INVESTIGATING THE GEOMETRICAL NON-LINEAR BEHAVIOR IN PERFORMANCE OF THE ASYMMETRIC STRUCTURES

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For purposes of designing and controlling the structures, proper understanding of their dynamical behavior is needed and necessary. In this paper, a novel model for irregular-plan buildings, subjected to earthquake and harmonic excitation, is presented to consider non-linear inertial coupling terms, which are ignored in conventional linear models. Furthermore, the effect of combination resonance is investigated. In this method dynamical characteristic like stiffness, has defined as dependent variable of rotary system of coordinates. First the governing equations of motion for a model of this type of structure are achieved in a non-inertial rotational system of reference, attached to the center of mass of the rigid diaphragm of its floor.

In addition to apply in one-story asymmetric structure, the novel viewpoint is generalizable in the multi-story structure, in such a way that because of the equal order rotations of the stories, caused by resisting elements of those stories having the same order, the local coordinate's system in each story is considered as dependent on the rotation of the proper story and ensued that the resisting structural elements are defined as springs and dampers in the direction of the direction of individual story's coordinates and their obtained dynamic equations include all of the linear terms as well as inertial and non-linear stiffness's.

$$\frac{\ddot{u}_x}{r} + 2\xi_x\omega_x\frac{\dot{u}_x}{r} + \omega_x^2\frac{u_x}{r} = -(-2\frac{\dot{u}_y}{r}\dot{\theta} - \frac{u_y}{r}\ddot{\theta} - \frac{u_x}{r}\dot{\theta}^2 + \frac{\ddot{u}_{gx}}{r}\cos\theta + \frac{\ddot{u}_{gy}}{r}\sin\theta) \tag{1}$$

$$\ddot{\theta} + 2\xi_\theta\omega_\theta\dot{\theta} + (\omega_{\theta R}^2 + \omega_y^2(\frac{e_x}{r})^2\theta + \omega_y^2\frac{e_x}{r}\frac{u_y}{r} = 0 \tag{2}$$

$$\frac{\ddot{u}_y}{r} + 2\xi_y\omega_y\frac{\dot{u}_y}{r} + \omega_y^2\frac{u_y}{r} + \omega_y^2\frac{e_x}{r}\theta = -(-2\frac{\dot{u}_x}{r}\dot{\theta} - \frac{u_x}{r}\ddot{\theta} - \frac{u_y}{r}\dot{\theta}^2 + \frac{\ddot{u}_{gX}}{r}\sin\theta + \frac{\ddot{u}_{gY}}{r}\cos\theta) \tag{3}$$

Then under earthquake and harmonic excitation, the difference between the responses of the proposed non-linear model and the conventional linear one is shown in time-history and frequency domain analyses. At the end by force-response & frequency-response curves, obtained by perturbation method, the stability regions of the typical structure are attained (for example, see Figure 1).

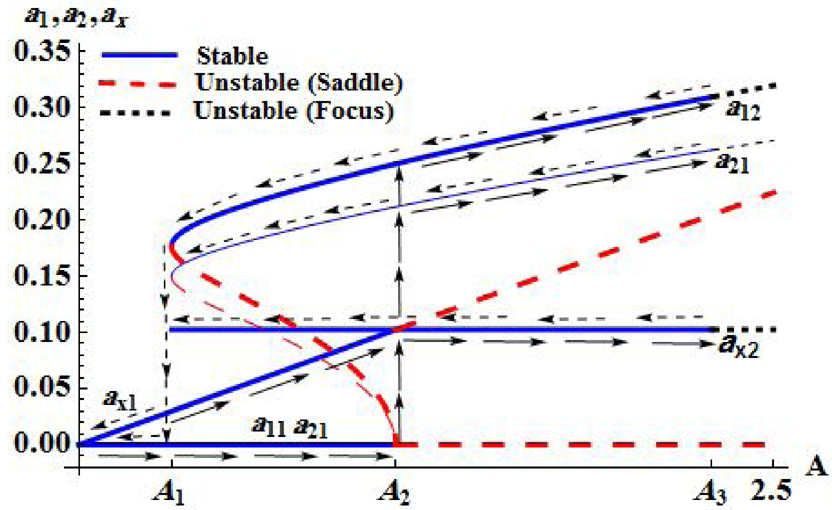

Figure 1. Variation of modal amplitude responses a_1, a_2 and a_x , vs, A, for the structure with $\Omega_{\theta R} = \Omega_y = \Omega = 1$, $\sigma_1 = 0.1, \sigma_2 = -0.2$ when $\chi_1 > 0$

Also some non-linear phenomena, such as saturation, hysteresis and jumping are studied.

REFERENCES

Amin Afshar M and Amini F (2012) Non-linear dynamics of asymmetric structures under 2: 2: 1 resonance, *International Journal of Non-Linear Mechanics,* 47(7): 823-835

Amini F and Amin Afshar M (2011) Saturation in asymmetric structures under internal resonance, *Acta Mechanica,* 221(3-4): 353-368

Deolasi PJ and Datta PK (1997) Simple and combination resonances of rectangular plates subjected to non-uniform edge loading with damping, *Engineering Structures*, 19(12): 1011-1017

Hosseini SAA and Khadem SE (2009) Combination resonances in a rotating shaft, *Mechanism and Machine Theory*, 44: 1535–1547

Li L, Li YH, Lv HW and Liu QK (2012) Flap wise dynamic response of a wind turbine blade in super-harmonic resonance, *J. Sound Vib,*331(17): 4025–4044

Nayfeh AH (2001) Combination Resonance of a Centrally Clamped Rotating Circular Disk, *Journal of Vibration and Control*, 7: 979-1011