A Study on Transient Behaviour of A RCC Floor Slab

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Abstarct - Modern construction systems use slender floor construction with high strength materials. The slender floor construction creates vibration problems. Vibration creates discomfort to the occupants. The usage of any floors should be recognized by the designer at the initial stage before construction. Nowadays the human activities are carried out in any of the floors under multi storied building. Based on such activities the analysis should be made prior and the effects should be handled in a safer manner before construction process. Human activities like jumping, dancing, walking create vibration. This paper analyse the dynamic behaviour of a RCC floor slab. The RCC floor slab size is 7mx 7.5m. The human rhythmic study is carried over the slab and the transient analysis is being done to know the behaviour study of the slab. ANSYS, a finite element method is used for the dynamic analysis. The rhythmic activities are created by making people to jump over the slab in the order of 2, 8, 12 & 18. Point A and B are selected over which the observations are made. Through transient analysis, Acceleration and Amplitude parameters are obtained. The results of maximum acceleration values are compared with I.S -800:2007 recommendations and the suggestion is provided.

Key words: vibration, acceleration, frequency, ANSYS, amplitude, time.

I. INTRODUCTION

The modern trend of construction technologies guide the structural Engineers to build with fast erection methods, light weight structures, large spans with minimum columns enabling greater construction space. These slender structures are made with the reduction of the structural elements cross section. The slender structure is more vulnerable to vibration problems. Generally, study of vibration and its effects are complex phenomena. The structures are with low natural frequencies which are closer to the frequency range associated with human rhythmic activities. Such vibration creates discomfort to the occupants.

The above matters lead a consistent structural analysis of the floor dynamic behaviour. These analysis make the structural Engineer to verify the stability of the structural systems and to reduce the human activities vibration problems.

The objective of the present study is to analyse the transient behaviour of a RCC floor slab when subjected to human rhythmic activities and to compare the maximum acceleration values with I.S800-2007 recommendation.

II. HUMAN INDUCED ACTIVITIES

In 1983, Ellingwood modified the concept of Reiher to account for the transient type of excitation using limit state. He suggested that large amplitude of transient motion which will be dissipated within few cycles can be accepted easily when compared to the steady state motion. He also extended that force-time relationship against dynamic effects was not supporting at that time. He mentioned stiffness and mass are the criteria responsible for dynamic effects in which if stiffness is increased, it is not the solution for reducing acceleration but at the same time there is a possibility for reducing the resonance. He concluded that maximum permissible deflection or increased span to depth ratio is not sufficient to meet the problems against vibration.

Allen (1987), made several research on human induced vibration on building structures. He concluded that dynamic actions from human body motions were simulated by a simple harmonic function with a frequency equal to the activity rate.

Occupancies affected by the vibration	Acceleration limit, percent gravity
Office and residential	0.4 to0.7
Dining, Dancing, Weight-lifting	1.5 to 2.5
Aerobics, rhythmic activities only	4 to 7
Mixed use occupancies housing aerobics	2

Table-1. Recommended acceleration limits for vibration due to rhythmic activities

D.E. Allen and G.Pernica (1998) suggested how to counteract resonance due to rhythmic activity, the floor must be designed to have natural frequency greater than the forcing frequency of the highest significant harmonic. He mentioned the vibration limits in terms of acceleration as percentage of gravity. In this paper they said that the vibration impact not only depend on the nature of material of the floor, its thickness and span but also depend on the nature of activity of the people.

Silva et al obtained the dynamic loads from Faisca 2003 whereas he conducted experiments based on rhythmic and non-rhythmic activities. Faisca concluded with the mathematical representation with human dynamic loading.

III. MATHEMATICAL EQUATION FROM FAISCA

Faisca (2003) considered the dynamic loads, based on results achieved through a long series of experimental tests made with individuals carrying out rhythmic and non-rhythmic activities. These dynamic loads, generated by human activities, are described such as jumps with and without stimulation, aerobics, soccer, rock concert audiences and dancing. The load modelling is able to simulate human activities like aerobic gymnastics, dancing and free jumps.

