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FINITE ELEMENT MODELING OF BEAM AND ITS VALIDATION USING EMA

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ABSTRACT:-

An vibration based analysis measurement requires data on the nyquist plot from a setup. It is necessary to acquire the impulse response resulting from the excitation's free decay in order to undertake a time-domain analysis, or to obtain the affect from ambient excitations. As there are several ways to get signals and do the measurement, the FRF of such beam is measured using one of the simplest and most adaptable techniques, and the procedure is described in this chapter. This approach involves exciting the structure with a particular input signal at a predetermined position, and measuring the force and the structure's reactions to that force. which, as a consequence, gives information about a particular set of FRFs, which may then be examined further to carry out modal analysis and produce the modal model that represents the structure.

KEYWORDS:-Modeling. Beam, Finite Element etc

The test structure and the FRFs derived from measurement must both be linear according to the fundamental premise and criterion of modal analysis. An easy experiment may be used to confirm this. The investigator may even be able to double the input strength level or the observed outcomes in order to ensure the reproducibility of either the FRF data since the excitation strengths in the operation are controlled. It is understood that conventional modal analysis based on observed FRF data can just reflect a linear statistical method and cannot account for the material's non-linearity if a structure deviates from the criterion of linearity perfectly. The reciprocity property, which has to be validated in the structure, is the second crucial premise in the modal analysis. It is rather simple to validate this premise in general. It is simple to check the reciprocity by leaving the structure at one site, taking a measurement at another location, and repeating the operation by switching the stimulating and measurement locations. In besides these presumptions, it is necessary that a structure's dynamic qualities remain constant during the experiment or subsequent measurements. It is necessary that the structure be time-invariant for this reason.

The measurement equipment and computing power of computers have rapidly improved in recent decades as a result of the enormous advancements in the electronic industry. This development has allowed reseacher to make FRF measurements using numerous different push inputs and output simultaneously, or MIMO analysis. It has become feasible to excite the structure with very consistent amplitudes when utilising many inputs and numerous outputs as opposed to their having a significant difference of amplitudes when using a single input alone. This is because energy used in MIMO testing comes from several sources, distributing it evenly, as opposed to a single input source, where energy must be provided all at once, resulting in high power density and huge amplitudes. Therefore, MIMO measuring techniques may provide more precise FRF data and, therefore, modal data. Time may be saved by using these kinds of tests. The MIMO tests need more advanced machinery to do numerous of these tests; as a result, they are often only performed in labs of large universities.

Measurement Setup

Three components should make up a typical measuring setup used in operational modal modeling.

1. a source capable of providing the systems with input force.
2. a tool for measuring the reaction signals.
3. an image processing device that can both capture and process signals to produce FRF data

The first component, known as the modal hammer, is used to generate significantly higher total signals and apply them to the test structure. The second component, known as the accelerometer, is used to test and collect statistical information from the structure. The third component establishes the link respectively the input and huge impression and conducts signal processing to obtain FRF data from the test structure.

An impact striking, the tool that applies an exciting force to the setup, is made up of a handle, a balancing mass, a force transducer positioned on the tip, and a hammer tip. The option to modify the hardness is provided by the interchangeable hammer tip. Steel, plastic, and rubber are the most popular materials utilised for the tip. The frequency range needed by the system first from input pulse force is directly proportional to the sharpness of such tip and thus the surface that has to be examined. When a hard tip is put on a hard surface, a force pulse is created that disperses energy throughout a broad spectrum. During the hammer excitation, the input sidebands are only controlled by this one mechanism.

The most extensively used and frequent sensor for dynamic testing is an accelerometer. It gives an output signal as a function of further voltage and is used to uniform acceleration generated in the test structure. These voltages are proportional in a direct manner to the body's gravity.

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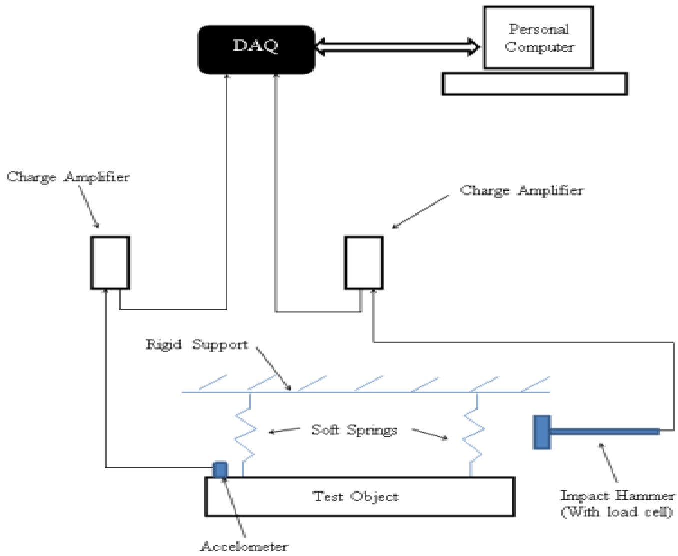

Figure :- Measurement Setup with impact testing

Then, due of their low amplitude and potential for noise, these signals are converted using signal conditioner. After that, they are analysed by an analysis, as opposed to processing hardware or software.

