

Investigating New Problems of Practical Interest on Bending and Vibration of Thin Elastic Plates and Shells of Various Shapes

Sangeeta^{1*} Dr. Sudesh Kumar²

¹ Research Scholar of OPJS University, Churu, Rajasthan

² Professor, OPJS University, Churu, Rajasthan

Abstract – Logical arrangement of different issues on plates and shells with variable versatile properties and warm properties are normally found in writing. Bending of consistently compacted roundabout plates of variable thickness was examined by Basuli. Stresses because of assembled couple at the focal point of a versatile elliptic plate with fixed edge were talked about by Bose. You, Tang, Zhang and Zheng acquired the stresses of a pivoting plate with power law variety of thickness and thickness utilizing numerical techniques. Lal talked about transverse vibrations of orthotropic non-uniform rectangular plate with exponentially shifting thickness and thickness. Guo, Wu, Sun and Ma explored the transient break conduct for a material with exponentially changing material properties. Ghosh and Kanoria broke down the thermo-flexible issue of roundly isotropic material with power law variety of thickness, warm conductivity, modulus of versatility.

Keywords: Practical, Interest, Bending, Plates, Shells

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INTRODUCTION

Obviously, this is one of the most sensational dynamical highlights that plate-like structures show, and it is foreseen that the enthusiasm of considering its properties lies past its applications in melodic acoustics. The primary inspiration at the source of this work is to be found accurately in its melodic application: toward the start, the thought was to build up a numerical code ready to mimic a wide range of plate elements, from the straight to the emphatically nonlinear case. Right now, proposition attempts to give a commitment to the domain of sound synthesis by physical displaying. Physical demonstrating is an exceptionally engaging, yet testing method for orchestrating sound: the waveform, right now, created by a PC routine which fathoms the dynamical conditions of a given instrument. The dynamical conditions are communicated as Partial Differential Equations (PDEs), in light of the fact that an instrument is frequently a continuum where the vibrations are a component of reality. The PC routine depends of a couple of reproduction parameters that control, for instance, how the instrument is set into movement, the geometry and material, or what sort of misfortune mechanism is being reenacted.

Obviously, the computational necessities for this sort of synthesis are tremendous, and as a rule a continuous reenactment is distant. Be that as it may,

the expanding computational intensity of new age processors and the utilization of realistic cards for equal registering has rendered the computational issues to a lesser degree a weight and this is the reason physical displaying has seen a developing measure of research over the ongoing years. Confining the regard for slight plates, one might be persuaded that the rich elements of their vibrations must be depicted by complex conditions. In undeniable reality, a wide range of elements of a plate can be reenacted inside the depiction given by the von K'arm'an conditions. Such conditions establish an arrangement of two PDEs which are nonlinear.

The hypothetical determination of such conditions isn't incredibly troublesome as it includes a solitary second-request revision of the strain tensor in the in-plane course as for the straight model by Kirchhoff. Regardless of this hypothetical effortlessness, the conditions are unsolvable diagnostically and hence numerics is actually the main instrument in the hands of the expert wishing to reenact without limitations the huge range of dynamical highlights that such a framework can offer. Note that, at any rate to a first guess, a homogeneous, isotropic, level rectangular plate can reenact productively the sound of a gong, which is a fairly unique structure that could exhibit in homogeneities, anisotropy and ebb and flow, other

than a roundabout geometry. Hence, the plate is exceptionally alluring to consider numerically on the grounds that, in spite of the fact that it is a basic structure, its elements is sufficiently rich to reproduce real percussive instruments. All things considered, building up a "decent" conspire for sound synthesis is definitely not a clear undertaking. There are, at any rate, two primary issues that should be tended to: exactness and dependability. An off base proliferation of the elements could ruin to various degrees the nature of the reproduction; then again, an exact routine probably won't be essentially steady, implying that the numerical reenactment could "explode" surprisingly much after numerous means of an apparently merged arrangement.

Bilbao can be viewed as the first since forever reference tending to these sort of issues in the domain of the von K'arm'an conditions. Bilbao illuminated the plate conditions by utilizing Finite Difference plans: specifically, he proposed a second-request exact plan whose positive definiteness of discrete vitality prompts a security condition. A similar thought of a positive-clear discrete vitality is behind the advancement of the plan displayed right now. Be that as it may, instead of receiving a completely discredited space-time network, as in a Finite Difference condition, the code created for this work utilizes a modular portrayal. A plate is a persistent framework, and in this way, in the language of Mechanical Engineering, it has a limitless number of degrees of opportunity. Shortening the degrees of opportunity from a limitless number to a limited one can lead in any case to a dependable propagation of the elements. This is basic practice in what is by and large known as "modular strategy", which is the technique created over the span of this work. By and by, the answer for the dynamical condition is composed as a weighted total of spatial capacities, whose time-subordinate loads can be gotten by illuminating an arrangement of Ordinary Differential Equations. Modular strategies applied to the arrangement of PDEs are extremely normal, and they have discovered applications in numerous fields, including that of melodic acoustics.

