vibration.

3 Loading induced by people walking

The design criteria for vibrations analysis associated to human induced activities presented in this work can be used to evaluate the structural systems supporting offices, shopping malls, footbridges and similar occupancies. The design criteria [6], was developed based on the following hypotheses:

a) The acceleration limit values were considered as recommended International Standard Organization ISO 2631-2 [10]. The ISO Standard [10], suggests limits in terms of *rms* (root mean square) acceleration as a multiple of the baseline line curve shown in the Fig. 3. The multipliers for the proposed design criteria, expressed in terms of peak acceleration, are equal to 10 for offices, 30 for shopping malls and indoors footbridges, and 100 for outdoors footbridges. For design proposes, these limits ranges from 0.8 to 1.5 times the recommended values [7], depending on the vibration duration and frequency.

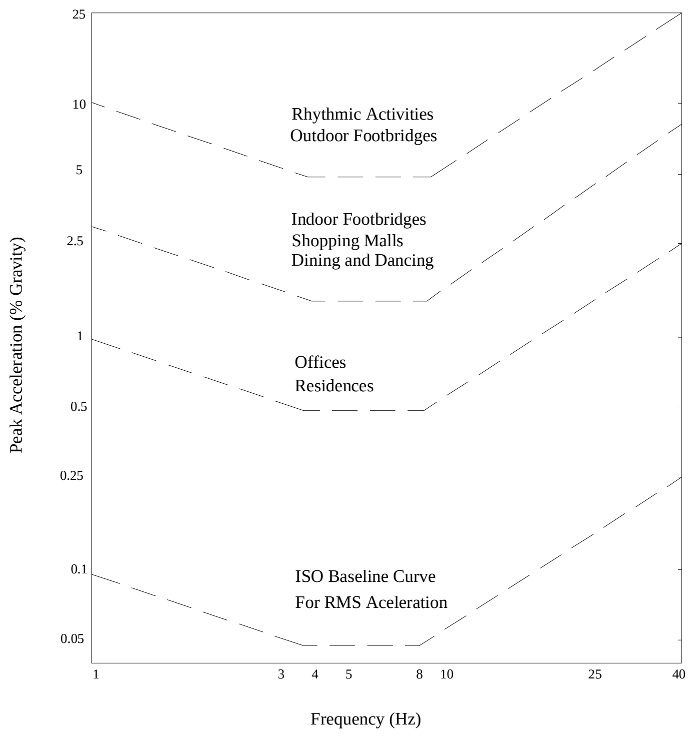

Figure 3: Recommended peak acceleration for human comfort for vibrations due to human activities [10].

b) A time dependent harmonic force component, which coincides with the floor fundamental frequency, was considered, as shown in the Eq. (2):

$$F(t) = P\alpha_i \cos(2\pi i f_s t) \tag{2}$$

As recommended by the design criteria only one harmonic component is used in the case associated to walking, since the participation of all other harmonic components is small when compared to the harmonic associated with the resonance condition. In the sequence, Tab. 1 presents average values of the forcing frequency, f_s, and dynamic coefficient, α_i, [6].

Table 1: Common forcing frequencies (f_s) and dynamic coefficients (α_i) [6].

Harmonic	Walking		Aerobics Class		Group Dancing	
(i)	f_s (Hz)	α_i	f_s (Hz)	α_i	f_s (Hz)	α_i
1	1.6 - 2.2	0.5	2.2 - 2.8	1.5	1.8 - 2.8	0.5
2	3.2 - 4.4	0.2	4.4 - 5.6	0.6	3.6 - 5.6	0.1
3	4.8 - 6.6	0.1	6.6 - 8.4	0.1	-	-
4	6.4 - 8.8	0.05	-	-	-	-
α_i = peak sinusoidal force/human weight						

Thus, considering all the before mentioned hypotheses, a resonance response function, in terms of the system maximum acceleration, can be written according to Eq. (3):

$$\frac{a}{g} = \frac{R\alpha_i P}{\beta W} \cos(2\pi i f_s t) \tag{3}$$

Where:

a/g: ratio of the floor acceleration to the acceleration of gravity;

g: acceleration of gravity ($g = 9.81 m/s^2$);

R: reduction factor;

β: modal damping ratio;

W: effective weight of the floor.