The mathematical representation of the human dynamic loading is described by the following equation(1) .This expression requires some parameters like the activity period T, contact period with the structure Tc, period without contact with the model Ts, impact coefficient Kp, and phase coefficient CD.

$$F(t) = CD\left\{K_p P\left[0.5 - 0.5\cos\left(\frac{2\pi}{T_c}t\right)\right]\right\}, \text{for } t \le T_c$$

$$F(t) = 0, \text{ for } T_c < t \le T \qquad \text{----------(1)}$$

Where:

F (t): dynamic loading, in (N); t: time, in (s); T: activity period (s); Tc: activity contact period (s); P: weight of the individual (N); Kp: impact coefficient; CD: phase coefficient.

IV. STRUCTURAL FLOOR DETAILS

The composite floor system consisted of span 7mx 7.5m .

RC Beam Details: 8"x 18"

RC Roof Slab Thickness: 8"

The concrete slab had a 25N/mm2 specified compression strength and a 2.4x104 N/mm2 Young's Modulus (Faisca).

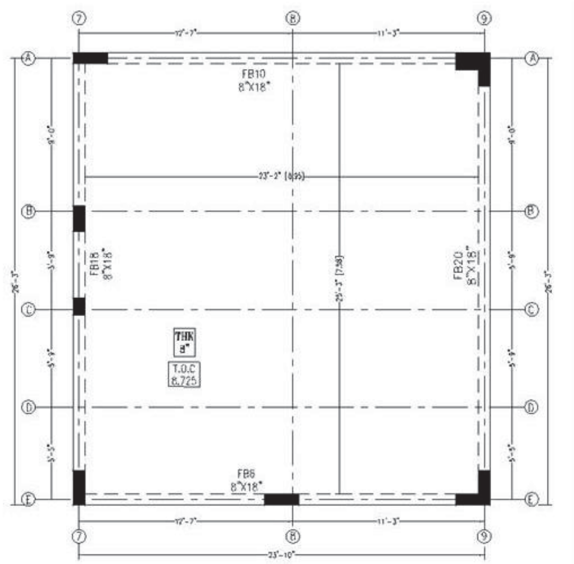


Fig.1 Layout of the floor plan.

V. FINITE ELEMENT ANALYSIS USING ANSYS

The proposed computational model, developed for the RCC floor dynamic analysis, adopted the usual mesh refinement techniques present in finite element method simulations implemented in the ANSYS program (ANSYS, 11). In the present computational model, the floor beams are represented by three-dimensional beam elements (BEAM44), tension, compression, bending and torsion capabilities. The floor slab is represented by shell finite elements (SHELL63).

In this investigation, it is considered that materials (beam and slab) presented total interaction and have an elastic behaviour.

VI. ANALYSES OF FLOOR MODEL

The individual person weight is equal to 70kg(0.8kN- Bachmann & Amman, 1987).The assumed Damping ratio is equal to 2%(ξ = 0.02(IS 800- 2007).

The human-induced dynamic action is applied to the dancing area, as shown in Fig.2. The composite floor dynamical response, are obtained on the nodes A and B to verify the influence of the dynamical loads on the adjacent slab floor. In the current investigation, the human rhythmic dynamic loads are applied to the structural model corresponding to the effect of 2, 8, 12, and 18 individuals practicing aerobics. Hence 18 individual practicing is the full load condition for the numerical model.