Whole ventures in the domain of sound synthesis, for example, are based around the possibility of modular projection. Their extension, in any case, is constrained to straight frameworks. In established truth, the modular decay shows up as the most normal depiction of straight dynamical frameworks, which can be thought of, by and large talking, as an aggregate of autonomous commitments vibrating at explicit frequencies, and known as the methods of the framework. At the point when nonlinear vibrations are set up, in any case, such commitments quit being autonomous of one another, and the modes "couple" together. The idea of these couplings relies carefully upon the idea of the issue, and even apparently slight changes of the idea of the framework can prompt a totally extraordinary arrangement of coupling mechanisms. On account of a rectangular plate, for instance, a "slight change" might be acknowledged by changing the angle proportion or by transforming one

limit condition along one of the edges. In a Finite Difference conspire, the issue of changing the viewpoint proportion is dealt with direct by embracing a fitting lattice; the diverse limit conditions can rather be recreated by adjusting the grids characterizing the distinction administrators. The close idea of the plan, in any case, stays unaltered.

This is really one of the most engaging highlights of Finite Differences conspires instead of modular strategies: they speak to a truly adaptable and general technique, that can be applied to a wide range of issues. Modular strategies, then again, endure an absence of sweeping statement. This is to some degree amazing given that such strategies were the first to show up as techniques for arrangement of PDEs. The most concerning issue in applying modular strategies is to have the option to compute the eigenfunctions and frequencies for subjective limit conditions. This is actually a fundamental assignment that can't be bypassed. Despite the fact that there are a few instruments available to the investigator, for example, the Rayleigh-Ritz technique, there is no all-inclusive system to achieve this undertaking, and a made to order study should be implemented.

A subsequent issue, which has just surfaced this conversation, has to do with the measure of modes to be held to mimic the nonlinear elements. Such a number is of the request for two or three hundreds, and in this manner an eigenvalue routine fit for figuring that numerous modes is fundamental. In a perfect world, a modular technique with application to sound synthesis ought to maintain a strategic distance from all specially appointed suppositions and repeat the elements steadfastly. Regardless of this obviously demoralizing layout, there are at any rate two valid justifications to attempt to perform modular synthesis of nonlinear plates. These have to do with the exactness of the determined arrangements, and the productivity of the numerical plan. Modular techniques, when appropriately set up, are precise.

Not just the trademark frequencies of vibrations can be figured with a huge exactness, yet the reality of having decayed the first, nonstop issue onto a progression of "building squares" permits to enhance the worldwide elements of the plate by improving the elements of each building square. Right now, specific intrigue is the chance of adding a damping proportion to every single one of the modes. Thusly, this permits to recreate a very enthusiastic misfortune impact without spending any extra scientific or computational exertion. Such a point of view is in fact alluring in perspective on an application to sound synthesis, to be specific since misfortune bears a ton of perceptual data, and it can help in improving the general apparent "quality" of the created yield. In any case, one may likewise wish to try different things with unreasonable damping laws, so as to produce sounds which can't be gotten when striking a genuine plate. Notwithstanding being exact, modular methods should be less expensive

than Finite Differences. In established truth, when a plate isn't excessively slight, a genuinely modest number of modes gets the job done to imitate the elements of exceptionally nonlinear wonders, and in this way in a reproduction one may simply keep the quantity of degrees of opportunity to an absolute minimum, prompting quick calculations. These two reasons (precision and productivity) are sufficient to check out the modular methodology in the domain of nonlinear vibrations. This inspiration is additionally exacerbated by the way that, for the von K'arm'an framework, the modular couplings can be measured effectively as far as the eigenfunctions of the related direct issues.

Consequently, on the off chance that one can ascertain with adequate exactness the eigenmodes of the issue, no specially appointed suspicions are required and the elements of the plate can be repeated loyally. The utilizations of the modular plan are not constrained to sound synthesis. The short conversation on the melodic parts of plates toward the start of this presentation uncovered that their acoustical properties are associated with increasingly central part of the study of vibrations and, all the more for the most part, material science. Along these lines, the diagram of this proposal will attempt to join an examination of these increasingly key angles.