The reduction factor, R, is equal to 0.7 for footbridges and 0.5 for floors structures in a two-way mode shape configuration [6]. The reduction factor considers that the full steady-state resonant motion do not happens for walking and that the human walking and the human annoyance are not simultaneously at the locations of maximum modal displacement [6].

The design criteria considers that the peak acceleration due to human walking can be calculated by Eq. (3), by selecting the lowest harmonic, i, for which the excitation frequency, $f = if_s$, matches with the composite floor natural frequency. This is usually followed by a comparison of the peak acceleration to the recommended peak acceleration to ensure human comfort [6,10], as illustrated in the Fig. 3.

On the other hand, the Eq. (3) can be simplified considering the relationship between the dynamic coefficient for the ith harmonic force component, α_i, and the forcing frequency, f, according to Eq. (4) [6]:

$$\alpha_i = 0.83\exp(-0.35f) \tag{4}$$

Thus, the Eq. (3) can be rewritten, based on the Eq. (4), as presented in the Eq. (5).

$$\frac{a_p}{g} = \frac{P_0\exp(-0.35f_n)}{\beta W} \leq \frac{a_0}{g} \tag{5}$$

Where:

a_p/g: estimated peak acceleration (in units of g);

a_0/g: acceleration limit recommended by ISO 2631-2 [10];

f_n: natural frequency of floor structure;

P_0: constant force ($P_0 = 0.29$kN for floors and $P_0 = 0.41$kN for footbridges) [6].

The numerator, $P_0\exp(-0.35f_n)$, as shown in the Eq. (5), represents a harmonic force due to human walking which results in resonance response at the floor natural frequency, f_n [6].

4 Loading induced by human rhythmic activities

Many design criteria have been developed for the vibration analysis of floors structures submitted to rhythmic human activities [1, 3–10, 12–14]. Generally, the design criteria presented in this work is based on the floor structures dynamic response submitted to rhythmic exercises forces considered as to be distributed over all or part of the floor. The design criteria can be used to evaluate structural systems submitted to dynamic forces such as: aerobics, dancing, audience participation and similar events [6].

As an example, Figs. 2 and 3 have presented time records of the dynamic loading functions for human activities such as: dancing and aerobics. Table 1 must be used to obtain average values of the forcing frequency, f_s, and dynamic coefficient, α_i, [6].

The floor structure peak acceleration due to a harmonic rhythmic force is calculated based on the classical solution considering that the floor has only one vibration mode [6].

$$\frac{a_p}{g} = \frac{1.3\alpha_i w_p/w_t}{\sqrt{\left[\left(\frac{f_n}{f}\right)-1\right]^2 + \left[\frac{2\beta f_n}{f}\right]^2}} \tag{6}$$

Where:

f: excitation frequency;

w_p: effective weight per unit area of participants distributed over floor panel (N/m^2);

w_t: effective weight per unit area of floor panel, including occupants (N/m^2).

Expression (6) can be simplified considering the floor resonance condition, $f_n = f$, as presented in Eq. (7).

$$\frac{a_p}{g} = \frac{1.3}{2\beta}\frac{\alpha_i w_p}{w_t} \tag{7}$$

Or even considering the condition, $f_n > 1.2f$, above resonance, as shown in the Eq. (8).

$$\frac{a_p}{g} = \frac{1.3}{\left(\frac{f_n}{f}\right)^2 - 1}\frac{\alpha_i w_p}{w_t} \tag{8}$$

Most of the problems associated to human comfort occur when the forcing frequency, $f = if_s$, is equal or even close to the floor structure natural frequency, f_n, for which the peak acceleration is calculated by Eq. (7). However, vibrations from lower harmonics, i.e., first or second, may still be substantial, $f_n > 1.2f$, and, in this situation, the peak acceleration is obtained by Eq. (8).