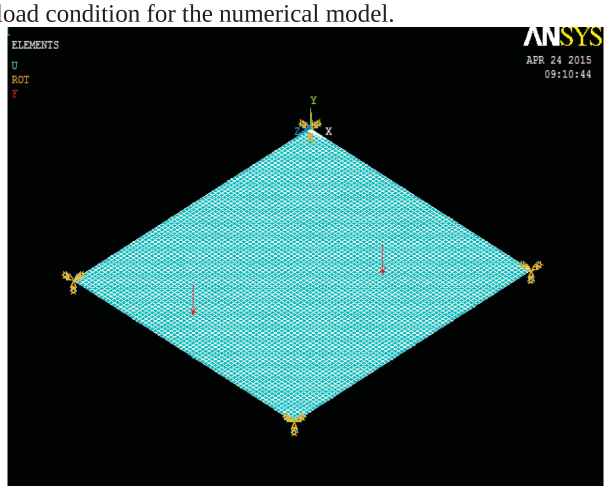


Fig.2 Load distribution Scheme associated to two persons

VII. TRANSIENT METHOD OF ANALYSIS

The following figures, 3,4,5,6,7,8,9,&10 present Acceleration versus Time graphs for the analyzed RCC floor slab at measuring point A and B, the person load is acting on the structural Model as human rhythmic activity.