For feebly nonlinear vibrations, the plentifulness recurrence reliance and soundness of intermittent arrangements ought to be dissected inside the structure on Nonlinear Normal Modes. The course of vitality to higher frequencies in an emphatically nonlinear system ought to rather by contemplated factually inside the structure of Wave Turbulence. The Nonlinear Normal Modes (NNMs) are a hypothetical expansion of the idea of straight modes. In a straight setting, modular deterioration takes into account a rearranged examination on the grounds that the modes are invariant (an answer beginning a given mode will remain indefinitely in a similar mode) and they establish the premise capacities for building the most broad answer for the PDE. In a nonlinear settings, such properties stop to exist. In undeniable reality, nonlinear frameworks show bounces, bifurcations, sub harmonic and super harmonic inward resonances, modular communications, disorganized movements and precarious arrangements. There is, in any case, a hypothetical system which permits to stretch out, with some alert, the idea of straight mode to a nonlinear setting, and in this way to help in the examination of the nonlinear highlights.

SURVEY OF ELASTICITY THEORY

The old style speculations of plates and shells are a significant use of the hypothesis of flexibility, which manages connections of powers, relocations, stresses, and strains in a versatile body. At the point when a solid body is exposed to outside powers, it disfigures, delivering inner strains and stresses. The

disfigurement relies upon the geometrical design of the body, on applied stacking, and on the mechanical properties of its material. In the hypothesis of versatility we confine our thoughtfulness regarding direct flexible materials; i.e., the connections among anxiety are straight, and the disfigurements and stresses vanish when the outside powers are evacuated. The old style hypothesis of flexibility expect the material is homogeneous and isotropic, i.e., its mechanical properties are the equivalent every which way and at all focuses. The present segment contains just a concise overview of the flexibility hypothesis that will be valuable for the improvement of the plate hypothesis. All conditions and relations will be given without inference. The peruser who wants to survey subtleties is asked to allude to any book on flexibility hypothesis – for instance.

Variation Principles

Since the fundamental conditions of flexibility have been inferred, the point is to have the option to decide the condition of a versatile body exposed to powers. The improvements will originate from Hamilton's rule. Newton's essential laws of physical science consider the instance of material particles followed up on by powers. The expansion of Newtonian strategies to a body involving a finite bit of room is finished by coordinating the impacts of the single "material particles" over the volume V . Lagrange summed up this procedure for a framework involving a finite number of degrees of opportunity, and the movement of the framework is completely indicated once position and speeds of the considerable number of segments are determined at a moment of time t_0 . Hamilton expressed the issue fairly in an unexpected way, by determining the situation of the framework at two moments t_0 , t_1 , and by demonstrating that the elements in that follows a geodesic. The numerical proclamation of this guideline is

$$\delta \int_{t_0}^{t_1} (T - U + W_e) dt = 0, \quad \delta u_i(t_1) = \delta u_i(t_2) = 0;$$

where T is the kinetic energy of the system, U is the potential energy, and W_e is the work done by the outer powers on the system. The image δ is expected in the feeling of math of varieties. The conditions of movement and limit conditions can be gotten from the fundamental above. The three terms including T , U , W_e are currently examined. The image $\bar{}$ will signify an amount for every unit volume. The body is accepted to have a steady thickness p . The kinetic energy thickness is

$$\bar{T} = \frac{\rho}{2} \dot{u}_i \dot{u}_i, \quad \delta \bar{T} = \rho \dot{u}_i \delta u_i.$$

Integrating by parts in the time variable gives

$$\delta \int_{t_0}^{t_1} \bar{T} dt = \underbrace{\int_V [\rho \dot{u}_i \delta u_i]_{t_0}^{t_1} dV}_{=0} - \int_{t_0}^{t_1} \int_V [\rho \ddot{u}_i \delta u_i] dV dt.$$

LITERATURE REVIEW

In the only remaining century, numerous scientists researched the issue of clasping of barrel shaped shells under outside tension theoretically and tentatively. Just notable literary works are examined here.

Investigative Approaches Followed for Determination of Critical Buckling Pressure of Thin Cylindrical Shell

The vast majority of the old style scientific methodology depends on old style elastic arrangements like Donnell and Függe theory. The principal logical work on thin tube shaped shell exposed to outside weight was completed by von Mises (2012) which is alluded by numerous creators (as referenced in Simites (2013)). Sturm (1941) contemplated tentatively just as systematically the elastic conduct of thin roundabout barrel shaped shells exposed to uniform outer weight and looked at the outcomes. Batdorf (2014) utilized disentangled Donnell-sort of shell condition to foresee the basic clasping loads. Nash (2015) and Galletly and Bart (2013) created expository answers for clasping weight of thin round and hollow shells with braced finishes and the outcomes show that the clasping weight of clipped closures are more than that of basically upheld boundary conditions.