According to these above mentioned aspects, the effective maximum acceleration, accounting for all harmonics, could be estimated from the combination rule [6], as presented in the Eq. (9).

$$a_m = \left[\sum a_i^{1.5}\right]^{\frac{1}{1.5}} \tag{9}$$

Where:

a_i: floor structure peak acceleration for the i^{th} harmonic;

a_m: effective maximum acceleration.

Therefore, the floor structure effective maximum acceleration is determined from Eq. (9) and can then be compared, for instance, with the acceleration limit value for people participating in rhythmic activities, which is equal approximately 5% of g, from Fig. 3 [10].

Usually, the dynamic forces for human rhythmic activities tend to be large while the resonance vibration is also significant, producing high accelerations values that require to be reduced in design practice by increasing the floor damping or mass. This implies that for design purposes the structural system natural frequency, f_n, must be made greater than the forcing frequency, f, of the highest harmonic that can cause large resonance vibration. Thus, Eq. (8) can be inverted to provide the system natural frequency (floor or footbridge), f_n, to avoid resonance.

$$f_n \geq f\sqrt{1 + \frac{k}{\left(\frac{a_0}{g}\right)}\frac{\alpha_i w_p}{w_t}} \tag{10}$$

Where:

k: constant equal to 1.3 (dancing), 1.7 (lively concerts or sports event), 2.0 (aerobics [6]);

a_0/g: acceleration limit (5% of g, or less, if sensitive occupancies are affected [6]).

5 Finite element modelling of the composite floor

Several models that include different structural components were used to represent the composite floor. The floor experimental data was also considered in the modelling. The proposed computational models, developed for the composite slab dynamic analysis, adopted the usual mesh refinement techniques present in finite element method simulations implemented in the Ansys program [2].

In the developed finite element models, floor steel girders are represented by three-dimensional beam elements, where flexural and torsion effects are considered. The composite slab is represented by shell finite elements. For all of the finite element models, the necessary constraints in the composite floor plane are provided to prevent rigid body movements. The finite element models of the investigated floor include:

1. Model I: A floor model with pinned supports from columns;
2. Model II: A floor model with fixed supports from columns;
3. Model III: A floor-column model. In this particular model a variation of the storeys height was considered ($4.0\text{m} \leq \text{H} \leq 6.0\text{m}$).

Offset rigid connections were also used to ensure that the compatibility of the deformations between the nodes of the plate element and the three dimension beams are satisfied, simulating a composite response. The adopted concrete and steel materials were supposed to be linear elastic.

6 Structural model

The studied composite floor, spanning 18.30m by 31.20m, is currently used for dancing in rock concerts, as presented in Fig. 4. The structural system is constituted of composite girders. The 150mm thick composite slab uses a steel deck with the following geometrical characteristics: 0.80mm thickness, and 75mm flute height.

The used steel sections were welded wide flanges (WWF) made with a 300MPa yield stress steel grade. A $2.05\text{x}10^5$MPa Young's modulus was adopted for the steel beams and deck. The concrete slab possessed a 18MPa specified compression strength and a $2.23\text{x}10^4$MPa Young's Modulus [11].

7 Dynamical analysis

The natural frequencies obtained from the numerical analysis and tests were be compared for each developed finite element model. It is important to identify the correct modes for comparison. The measurements were taken from heel drop tests at each panel centre. As a result,

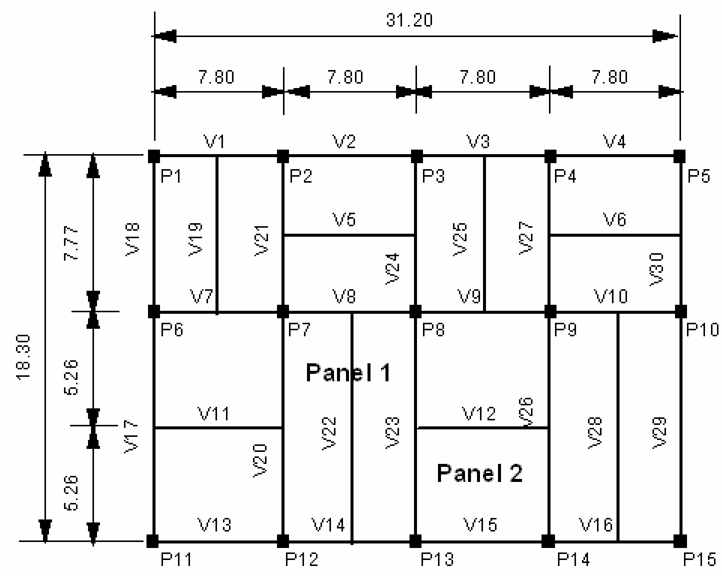

Figure 4: The structural model (dimensions in meters).

