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NUMERICAL SIMULATION OF THE HUMAN BEHAVIOUR IN A MEDIUM POLLUTED BY SHOCKS AND VIBRATIONS

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ABSTRACT

Vibration is most simply defined as oscillating motion. It could be periodic or nonperiodic. Repeated loading of the lumbar spine occurs in activities of daily living like lifting and driving. The chronic exposure results in mechanical and chemical changes in the spinal components leading to spinal degeneration. These disorders in a person may lead to discomfort, loss in productivity, and an enormous increase in health care cost to society. In a chronic vibration environment, the prevalence of low-back problems is dependent on a host of factors including subject age, subject posture, magnitude of input vibration, and exposure time. It is imperative that efforts be made to understand the effects of whole body vibration on the spine and how these can be prevented. The aim of this paper is to presents an original simulation of the human behavior in a medium polluted by shocks and vibrations.

Keywords: Vibration, Human Body, Numerical Simulation

1. INTRODUCTION

Vibrations can be defined as oscillations of mass about a fixed point. Although the human body is a unified and complex active dynamic system, lumped parameter models are often used to capture and evaluate human dynamic properties. Lumped parameter models consisting of multiple lumped masses interconnected by ideal springs and ideal dampers have proven to be effective in many applications, including those involving human exposure to whole-body vibration. Figure 1 illustrates an example of a lumped parameter human model useful in the simulation of human response to vertical vibration. The head, upper, centre and lower torsos, right and left arms, and right and left legs are modelled as lumped masses. The masses are connected together in the vertical direction by mass less springs and dampers that capture human viscoelastic properties.

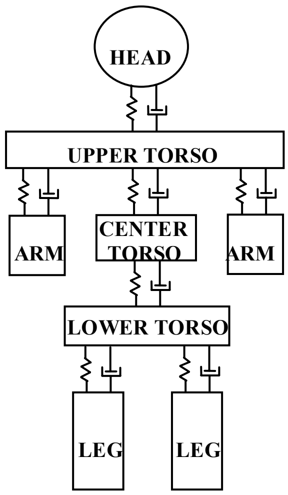


Figure 1. General lumped parameter human model

2. PROPOSAL MODEL

2.1. Assumption to simplify the human body

In this paper we assumed that parts of the human body would only swing back and forth as well as move up and down. Because it was apparent that the human body would remain physically symmetry during exposure to vibration in a vertical direction. Thus, in the physical vibration model, the transverse shaking of the human body is ignored. Therefore, we can assume that a two-dimensional model projected on the central plane, which is a midsagittal plane, of the human body would simulate the realistic vibration behaviour of the human body.
As is noticed in figure 2, the structure is formed from the follow components: visual analyzer (eye); head; internal viscera; thorax; scapular belt; superior member; pelvis.

The dampers and the springs represent joints, tendons and another ale bindery organs modeling. Is considered that the subject is submissive of a formal disturbances $F_p = F_0 \sin \omega t$ and is followed the analysis behavior of human organism (the precise maul of the seven parts of human organism) to this type of vertical vibrations.
Additionally, to simplify the model of the human body further, the following conditions were assumed:
(1) It was assumed that the human body consists of visual analyzer (eye), head, internal viscera, thorax, scapular girdle, superior member and pelvis.. Each part of the human body has a mass and a rotating inertia at the centre of gravity (Fig. 2).
(2) The lower leg could be connected to the thigh and the thigh to the abdomen by a joint with an axis of rotation and generating a viscosity resistance moment. The resistance moment represents the passive resistance element of ligaments. The abdomen and chest are connected by a visco-elasticity element that consists of a spring and a damper and the thorax and head are connected in the same way.
(3) Only portions of the back of head, the back and the lower pelvis are exposed to the external force of the vibration.
(4) So that the head, trunk (chest, abdomen) and pelvis would never slip on the surface of the chair, there is sufficient frictional force at each point of contact.