Langhaar and Boresi (2017) created diagnostic arrangement dependent on potential energy shell to decide the clasping quality of round and hollow shell and contrasted the investigative outcome and trial esteems exhibited in the past written works. Vocalist et al. (1969) in his investigative work showed that the expansion in the clasping weight of braced round and hollow shell is credited to pivotal imperative as opposed to rotational limitation.

Investigative answers for basic weight, bifurcation methods of shells with just bolstered boundary condition within elastic farthest point adjusting uncoupled type of Donnell condition, is given in Timoshenko and Gere (2013) and Brush and Almroth (2014) and dependent on versatility is given in Dubey (2015). Sobel (2016) learned about the impact of boundary conditions on the security of tube shaped shell exposed to hydrostatic weight stacking. It was demonstrated that there is insignificant distinction between the clasping weights of barrel shaped shell exposed to hydrostatic weight and to that of parallel weight when L/R proportion is more noteworthy than.

Exploratory Approaches Followed for Determination of Critical Buckling Pressure of Thin

The testing of chambers under outside tension stacking was taken for examination as essential wellspring of shakiness in eighteenth century and they are talked about in detail in Singer et.al. (2012). The greater part of the test works were done on round and hollow channels (for instance Dyau and Kyriakides (2013 an and b), Park and Kyriakides (2015), Karamanos and Eleftheriadis (2014), Lee et al. (2015), Sakakibara et al. (2008), Lo Frano and Forasassi (2008 and 2009), Alberani et al. (2013)) and just barely any exploratory works were completed in thin round and hollow shells. Just exploratory works identified with thin barrel shaped shells exposed to outside weight (both hydrostatic outer weight stacking and parallel uniform weight loadings) are examined here. The most punctual exploratory investigations of shell buckling tests under outside tension was done by Fairbairn in the year 1857 and detail conversation about that test arrangement is given in Ref. [Singer et.al. 2002].

Windenburg and Trilling (2013) additionally completed both explanatory and trial chip away at tubes and round and hollow shells under both sidelong tension and hydrostatic weight stacking conditions and contrasted the test results and expository arrangements and experimental arrangements created from before contemplates. It was inferred that von Mises condition for basic weight of barrel shaped shell exposed to hydrostatic weight stacking condition well matches with exploratory outcomes. Sturm (1941) considered tentatively just as systematically the elastic conduct of thin roundabout barrel shaped shells exposed to uniform outside weight (both hydrostatic and uniform parallel weight stacking) to decide breakdown pressure for basically bolstered and fixed boundary conditions and furthermore learned about impacts of plastic conduct of the material, out-of-roundness and ring stiffeners on breakdown weight of the tube shaped shell and contrasted the theoretical outcome and trial results.

Further, he recommended that if the weight is not exactly certain point of confinement, outside weight load on the round and hollow shell can be applied through vacuum pressure stacking inside the barrel shaped shell. From the investigations it was indicated that if there should arise an occurrence of hydrostatic weight stacking condition, if the hub power F isn't excessively extraordinary, the shell accept a fluted structure when it clasps and when the pivotal power F prevails, the clasped shell expect a structure where precious stone formed features happen.

Egorov and Andrievskaya (2016) tentatively learned about the buckling conduct of steel tube shaped shell with free help boundary condition. The tentatively decided buckling pressures were contrasted and theoretical qualities. Yamaki and Otoma (2016)

learned about the post buckling conduct of braced round and hollow shell under hydrostatic tension condition tentatively. Six polyester test chambers with Batdorf number change from 20 to 100 were utilized and the test results are contrasted and theoretical estimations of basic weight and wave number. Malik et al. (1979) tentatively researched about the buckling of barrel shaped shells of variable-divider thickness under outside tension. Seleim and Roorda (2016) tentatively learned about the neighborhood (exposed barrel shaped shell disappointment between ring stiffeners) and general insecurity of machined ring stiffened round and hollow shell under outer tension. It was presumed that buckling pressure got from trial results are within $\pm 30\%$ of theoretically acquired outcomes from before written works.