The structure's linearity is not assumed by the voltmeter, which just measures the structure's acceleration. Only the location's acceleration is recorded by an accurate accelerometer.

The base, which is characterised by a spring and damper, has a major impact on how accurately acceleration is measured. When the mounted is firm, the accelerometer, which is dreamed up of a mass, a stiffener, and a damper, delivers precision. The measuring parameters of the voltmeter are affected as a result of the mounting's flexibility. As a result, the structure's reported pressure may not be precise and may deviate somewhat from the accelerometer's reading. However, the frequency and phase distortion will increase if the spring constant of the system to still be measured, or the SDOF system, is five times or more than the speed of the impetus from the measured structure. The acceleration that is presently being measured will perfectly match and mimic that of the framework. The piezoelectric kind of accelerometer is the most used. It implies that the phenomena of strain-induced charge inside this crystal lattice underlies piezoelectricity. As a result, the electric charge changes to reflect the produced strain. Due to the reduced frequency range, piezoelectric accelerometers often display no yeah to DC. The intrinsic resonance of the sensor prevents precision from being obtained at high frequencies. Thus, during testing, the choice of accelerometer is crucial. It is important to consider a number of parameters when choosing an accelerometer for a modal test. The frequency response, the selectivity of the accelerometer, and its endurance against any changes in temperature are the main variables influencing its performance. base-level cross-axial awareness and strain.

Preparation of the Test Structure

Real structures often have connections to their foundation or surrounds. As a result, the dynamic properties of such a body depend both on its own properties and on its boundary conditions. Knowing if the dynamic features needed by the examination should always be present is crucial when measuring a redeeming value and determining the FRF from the measurement What circumstances call for the test structure to have boundary conditions or whether it must be used independently? The solution is found in the two factors that were taken into account while creating the exam format for the modal test. First, is it necessary for the structure's modal model to be in operational mode or in a real-world setting? Second, is it reasonable to run the modality test on the component alone? The dependence on the outcomes is required by the first factor. For certain buildings, it can be necessary to understand their dynamic behaviour under their actual working settings with all of their natural surrounds. If this is the case, having the generated modal modelling for real circumstances would be beneficial. When predicting structural coupling study or dynamic design, the modal model that was produced from the bending test may also be utilised. The model obtained from the test structure must be employed in an isolated setting or under free-free circumstances for these applications.

The feasibility of testing a structure under the desired circumstances must be evaluated and estimated as a second factor. Because of limitations in existing measuring technology or the proximity of the measurement site or excitation location, it may not be able to conduct the modal test on certain buildings under real-world circumstances. It will be necessary to further evaluate and then simulate the required dynamic behaviourutilising the modal data so collected from a limited measurement. Therefore, it is desirable and absolutely necessary to make sure that its test circumstances are consistent and reproducible and that the data used to calculate FRFs is trustworthy and representative. Two similar soft springs are used to hang a simple block in Figure 3.1. A large and heavy structure may be placed atop a mound of thick porous packing material or a simple inflated tyre tube using the same approach. But in the other hand, simulating the grounded lower bound under laboratory settings may be more challenging. All six angles must be restrained in order to imitate a grounded situation, and the boundary must be set tightly. This is impossible to do in real life. In order to get all DOFs being confined, it is standard practise in modal testing to anchor the test structure it to a more rigid and heavy item. This may be accomplished by fastening the superstructure to a heavy foundation like a concrete floor.

Only in very rare circumstances can a genuine grounded situation be recreated. For instance, it may be challenging to establish a hard equilibrium conditions at the fastening end under actual circumstances in order to accurately measure the cantilever. By measuring the opposite side's beam, which is maintained in free-free circumstances and has a twofold length, the alternate configuration may be created. The analogous modes for the deflection will be any odd-numbered modes from this changed configuration of the beam. It is necessary to understand the restriction from the rigid body modes' inherent frequencies in order to replicate the free boundary condition. To replicate a grounded state,

Selection of excitation forces

The excitation technique is crucial in modal testing in order to achieve the right FRF measurement. Theoretically, the excitations and responses do not affect the FRF data collected from modal tests, but in practise, the accuracy and quality of the FRF rely more on the activation and responds, including, among other things, the choice of activation. The choice of excitation is mostly determined by the necessary best approach for obtaining accurate measurement data that is suitable for test goals and the structure. Therefore, in order to acquire all the excitation techniques that are most suitable for testing, modal analyzers must choose the most appropriate way. Although it is unrealistic and perhaps unnecessary to demand a flawless measuring setup. Along with the measuring apparatus, time constraints play a significant deciding role. The amount of time needed to complete various exam objectives varies.