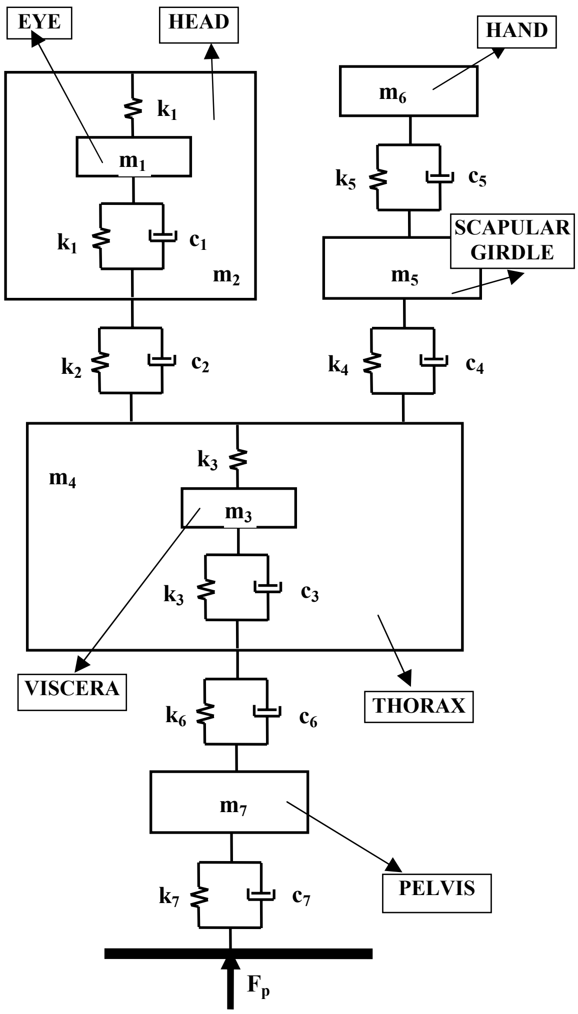


Figure 2. Proposal Model

Finally, we simplified the human body to a two-dimensional vibration model consisting of masses, rigid links, springs and dampers with nine degrees of freedom (Fig. 2).

2.2. Formulation of the equation of motion for the simplified human vibration model

In order to simplify the formulation of the equation of motion for the two-dimensional vibration model, we further assumed the following:
(1) Each part of the vibration model slightly vibrates around each static force equalizing position.
(2) The righting moment of springs and the attenuating force of dampers are in proportion to the displacement and the velocity, respectively.
(3) The saturation viscosity resistance moment is applied to the resistance moments between the lower leg and the thigh and between the thigh and the abdomen.
Finally, the equation of motion consists of the coefficient matrices illustrating the effects of the masses, rigid links, springs and dampers. The equation also has nine degrees of freedom, which were 3 rotations and 6 translations, which did not perpendicularly intersect each other.

$$\begin{cases} m_1\ddot{y}_1 + c_1\dot{y}_1 - c_1\dot{y}_2 + 2k_1y_1 - 2k_1y_2 = 0 \\ m_2\ddot{y}_2 + (c_2 + c_1)\dot{y}_2 - c_2\dot{y}_4 - c_1\dot{y}_1 + (k_2 + 2k_1)y_2 - k_2y_4 - 2k_1y_1 = 0 \\ m_3\ddot{y}_3 + c_3\dot{y}_3 - c_3\dot{y}_4 + 2k_3y_3 - 2k_3y_4 = 0 \\ m_4\ddot{y}_4 + (c_6 + c_3 + c_2 + c_4)\dot{y}_4 - c_6\dot{y}_7 - c_3\dot{y}_3 - c_2\dot{y}_2 - c_4\dot{y}_5 + \\ \quad + (k_6 + 2k_3 + k_2 + k_4)y_4 - k_6y_7 - 2k_3y_3 - k_2y_2 - k_4y_5 = 0 \\ m_5\ddot{y}_5 + (c_4 + c_5)\dot{y}_5 - c_4\dot{y}_4 - c_5\dot{y}_6 + (k_4 + k_5)y_5 - k_4y_4 - k_5y_6 = 0 \\ m_6\ddot{y}_6 + c_5\dot{y}_6 - c_5\dot{y}_5 + k_5y_6 - k_5y_5 = 0 \\ m_7\ddot{y}_7 + (c_7 + c_6)\dot{y}_7 - c_6\dot{y}_4 + (k_7 + k_6)y_7 - k_6y_4 = -F_p \end{cases}$$

in which: m_i - masses; c_i - amortizations; k_i - rigidities; y_i - displacements; $\dot{y}_i$ - velocities, $\ddot{y}_i$ - accelerations and F is a sinusoidal force.