the test generated the mode with the maximum response at the centre of the considered panel. When vibration modes were calculated, maximum relative displacements were determined later to be compared to experimental measurements.

It is known that the measurement of the mode shapes would have provided further information for comparisons to the theory. However, mode shape measurement for each mode throughout the building would require a far more comprehensive test programme, although much could be gained by using the measured natural frequencies.

The composite floor natural frequencies were determined with the numerical simulations, Tab. 2 while the associated composite floor vibration modes are shown in Figs. 5 to 14.

It can be clearly noticed in Tab. 2 that there is a good agreement, in terms of the first natural floor frequency evaluated with the finite element method and with the experimental results f_{01}=6.60Hz (Panel 1, Fig. 4) and f_{01}=6.25Hz (Panel 2, Fig. 4), [11]. This fact is a strong indication that the numerical models, associated results and conclusions here developed are valid. However, it should be mentioned that Ref. [11] does not present any of the other composite floor natural frequencies for further comparisons.

Looking closely at Tab. 2 it is clear that the model fundamental frequency value, when the columns are considered rigid in the vertical direction and simulated as simple supports, is lower than the experimental result. This can be explained since the model columns are not subjected to any rotation restriction. This fact made the connections between the composite floor and the columns not sufficiently rigid leading to the finite element model results be more flexible than the actual structure, as shown in Tab. 2. On the other hand, the system mass was properly

Table 2: Composite floor natural frequencies.

Natural Frequencies f_{0i} (Hz)	Experimental Results [1]	Model I	Model II	Model III		
				H=4.0m	H=5.0m	H=6.0m
f_{01}	6.50Hz Panel 1 (Fig. 4)	5.90	7.75	6.40	6.25	6.15
f_{02}		6.05	7.90	6.50	6.40	6.30
f_{03}		6.50	8.10	6.75	6.70	6.65
f_{04}		6.75	8.40	7.00	6.90	6.85
f_{05}		8.10	10.40	8.40	8.30	8.20
f_{06}	6.25Hz Panel 2 (Fig. 4)	8.80	10.85	9.00	8.90	8.85
f_{07}		9.10	11.00	9.40	9.30	9.20
f_{08}		9.66	11.30	9.80	9.70	9.60
f_{09}		9.95	11.40	10.35	10.30	10.20
f_{10}		10.20	11.50	10.60	10.50	10.40

modelled for a dynamical analysis of a structural system subjected to the loadings of this nature.

It is also clear that the model fundamental frequency value, when the columns are considered even stiffer in the vertical direction and simulated as fixed supports, is higher than the experimental result. This can be explained since the column model is not subjected to any rotation restriction because the connections between the composite floor and the columns are extremely rigid leading to the finite element model results be more rigid than the actual structure, as can be seen in Tab. 2.

The results indicated that computational model that properly considered the actual column stiffness should be adopted, Tab. 2. It is clear from Tab. 2 natural frequency results that the fundamental frequency f_{01}, in finite element models that properly considers the actual stiffness of the column led to value closer to the experimental results. When the vibration modes obtained in the different computational models were compared they proved to be similar without any significant change in their configurations, Figs. 5 to 14.

After a careful analysis of the investigated composite floor natural frequencies and associated vibration modes, an evaluation of the structural system performance, when subjected to rhythmic dynamical excitations, in terms of human vibration discomfort was executed. These excitations are usually associated to dance in modern music concerts (rock, pop, etc). The study started with the determination of the structural system maximum accelerations.

