Modal Testing of Reinforced Concrete Single Storey Roof Slab (B) of Structural Laboratory at IIT Kharagpur with Construction Joint using Reaction Mass Shaker (Indirect Method)

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Abstract

Modern structures are becoming more and more slender but with improved stiffness with use of large number of materials in combination, making the predictions of dynamic characteristics of such structures extremely difficult for the analysis using commercially available general purpose finite element softwares. On the other hand, if a building floor is properly excited and the input force and the resulting responses are accurately measured with proper hardware, the dynamic characteristics can be found out without much error. In indirect method of analysis, the structure is excited using reaction mass shaker and the force input to the structure was measured by Measuring the acceleration of the shaker armature and by multiplying it by the mass of the combined armature and reaction mass assembly. The present work is focused on actual physical measurement of input force of a reaction mass shaker to a typical building floor to determine the floor dynamics. A case study on a Single storey roof slab (B) of Structural laboratory at IIT Kharagpur with Construction Joint establishes the advantages of this kind of combined experimental and numerical methods.

Keywords: FEM – Finite Element Modeling, EMA – Experimental Modal Analysis, Modal Analysis – A method to obtain the modal parameters of any structure, FRF – Frequency Response Function, Stiffness – It is the rigidity of an object, indirect method

I. INTRODUCTION

Modal testing procedure was thought to be practiced on different types of Reinforced Concrete floor systems. The usage of this type of system is actually independent of the size, type and properties of any flooring system. A Single storey roof slab was chosen for testing. It was a RC roof slab of structural lab 'B', near to the laboratory. It is simply supported on the walls from three sides and Construction Joint one side. It's one part of structural lab slab to start with indirect method for measurement of Modal Parameters.

II. CASE-STUDY

The test structure is a slab of structures lab in Civil Engineering Department, IIT Kharagpur. The dimension of the roof slab is 20.25m x 10.4m along with over all depth 0.12m. The beams are of dimension 0.50m x 0.30m (primary beam) and 0.30m x 0.20m (secondary beam) and columns are of dimension 0.45m x 0.30m. the primary beam is in the direction of shorter side and secondary beam is in the direction of longer side.

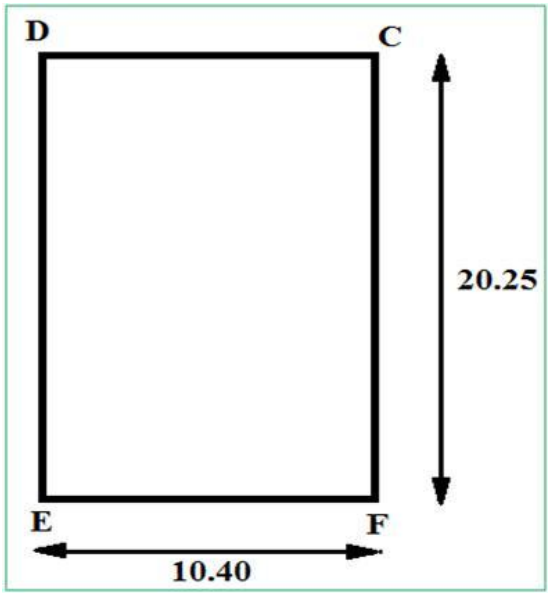


Fig. 1: Plan of Test Single Storey Roof Slab (B)

- Young's Modulus of elasticity of slab = 2.0 x 10^{10} Pa
- Young's Modulus of elasticity of columns and beams = 2.0 x 10^{10} Pa
- Poisson's ratio = 0.2
- Density of concrete = 2400 Kg/m^3

In case of analytical analysis, we consider the construction joint CD assumed to be a fixed joint.

A. Preparatory phase (Pretest analysis of the test floor):

The purpose of a pre-test analysis is to give an indication of likely natural frequencies and mode shapes of the structure prior to testing. A pre test analysis gives an indication of a frequency range to be used for the experiment so that the floor is safely excited. The supporting columns were considered fixed at the floor below, which was at the height of 5.85 m.
The element constants for the beams, Columns and slab are as given below:-

Table–1: Element constants for pre test model

Element type	*Parameter*	*Value*
Primary beam (0.50 x 0.30)	*TKZ*	*0.50*
	TKY	*0.30*
	Area	*0.15*
	IZZx10^{-3}	*3.125*
	IYYx10^{-3}	*1.125*
Secondary beam (0.30 x 0.20)	*TKZ*	*0.30*
	TKY	*0.20*
	Area	*0.60*
	IZZx10^{-4}	*4.50*
	IYYx10^{-4}	*2.00*
Column (0.45 x 0.30)	*TKZ*	*0.45*
	TKY	*0.30*
	Area	*0.135*
	IZZx10^{-3}	*2.28*
	IYYx10^{-3}	*1.0125*
Slab	*TKI, TKJ, TKK, TKL*	*0.12*

