Comment on Estimates of the ground accelerations at Point Reyes station during the 1906 San Francisco earthquake by A. Anooshehpoor, TH Heaton, B. Shi, and.

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Comment on “Estimates of the Ground Accelerations at Point Reyes Station during the 1906 San Francisco Earthquake” by A. Anooshehpoor, T. H. Heaton, B. Shi, and J. N. Brune

Jian Zhang; Nicos Makris

Bulletin of the Seismological Society of America (2000) 90 (5): 1342-1348.

Article Contents

https://doi.org/10.1785/0119990130
Article history

The above-titled article presented response-time histories and spectra for the minimum acceleration amplitude of a full sine pulse that is needed to overturn a rigid, rectangular, free-standing block. The construction of the overturning spectra is achieved with the analytical solution of the linearized equations of motion of a rocking block which is pieced together at the instant when the rotation reverses and at the instant when the block enters the free-vibration regime.

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The above-titled article presented response-time histories and spectra for the minimum acceleration amplitude of a full sine pulse that is needed to overturn a rigid, rectangular, free-standing block. The construction of the overturning spectra is achieved with the analytical solution of the linearized equations of motion of a rocking block which is pieced together at the instant when the rotation reverses and at the instant when the block enters the free-vibration regime.

While some segments of the methodology presented are correct the article contains several logical, algebraic, and typographical errors which are reflected in nearly every result presented. This discussion addresses systematically these errors and oversights. The same notation used in the original article is adopted herein. The noun *article* refers to the article under discussion by Anooshehpoor *et al.;* the noun comment refers to this discussion.

With reference to its Figure 3, the article investigates the rocking response of a rigid block subjected to a horizontal backwards displacement (motion from the right to the left of the page) with acceleration history

$$a(t) = \begin{cases} -A\sin(\omega t + \psi) & -\psi/\omega \le t \le (2\pi - \psi)/\omega \\ 0 & \textit{otherwise} \end{cases} \quad (1)$$

where ψ is the phase angle when rocking initiates, with $\sin\psi = \alpha g/A$. In equation (1) $A > 0$, and for the acceleration history given by (1) the block will first experience a positive rotation, $\theta > 0$, (rotate about point O_1 of Figure 3 of the article). Assuming zero vertical base acceleration the equations of motion of the rocking block are

$$I\dot{\theta}(t) = -mgR\sin(\alpha - \theta) - ma(t)R\cos(\alpha - \theta),\ \theta \ge 0 \quad (2)$$

and

$$I\dot{\theta}(t) = -mgR\sin(-\alpha - \theta) - ma(t)R\cos(-\alpha - \theta),\ \theta < 0 \quad (3)$$

Equation (2) and (3) are well known to the literature (for example, Yim *et al.*, 1980; Spanos and Koh, 1984; Hogan, 1989; Makris and Roussos, 1998, among others). The sign of the last term that contains the horizontal ground acceleration is negative. Unfortunately, equation (3) of the article which corresponds to equation (2) of this discussion, has an incorrect positive sign in front of its last term. Surprisingly, this error is not reflected in the linearized equation of motion for positive rotations (equation (5) of the article); however, it is reflected in the linearized equation of motion for negative rotations (equation (7) of the article).

For tall, slender blocks, the angle $\alpha = \text{atan}\,(b/h)$ is relatively small, and equations (2) and (3) can be linearized. Within the limits of the linear approximation and for the ground acceleration given by (1), equations (2) and (3) of this comment become:

$$\dot{\theta}(t) - p^2\theta(t) = p^2\alpha\left[\frac{\sin(\omega t + \psi)}{\sin\psi} - 1\right],\ \theta \ge 0 \quad (4)$$

and

$$\dot{\theta}(t) - p^2\theta(t) = p^2\alpha\left[\frac{\sin(\omega t + \psi)}{\sin\psi} + 1\right],\ \theta < 0 \quad (5)$$

where $p = \sqrt{3g/(4R)}$ is the frequency parameter of a rectangular block with a half diagonal = R. Equation (5) of the article, which corresponds to equation (4) of this comment is correct; whereas, equation (7) of the article, which corresponds to equation (5) of this comment is incorrect, since negative signs appear in its right-hand side. This algebraic error is not typographical, since its effect is reflected in Figure 4 of the article that plots the normalized rotation, θ/α and angular velocity, θ of a rigid block with $\omega/p = 4$ and a coefficient of restitution $\eta = 0.95$. The block is subjected to the acceleration history given by (1) (backwards motion from right to left) and the block initially is subjected to a positive rotation and positive angular velocity as correctly shown on Figure 4 of the article (surprisingly, the acceleration history is plotted incorrectly in Figure 4 of the article with reversed sign). The results presented in Figure 4 of the article are correct until the first impact occurs. At the instant of impact (rotation reverses sign, but angular velocity does not), Figure 4 of the article indicates a sudden reversal of the sign of angular velocity that is incorrect. The erroneous results of Figure 4 after the impact indicate that while the block is rocking from right to left with an increasing negative rotation its velocity is positive (as if the block was rocking from left to right), which is absurd. In reality at the instant of impact the angular velocity experiences a

Index Terms/Descriptors

algorithms California earthquakes ground motion Marin County California Point Reyes San Francisco earthquake 1906 seismicity United States

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