The structural system maximum accelerations, numerically obtained, were compared to limiting values proposed by several authors [3,6,8,10]. The present analysis considered a structural system damping coefficient equal to 3.5% (ξ=3.5%). The current study only presents the ac-

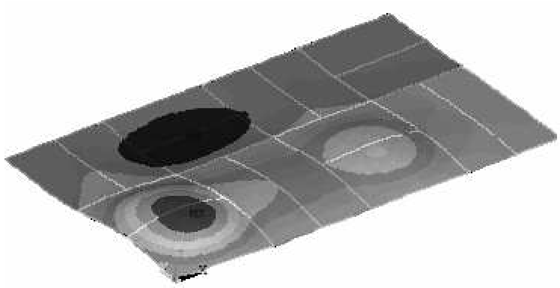

Figure 5: Mode shape associated to the 1st natural frequency: $f_{01} = 5.90$Hz. Model I.

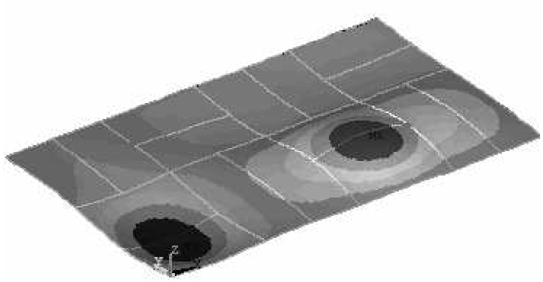

Figure 6: Mode shape associated to the 2nd natural frequency: $f_{02} = 6.05$Hz. Model I.

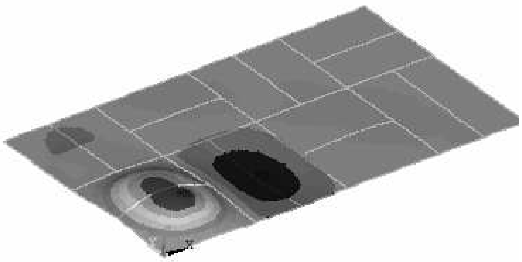

Figure 7: Mode shape associated to the 1st natural frequency: $f_{01} = 7.75$Hz. Model II.

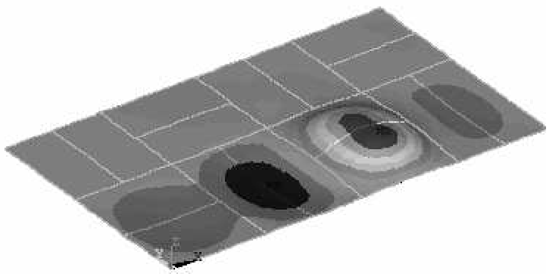

Figure 8: Mode shape associated to the 2nd natural frequency: $f_{02} = 7.90$Hz. Model II.

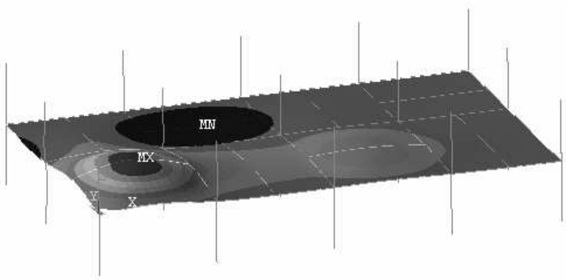

Figure 9: Mode shape associated to the 1st natural frequency: $f_{01} = 6.40$Hz. Model III, H=4.0m.

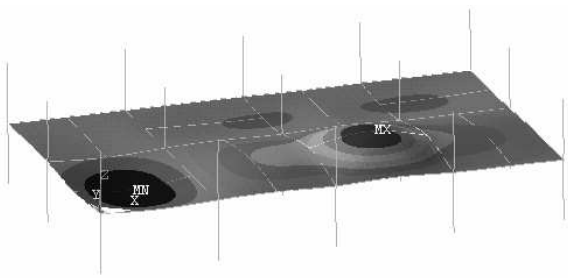

Figure 10: Mode shape associated to the 2nd natural frequency: $f_{02} = 6.50$Hz. Model III., H=4.0m.