Hornung and Saal (2013) contemplated about buckling heaps of both genuine and model tank shells with flaws both numerically and tentatively with vacuum pressure condition. In that work it was presumed that solitary the numerical examination with a model of the total tank shell with the deliberate defects gave results which concurred with the buckling test. In the paper by Aghajari et al. (2016), numerical and test examination completed to contemplate the buckling and post-buckling conduct of thin-walled tube shaped steel shells with differing thickness exposed to uniform parallel outer weight. In the trial study, barrel shaped steel shells with changing thickness were tried to crumple utilizing vacuum based test rig. So as to confirm the exactness and legitimacy of the finite component demonstrating, the numerical outcomes, acquired from nonlinear finite component breakdown investigations, were contrasted and the aftereffects of the test study and found that nonlinear finite component breakdown examinations followed intently the exploratory conduct. It is additionally discovered that the buckling mode can be created in entire length of the shell if the thickness variety is low and instance of high variety of thickness, the buckling mode is framed in thinner part as it were. Likewise, impacts of circumferential and vertical weld line on the buckling quality and mode shapes were checked. The buckling limit of thin defective round and hollow jars subject to uniform outside weight was researched in the paper by Paor et al. (2010).

Defect estimations were taken for little scope steel jars and these estimations were demonstrated and broke down utilizing a geometrically nonlinear static finite component analysis. The jars were then tried in the research facility and the outcomes contrasted and those anticipated by the FE models and theory. Wang and Koizumi (2012) examined about the kicking of tube shaped shells with longitudinal joint through the test and numerical analysis. The buckling tests were conveyed utilizing vacuum based weight rig. It was discovered that the buckling of tube shaped shells with inflexible joint clasps just once and is in multi-flap structure. In any case, round and hollow shells with adaptable joints locks twice and right off the bat in

single-flap buckling in the region of the joint, besides in multi-projection buckling in outstanding un-twisted region with lower buckling pressure. FE analysis results were contrasted and test results and discovered great concurrence with one another. Aghajari et al. (2013) tentatively learned about the impacts of thickness variety and geometric flaws on the buckling and post buckling conduct of tube shaped shells under uniform horizontal tension.

Sliz and Chang (2013) displayed solid and exact technique for the trial buckling forecast of thin-walled tube shaped shell under an offbeat burden. The geometric defects of the example's surface were estimated utilizing a CMM. Notwithstanding beginning geometric defects, load unusualness, diverse boundary conditions impacts were additionally contemplated in detail. FE results firmly coordinated with the test esteems.

Fatemi et al. (2013) tentatively learned about hindering impacts on the buckling obstruction of shells having weld-instigated geometric blemishes under uniform outside tension. It was accounted for that buckling and post buckling limit of the shells rely impressively upon the cross-sectional structure and profundity of the geometric blemishes and this was likewise depended with shell having distinctive H/R and R/t proportions. The consequences of testing under various codes were thought about. GhanbariGhazijahani et al. (2014) tentatively concentrated the buckling and disappointment reaction of harmed exceptionally thin round and hollow shells subject to pivotal stresses with 27 examples having various marks. GhanbariGhazijahani et al. (2015) in their paper announced about the trial program on the buckling and post-buckling reaction of thin barrel shaped shells with nearby gouge flaws under hydrostatic outside tension. To best information on creator from the above writing study, it is presumed that not very many test works are accessible in literary works about the buckling conduct of barrel shaped shell exposed to just sidelong outside weight stacking.

CONCLUSIONS

An Orthotropic Plate Model has been made as a proficient helper substitute for Hat Stiffened Plate subject to the proportional unbending nature thought, which uses Orthotropic Rescaling Technique. The Orthotropic Plate Model created for a Representative Unit Cell of Hat Stiffened Plate has been endorsed with the efficient course of action available for orthotropic plate. The pressure and redirection of Representative Unit Cell of Hat Stiffened Plate shown using isotropic dainty shell part and its proportionate Orthotropic Plate Model using orthotropic slim shell segment have been foreseen using ANSYS 12. Examination has been finished for a uniform weight load and the two limit conditions viz., every one of the four edges just

supported similarly as two edges fixed and two edges basically maintained. A connection of results procured for Hat hardened Plate and its proportionate Orthotropic Plate Model has been shown in the table structure. For just reinforced limit condition the Orthotropic Plate Model could envision the most extraordinary shirking and worry with enough incredible exactness. Direct fastening examination and outrageous quality investigation of Hat Stiffened Plate and its indistinguishable Orthotropic Plate Model has been accomplished for every one of the four edges basically maintained limit condition and the results have been taken a gander at. The Orthotropic Plate Model could predict the direct fastening load with extraordinary accuracy and outrageous quality with a precision of 18.5% in a manner of speaking.

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Corresponding Author

Sangeeta*

Research Scholar of OPJS University, Churu, Rajasthan