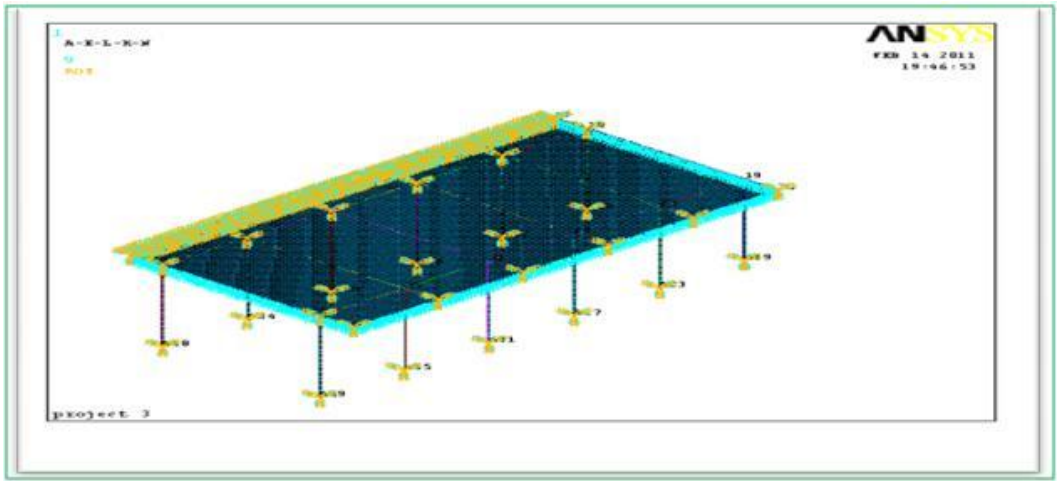


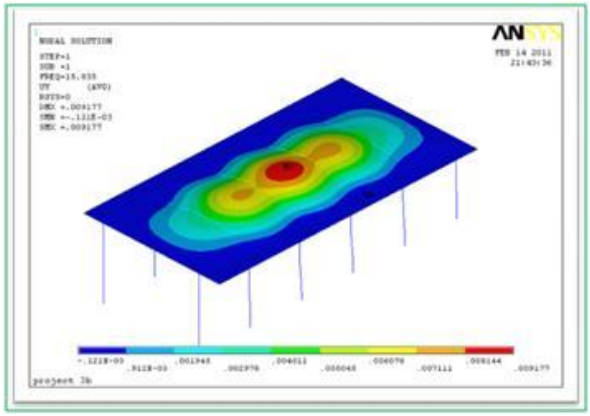
Fig. 2: Pre Test FE Model of Single Storey Roof Slab (B)

The first four natural frequencies were recorded and are as tabulated below:

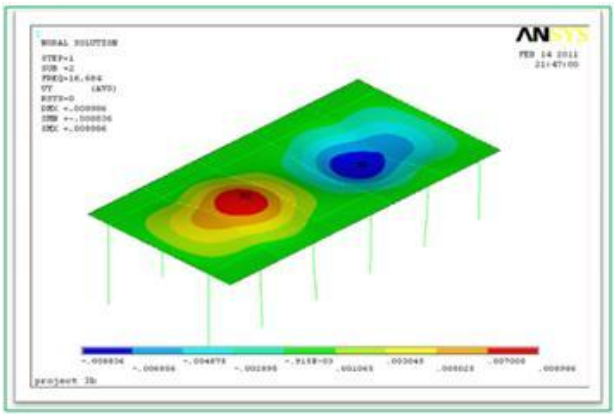
Table–2: First four frequencies of Pre test model

Mode	*Natural Frequency(Hz)*
1	*15.835*
2	*16.684*
3	*18.278*
4	*20.814*

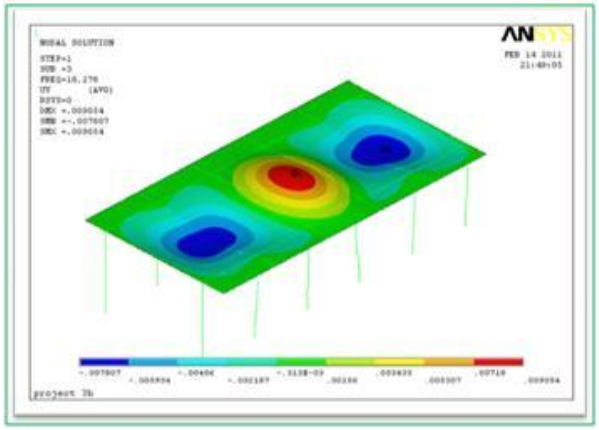
The first four frequencies and mode shapes after pretest analysis are:



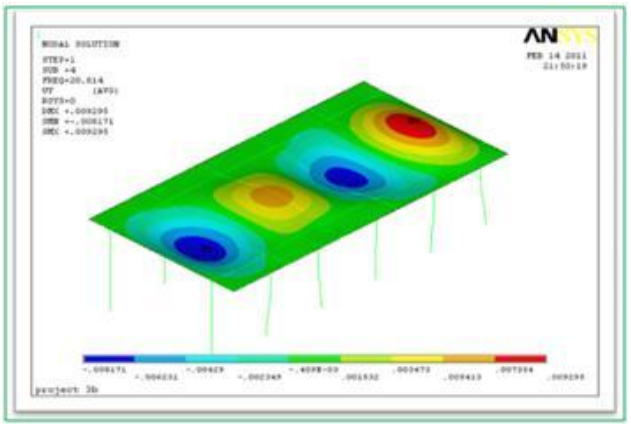
(a): First Mode



(b): Second Mode



(c): Third Mode



(d): Fourth Mode

Fig. 3: Pre Test Analysis of Single Storey Roof Slab (B): Mode Shapes

B. Measurement and Post Analysis Phase (Indirect Method):

The grid consisted of 66 points which was created seeing the most likely points of excitation and nodes. It was suspected that there would be no movement near the partition walls. However some points were taken to test the response of slab at those points. In indirect method of analysis, the structure is excited using reaction mass shaker and the force input to the structure was measured by Measuring the acceleration of the shaker armature and by multiplying it by the mass of the combined armature and reaction mass assembly. The setup for this work was, three accelerometers were used as roving accelerometers and the shaker was placed stationary. Since the readings were taken in open, lot of care was taken to record when there was less wind. There was no response seen at the edges of slab and at the line of columns, so the points at the walls were neglected. The same signal (chirp) was taken for this experiment.

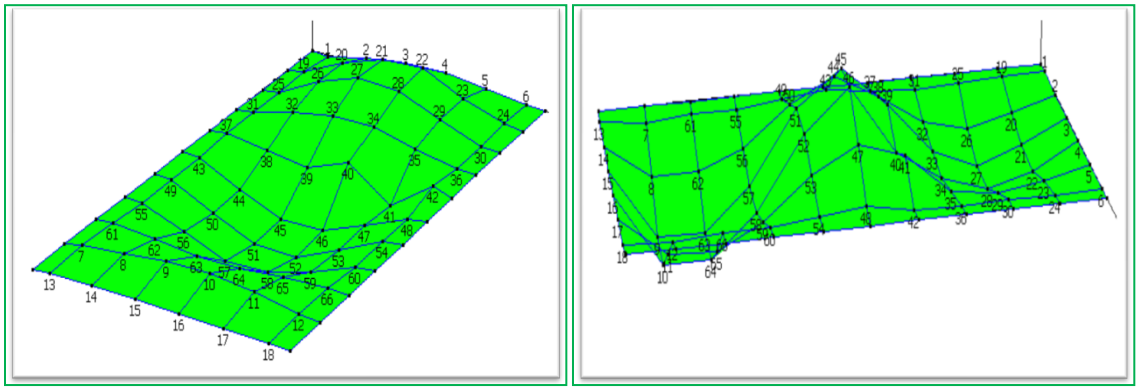
Table–3:
Data acquisition parameters

Parameter	*Setting value*
Acquisition Bandwidth	*Zoom 5 - 25 Hz*
Acquisition Duration	*20 s*
No. of Frequency Domain Averages	*7*
Force Window Duration (% of Acquisition)	*45%*
Exponential Window Time Constant	*0.35*
Excitation Type	*Chirp*
Excitation Duration	*8 s*
Excitation Frequency Limits	*5 - 30 Hz*

After these tests being conducted, FRFs were recorded. The available FRFs were exported to MEScope for modal parameter estimation. The values obtained from MEScope are given in table below. The comparison of frequencies of the pre test model and the experiment shows some variation.

Table–4:
Modal Parameters Extracted using Mescope

Mode	*Frequency(Hz)*	*Damping Ratio(ζ) (%)*
1	-	-
2	*13.65*	*1.62*
3	*14.98*	*1.09*



Second mode Third mode

Fig. 4: Experimental Mode Shapes of Single Storey Roof Slab (B)

Table–5:
Comparison of Frequencies (Hz)

Mode	*Frequency (Hz)*	
	Experimental	*ANSYS*
1	-	*15.835*
2	*13.65*	*16.684*
3	*14.98*	*18.278*
4	-	*20.814*

III. CONCLUSION

The comparison of frequencies shows that the stiffness of the slab in pretest modeling was high.

REFERENCES

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