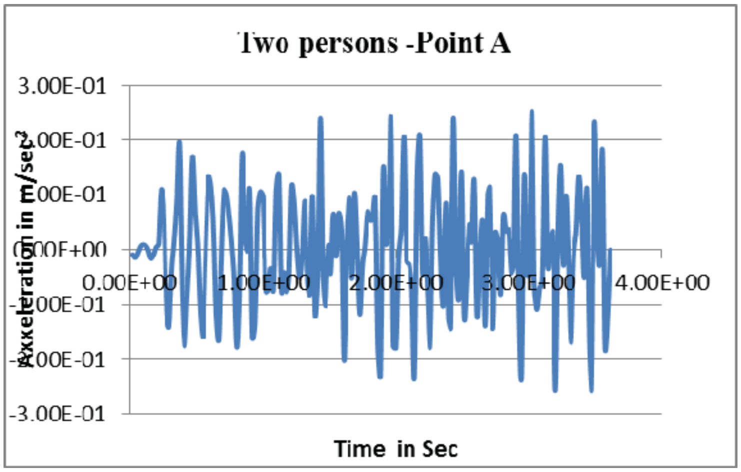


Fig.3- Acceleration Vs Time for 2 persons loading at Point A

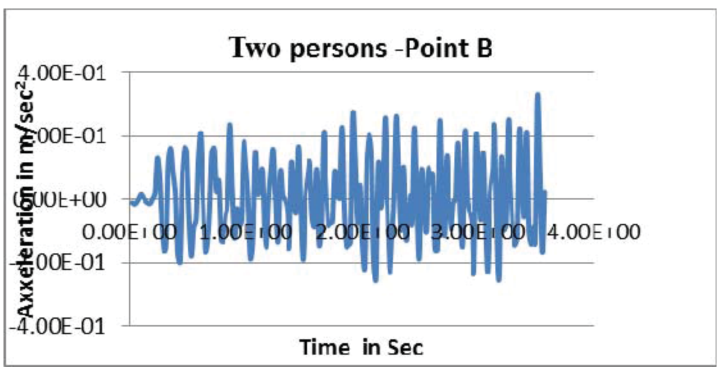


Fig.4- Acceleration Vs Time for 2 persons loading at Point B

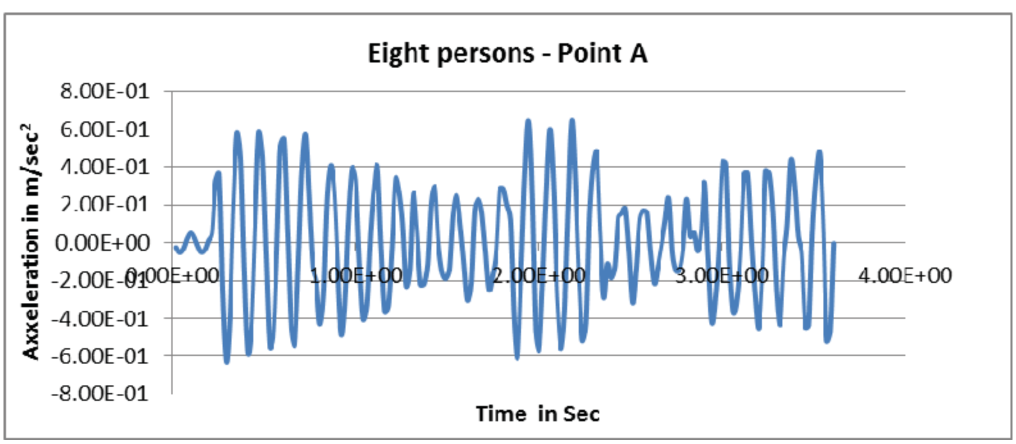


Fig.5- Acceleration Vs Time for 8 persons loading at Point A

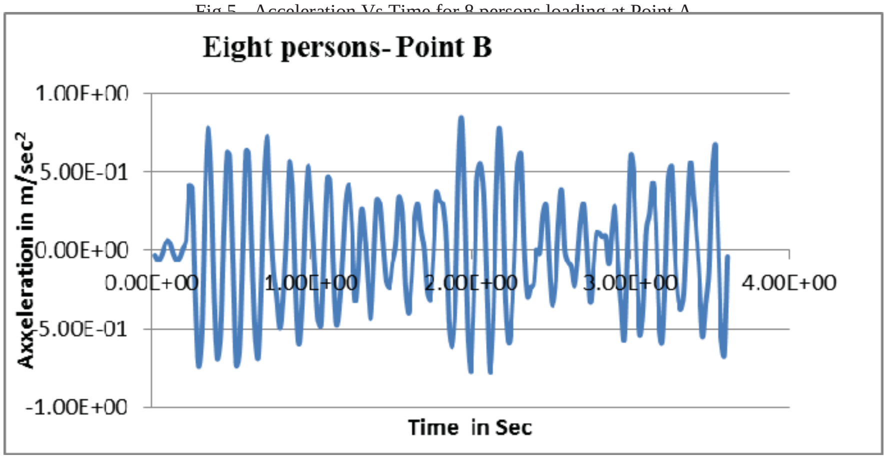


Fig.6- Acceleration Vs Time for 8 persons loading at Point B

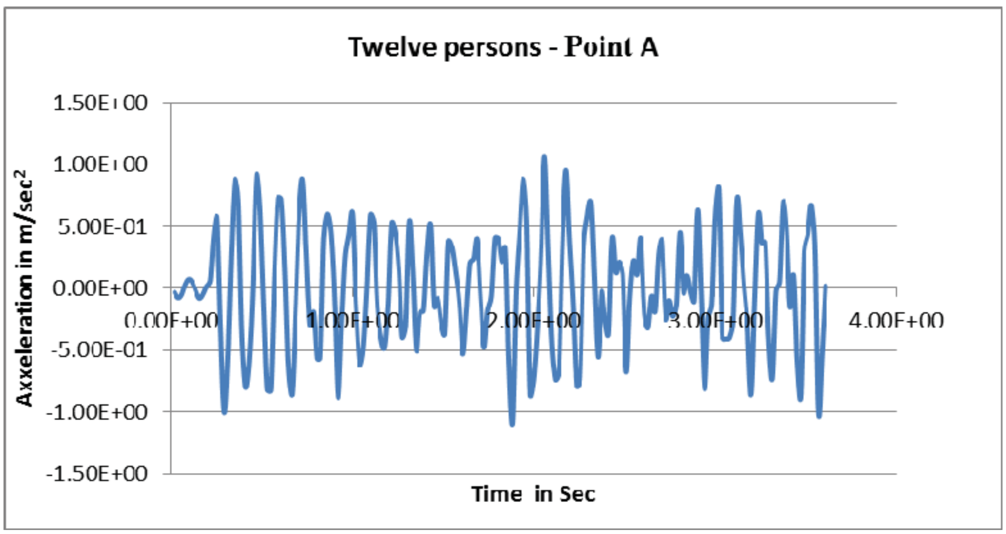


Fig.7- Acceleration Vs Time for 12 persons loading at Point A

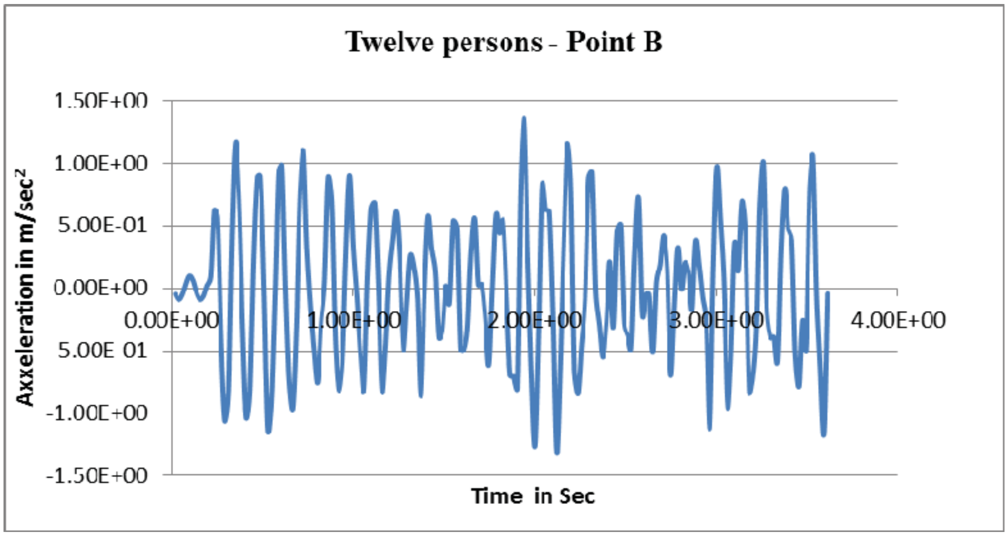