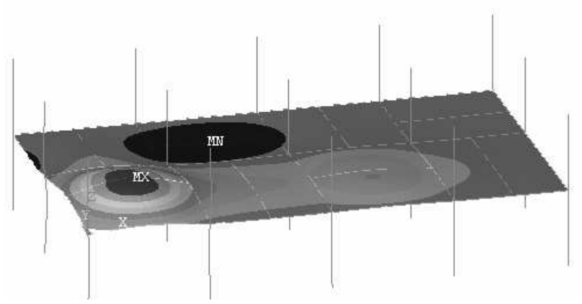

Figure 11: Mode shape associated to the 1^{st} natural frequency: $f_{01} = 6.25$Hz. Model III, H=5.0m.

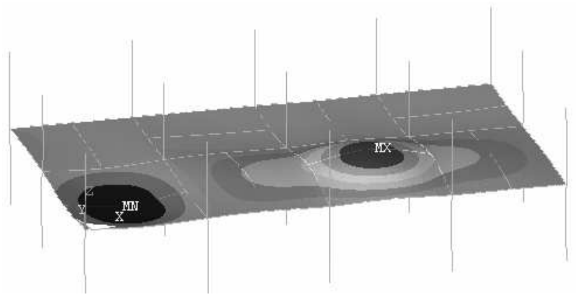

Figure 12: Mode shape associated to the 2^{nd} natural frequency: $f_{02} = 6.40$Hz. Model III., H=5.0m.

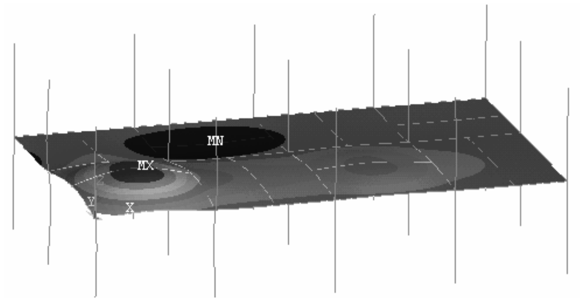

Figure 13: Mode shape associated to the 1^{st} natural frequency: $f_{01} = 6.15$Hz. Model III, H=6.0m.

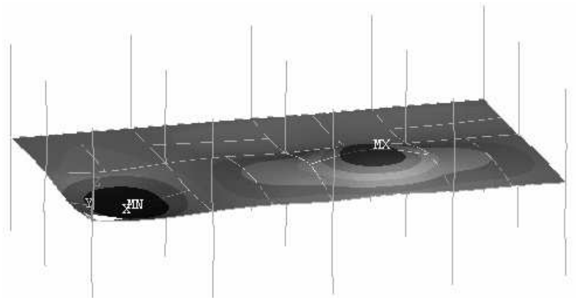

Figure 14: Mode shape associated to the 2^{nd} natural frequency: $f_{02} = 6.30$Hz. Model III., H=6.0m.

celeration peak results associated to the first model (A floor model with pinned supports from columns).

The technical literature specifies a series of acceleration limiting values to ensure human comfort, [3, 6, 8, 10]. These values are usually expressed in terms of a percentage of the gravity acceleration (g=9.81m/s^2).

Figure 15 depicts the composite floor response spectrum to enable a quantitative and qualitative result evaluation, according to the proposed analysis method. This spectrum is defined in terms of the composite floor maximum acceleration values, in the ordinate axis, for a frequency range up to 20Hz.

The graph, illustrated in Fig. 15, was created considering all the detailed recommendations presented in sections 2, 3 and 4 of the present paper. Two harmonic values, defined according to Tab. 1 [6], were used in the definition of the dynamical loads that were applied to the structural system. The structure maximum accelerations, for each frequency, were individually obtained for each harmonic later to be superposed according to Eq. (9).