3. RESULTS

3.1. The Own Vibrational Modes

The own pulsations and the forms of own modes (fig. 6) are obtained through the solution of the system of homogeneous equations for the free vibrations unamortized with next form:

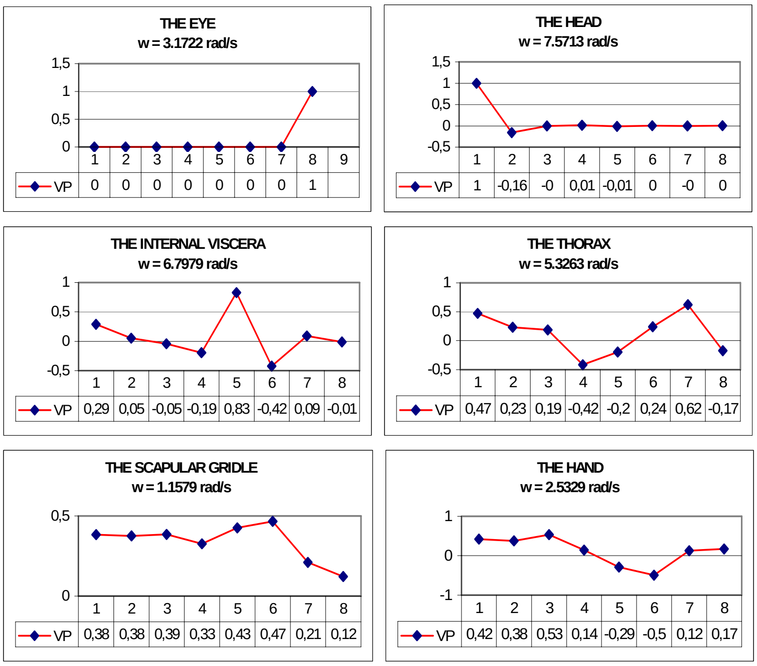
$$[M]\{\ddot{y}\}+[K]\{y\}=\{0\}$$

3.2. The graphic representation of the system solutions

Each solution of the system can be writhed in the likeness of:

$$M_r\ddot{\xi}_r + C_r\dot{\xi}_r + K_r\xi_r = f_r$$

which describes the modulo of motion, characterized by the variation of main coordinate ξ_r.



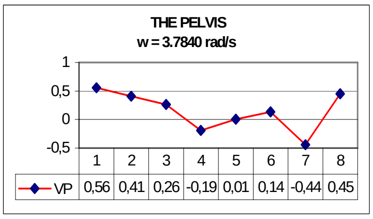


Figure 3. The own modes of vibration

Each such equation can solved asunder, identically with the equation of constrained vibrations ale of the system with a degree of freedom and can be writhed like:

$$x = x_0 \cos pt + \frac{1}{p}\left(v_0 - \frac{q\omega}{p^2-\omega^2}\right)\sin pt + \frac{q}{p^2-\omega^2}\sin \omega t$$

where: $p=\sqrt{k/m}$, $q=F_0/m$, $F_p=F_0 \sin \omega t$ and x_0, v_0 are initial displacements, respectively velocities. If $x_0=0$, $v_0=\frac{q\omega}{p^2-\omega^2}$, than $x=\frac{q}{p^2-\omega^2}\sin \omega t$.

For the proposal model, we consider: $p=\sqrt{k_r/m_r}$, $q=F_0/m_r$, $F_p=F_0 \sin \omega t$.

Reduced masses are identically with the masses of the system's elements and the reduced rigidities are:

$k_{r_1}=2k_1, k_{r_2}=2k_1+k_2, k_{r_3}=2k_3, k_{r_4}=k_2+2k_3+k_4+k_6, k_{r_5}=k_4+k_5, k_{r_6}=k_5, k_{r_7}=k_6+k_7$

or $y(\omega,t)=\frac{F_0}{k-\omega^2 m}\sin \omega t$. This is the expression of the system's movements. For $F_0=4\cdots60$ and $\omega=6\cdots50 \quad rad/s$, we obtained the movements represented the charts (fig. 4-10).

4. CONCLUSIONS

In the previously figures we represented in MAPLE the variations of displacements, velocities and accelerations of the system for ω = 6…50 rad/s, t = 0…100 s and F_0 = 30 N. As per graphic the movement of the eye varies between 80 and 80 mm, with speeds contained between 600 and -600 mm/s and accelerations of -4000 to 4000 mm/s^2, what represents the very big values. Thence, such force solicits much eye and, by default, he steps in operable see. Is can noticed from charts that the movements other systems are very little (do not exceed 2 mm, what means that applied force do not influences very many state of the systems. In addition, the values of the speeds and the found accelerations are very little by-paths.