Experimental Setup

Figure Experimental Setup for Cantilever Beam

Figure 3.2 depicts a graphical depiction of the point load experiment setup. A clamp is used to secure one end of the aluminium beam specimen, and an accelerometer is connected to the free

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end in order to quantify the free vibrations. With the use of a clamp, the fastened end of said beam is held in place.

Figure Close view of accelerometer

A close-up view of BNC local stations is shown in Figure 3.3. These wires provide the data collection system with the signals it needs to generate signals for the digital computer that correspond to the gravity from the accelerometer and the stimulating hammer. By hitting the structure, an impact hammer, a specialised measuring instrument, generates brief impulse vibrations. A load cell, an internal sensor in the hammer, generates a signal that is proportionate to the shock wave. This makes it possible to measure force accurately. Additionally, an impact hammer is utilised for modal testing of fragile or unique structures where a mechanical vibrator would not be practical;

Figure Close view of PCB signal conditioner

Figure Close view of exciting hammer with accelerometer

Figure Computer system used to measure FRF

Beam Details

A mild steel beam that is clamped at one end, with the following dimensions

Length1.05m

Width 0.05m

Height 0 . 0 0 9 m

The mild steel used for the beam has the following material properties.

Density78300kg/m^3

Young's Modulus 210GPa

Poisson Ratio 0.3

The FRF curve is drawn from this figure which gives the natural frequency for different modes.

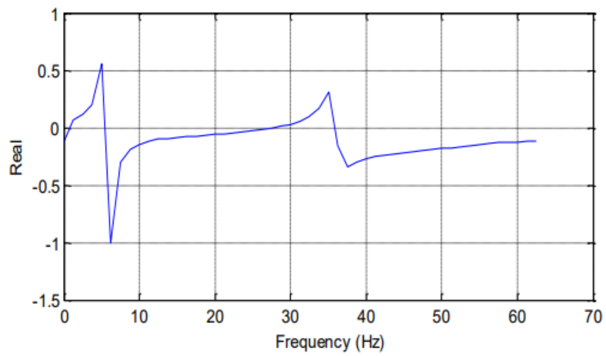

Figure FRF Amplitude Vs Frequency On Real Scale

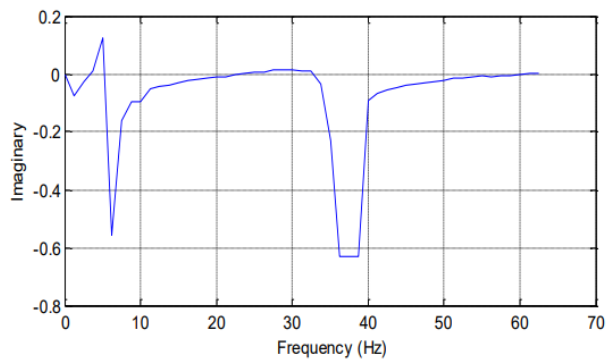

Figure FRF phase Vs frequency On Real Scale

In above figures, two peaks show the natural frequencies of the beam on nodes one and two respectively.

RESULTS

To get the Natural Regularity from the experiment, the research model was solved. It provides the first two Natural Frequencies, which are 5.6 and 37.0 Hz. The first six Organic Harmonics for a one component FE model are found to be 6.2033 Hz and 60.10 Hz, respectively, showing significant variations between second Natural Wave of the experimentally induced and the one part FE model. This results from the FE model's coarse approximation. In the first and final Natural Frequencies, the percentage error is 10.77% and 62.16%, respectively.

For a two-element FE model, the first 2 corresponding values are found to be 6.5743 and 50.862

Hz, where the difference between the first and second vibrations is raised to 17.39% while the difference between the first and second resonance frequency is decreased to 37.46%.

The two Natural Clocks for an ANSYS-based ten-element FE model are found to be 6.5009 and 41.594 Hz. The percentage inaccuracy in the first and second frequency, respectively, is 16.08% and 12.41%.

In order to get reliable results, an Equation with a lot of components is preferred. Using ANSYS, the two Normal Frequencies for a 20 element FE model are found to be 6.4969 and 40.917 Hz, which are closer to the actual model. The percentage inaccuracy in the first and subsequent natural frequencies, respectively, is 16.01% and 10.58%. This demonstrates unequivocally that the percentage error decreases as the number of items rises.

The inaccuracy for the first and fourth natural frequencies is rather significant for a one element FE model, but it is much smaller for a bigger number of nodes, as can be observed from the aforementioned talks. The inaccuracy for the first and secondly natural frequencies essentially stays constant after the 50-element modelling. The results are shown in the table 6.1 below. Additionally, the first and secondly natural frequencies found in the MATLAB CODE are 6, and 41, respectively, Hz. When compared to ANSYS analysis, the percentage error is relatively low at 0.00% and 9.7%.

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