Table 3 also present various similar nature recommendations to enable a comparison to the

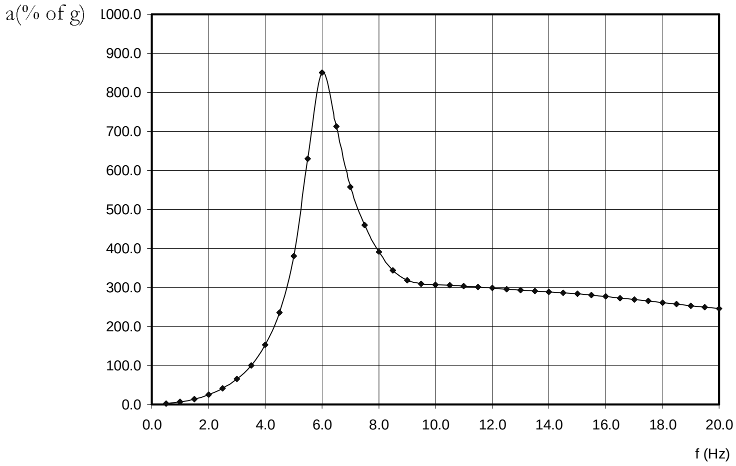

Figure 15: Response Spectrum. Structural system maximum accelerations (Model I).

investigated composite floor maximum accelerations. This was made by varying the excitation frequency, corresponding to rhythmic dynamical excitations associated to modern music dance (rock, pop, etc), up to the value corresponding to the composite floor fundamental frequency.

Based on the response spectrum depicted in Fig. 15 and on the composite floor maximum acceleration values, a_{max}(% of g), presented in Tab. 3, it is clearly noticeable that these acceleration peaks violate the acceptable conditions, in term of human comfort, when compared to the limit acceleration, a_{lim} (% of g), recommended by many authors [3, 6, 8, 10].

Table 3: Structural system maximum accelerations.

Excitation Frequencies	Maximum Accelerations (Model I) (% of g)	Proposed Acceleration limits			
		Murray et al (1997) [6]	Bachmann & Ammann (1987) [3]	NBC (1995) [8]	ISO 2631-2 (1989) [10]
f(Hz)	a_{max}(% of g)	a_{lim} (% of g)	a_{lim} (% of g)	a_{lim} (% of g)	a_{lim} (% of g)
1.5	13.05% of g	5% of g	5 to 10% of g	5% of g	5% of g
2.0	24.40% of g				
2.5	40.90% of g				
3.0	64.65% of g				
5.9	850.0% of g				

Additionally, when the resonance condition was considered, as expected, the composite floor maximum acceleration reaches extremely high values, violating the human comfort conditions.

Finally, it is necessary to observe that these acceleration values, some of each very high, certainly indicates a violation of the investigated composite floor serviceability limit state, in this case, related to excessive vibrations.

8 Final remarks

This paper presents an initial contribution towards the understanding of composite floors dynamic structural response when subjected to human activities such as: people walking, sporting events, dancing in rock, pop concerts or even gymnastics. The proposed methodology is applied to the investigation of the dynamic response in service conditions of a typical composite floor (steel and concrete) commonly found in a concert hall.

Five different numerical models were investigated in conjunction to experimental measurements of natural frequencies. The models were based on usual finite element modelling strategies with the aid of the Ansys program. This enables the identification of an appropriate model to evaluate if a structure can be subjected to a certain vibration level, throughout the determination of the structure dynamic response.

The composite floor models were developed and refined according to comparisons made to numerical simulations and tests associated to the investigated structure fundamental frequency. The results indicated that, for every investigated structural model, although significant differences in terms of the natural frequencies values occurred, the vibration modes were very similar. This led refined finite element models and indicated that a floor-column model should be used for studying the dynamic behaviour of a long-span flat composite floor supported by columns.

The composite floor aptitude, related to human comfort criteria, was investigated. The system dynamical response, in terms of peak accelerations, was obtained and compared to limiting values proposed by various authors. The results indicated that the composite floor do not comply with the human comfort criteria, when compared to important excitation frequency values associated to dance ($f = 1.0$Hz to $f = 3.0$Hz).

The present investigation results pointed out for the continuity of the study, based on the development of an extensive parametric analysis. The parametric analysis should cover design parameters related to the floor and column modelling, slab span, geometric characteristics of the steel beams and concrete slab, structural system, among others to better understand the structure actual response.

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