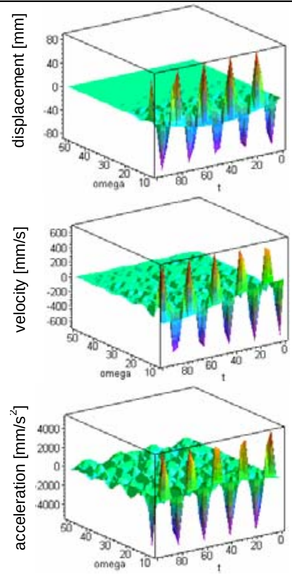


Fig. 4. The eye

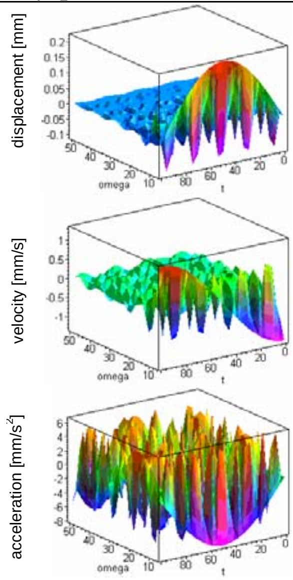


Fig. 5. The head

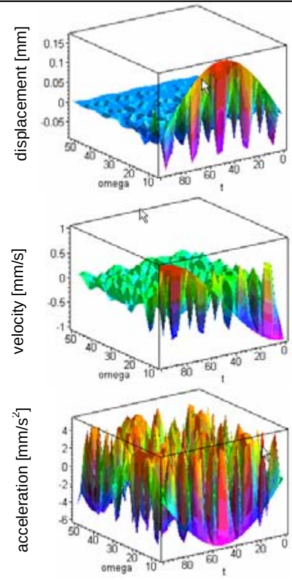


Fig. 6. The viscera

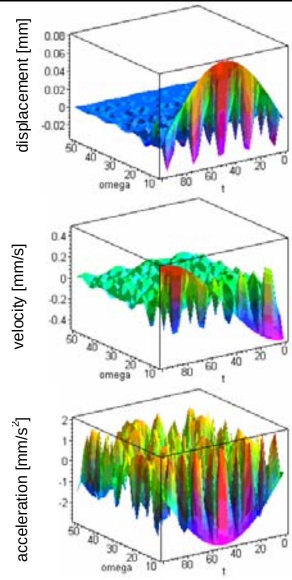


Fig. 7. The thorax

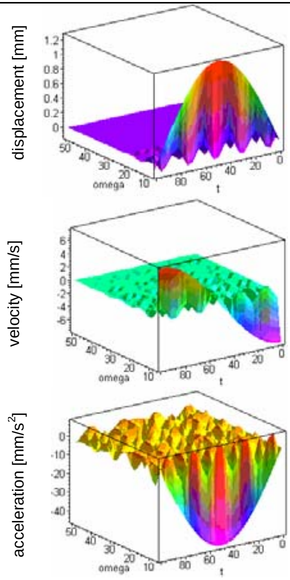


Fig. 8. The scap. gridle

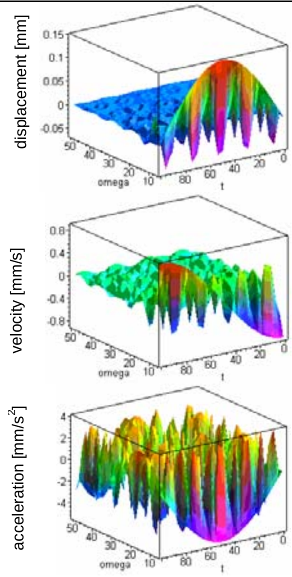


Fig. 9. The hand

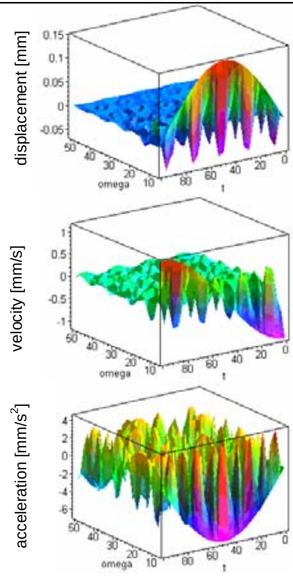


Fig. 10. The pelvis

As a general conclusion, we can say that the human organism modelled as a system of table, springs and dampers is behaved like every mechanical systems. Most affected parts ale the organism are eye, head (the neurological systems) and the internal viscera. Law for which first sensations perceived by organisms to resonance is the sensation of bad (dizziness, sickness), as well as the disturbance of the sight and, here, he diminishes the orientation in space. The visual function is stricken, in fore rank, because the visual analyzer is a sensory system, but and because of this orientation after a visual axis, carry temporally the vibration is earnest affected.

5. REFERENCES

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