Fig.8- Acceleration Vs Time for 12 persons loading at Point B

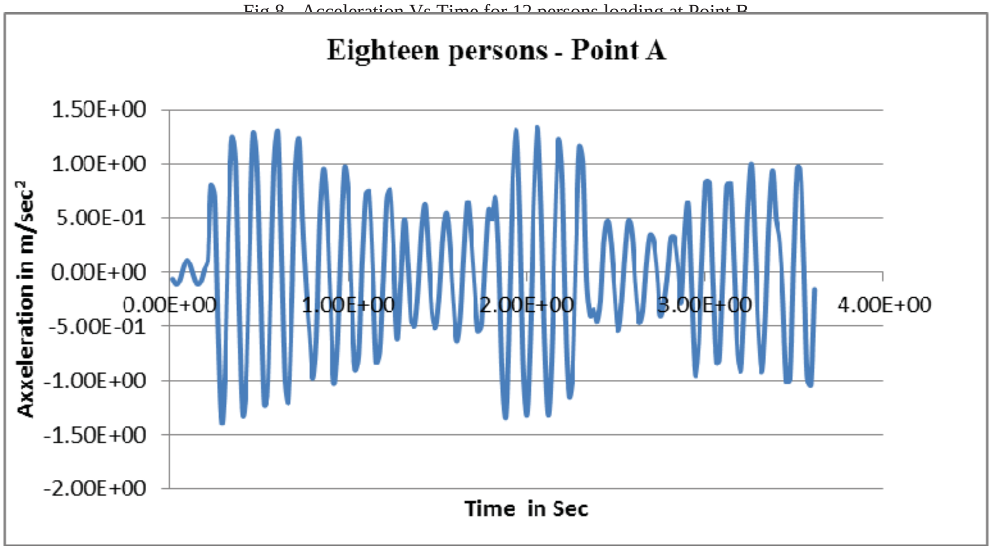


Fig.9- Acceleration Vs Time for 18 persons loading at Point A

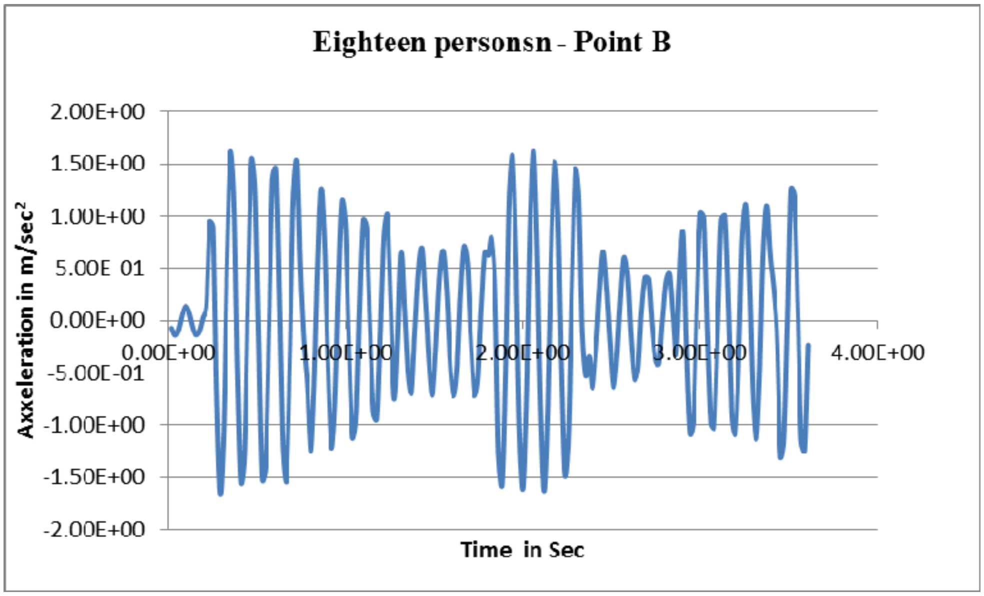


Fig.10-Acceleration Vs Time for 18 persons loading at Point B

Table-2: Maximum Amplitude values

No of Persons	Maximum Amplitude	
	Point A	Point B
2	0.062	0.068
8	0.21	0.263
12	0.32	0.39
18	0.47	0.58

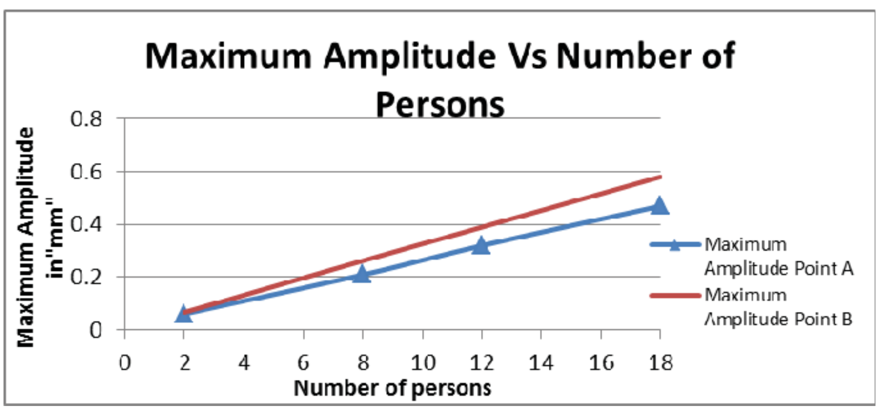


Fig.11-Maximum Amplitude comparison between Point A and B

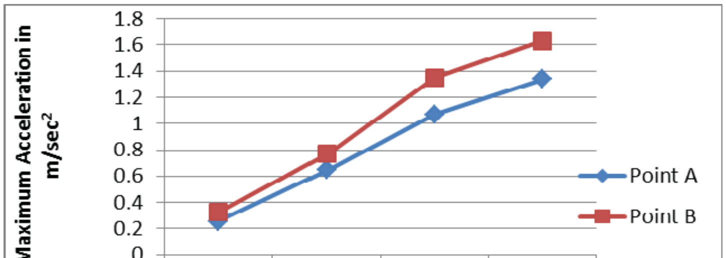
VIII. DISCUSSIONS

A. Comparison of values between point A and point B .

1. From the result, it is observed that peak acceleration value is increased nearly 22% in point A when compare to point B for 2 persons loading with the acceleration values are 0.254 m/sec2 & 0.324 m/sec2respectively.
2. For 8 persons loading, it is observed that peak acceleration value is increased nearly 24% in point A when compare to point B with the acceleration values are 0.646 m/sec2& 0.846 m/sec2respectively.
3. The maximum acceleration values is increased nearly 21% in point A when compare to point B for 12 persons loading with the values are 1.07 m/sec2& 1.35 m/sec2 respectively.

4. For full loading condition, peak the acceleration value is increased nearly 15% for point B when compare with point A.
5. Nearly 1/4th of the values are increased in point B when compare to point A for 2,8 and 12 persons loading.
6. For 18 persons loading condition only one seventh of value is increased at point B than point A.

B. Comparison of Maximum acceleration values with Threshold limit.



	2 persons	8 persons	12 persons	18 persons
Point A	0.254	0.646	1.07	1.34
Point B	0.324	0.771	1.35	1.63

Fig.12- Maximum acceleration values

The maximum values of acceleration observed at point A and B for two persons loading are 0.254 & 0.324 respectively. The present code of practice in steel (IS 800-2007) limits the maximum acceleration levels to a value of 0.5% g =0.05m/sec 2 which is a very stringent vibration criteria.

IX. CONCLUSION

1. It is concluded that for maximum loading condition ,number of persons are scattered throughout the slab at the maximum level. On account of this, the vibration effects are also scattered fully over the floor slab. Therefore the observations at point A & B are nearly closer with the values of maximum acceleration as 1.39 and 1.63 for 18 persons loading. In this case ,17% increase value is observed at point B when compare with point A whereas for 2,8 and 12 persons loading 22-23% difference is observed.

2. The maximum vertical response acceleration at critical measurement points in the floor system are found to be in the range of 0.254-1.39m/sec2 in point A and 0.324-1.63m/sec2 in point B for 2,8,12 &18 persons loading condition. This shows that, there is not a substantial increase due to cumulative loading of number of persons simultaneously jumping on the floor as compared to single person or a couple jumping. There is a non-linear relationship found from the study between the maximum peak response acceleration versus number of persons inducing dynamic excitation.

However it is concluded and cautioned that even for the two persons generally the rhythmic activity response acceleration is for higher than what is permitted in I.S 800-2007 as the governing maximum acceleration. Hence, it is suggested that suitable stiffening or enhanced damping shall be available for floor system meant for these kinds of rhythmic activities.

REFERENCES

[1] Allen ,D.E et al(1985) Vibration criteria for assembly occupancies, Canadian journal of Civil engineering, vol.12, pp. 617 – 623.
[2] Allen ,D.E (1990) Building vibration from human activities, ACI concrete International -Design and Construction.
[3] Bachmann. H (1992) Case studies of structures with man induced vibration, Journal of Structural Engineering, vol-118,No:3.
[4] Bruce Ellingwood. M and Andrew Tallin (1984) Structural Serviceability- Floor vibration, Journal of Structural Engineering, vol.110, No.2, ISSN 0733-9445.
[5] Da Silva, J.G.S. et al(2006) Dynamical response of composite steel deck floors, Latin American Journal of Solids and Structures, 3 .
[6] Da Silva, J.G.S. et al(2008) Vibration Analysis of orthotropic composite floors for human rhythmic activities, Journal of Brazilian Society of Mechanical Sciences and Engineering, pp. 56 – 65, 2008.
[7] Da Silva, J.G.S. et al(2011) Vibration Analysis of long span joist floors submitted to Human Rhythmic Activities, State University of Ride janeiro , ISBN 978-953-307-209-8, pp. 231 – 244, 2011.
[8] Faisca, R.G. (2003) Caracterização de cargas dinâmicas geradas por atividades humanas (Characterization of Dynamic Loads due to Human Activities), PhD Thesis (in Portuguese), COPPE/UFRJ, Rio de Janeiro, RJ, Brazil, pp. 1-240
[9] IS 800:2007, Indian standard general construction in steel – code of practice- third revision
[10] Murray,T.M et al (2003) Floor vibrations due to human activity, Steel design guide series by American institute of steel Construction.