ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 9 , September 2021

Propagation of Vibrations in Soils from Subway Tunnels Taking into Account Open Tranches Constructed To Reduce Vibration Level

M.U. Karabaeva

Lecturer, Department of "Material Resistance and Mechanics", Namangan Engineering – Construction Institute, Namangan, Uzbekistan

ABSTRACT: The trench can act as a barrier to ground vibration and is a potential measure to mitigate low frequency vibration caused by the movement of subway trains. The study looks at more practical aspects in which the sides of the trench are angled. The study uses a finite element model. The results show that in all conditions considered, open trenches that are located at an angle on both sides perform best.

KEY WORDS: Vibration, differential equation of soil, subway, frequency, theory of elasticity, barrier, trench, amplitude, train.

I. INTRODUCTION

Ground vibration from subway trains is an increasingly important environmental issue. It manifests itself in two ways: low-frequency vibration in the range of 1-80 Hz is perceived by the inhabitants of the line as a vibration of a whole body, while vibration of a higher frequency in the range of 16-250 Hz is emitted as sound inside buildings and is known as ground noise [1,2]. Trains operating on land railways, especially where the ground is soft, often produce vibration with the highest components in the range below 40 Hz, which is mostly felt as a perceptible vibration. Velocity amplitudes are usually between 0.1 and 1 mm / s. In contrast, trains operating in tunnels tend to generate higher frequency vibration at significantly lower amplitudes.

In principle, there are a number of possible ways to reduce the vibration caused by the railway [1,2,3], including changes in the vehicle, changing the track [4] or the ground below it [5,6] or the introduction of some form of barrier next to the track.

An open trench is commonly used to attenuate ground vibration [7]. This can act in a similar way to a noisy airborne sound barrier: the vibration is diffracted by the "shadow zone" behind it. An ideal open trench with vertical sides is unstable, so in practice it requires either sloped sides or reinforcing walls.

An open trench has long been considered a possible solution to ground vibration caused by the movement of railroad cars and trains. Early field trials were presented by Woods [7,8]. The results were presented as amplitude reduction factors, and a reduction of at least 0.25 (ie 12 dB) was considered "dramatic". This was achieved using trench depths of at least 0.6 part of the Rayleigh wavelength. The width was not critical. It was found that trenches in the far field from the source were less effective.

II. LITERATURE SURVEY

Let us consider the problem as a plane problem of the theory of elasticity with respect to the longitudinal axis of the tunnel by the method given in [9, 10], taking into account the symmetry of the problem, it is possible to single out a rectangular excited section near the railroad bed (see Fig. 1.). Dividing the selected area into finite elements, we write the equation of motion of the system in matrix form

$$[M]\left\{\ddot{u}(t)\right\}+[C]\left\{\dot{u}(t)\right\}+[K]\left\{u(t)\right\}=\left\{P(t)\right\}-[\Gamma]\left\{\dot{u}\right\} \tag{1}$$

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 9 , September 2021

In this place: $[M]$, $[C]$ и $[K]$ -mass, damper and virginity matrices of the system, respectively, $\{u(t)\}, \{P(t)\}$-vectors of node displacement and impact forces, $[\Gamma]$- matrix that takes into account the viscosity of the boundaries, simulating the radiation of elastic waves at the boundary, i.e. [11].

$$\begin{Bmatrix} \Gamma(i-1,i-1) \\ \Gamma(i,i) \end{Bmatrix} = \begin{Bmatrix} V_P \\ V_S \end{Bmatrix} b\Delta l_i \rho_i \qquad (2)$$

In this place: b - thickness of the element; Δl_i - average element size around the i-th boundary point; ρ_i-the density of the material around the i-th boundary point.

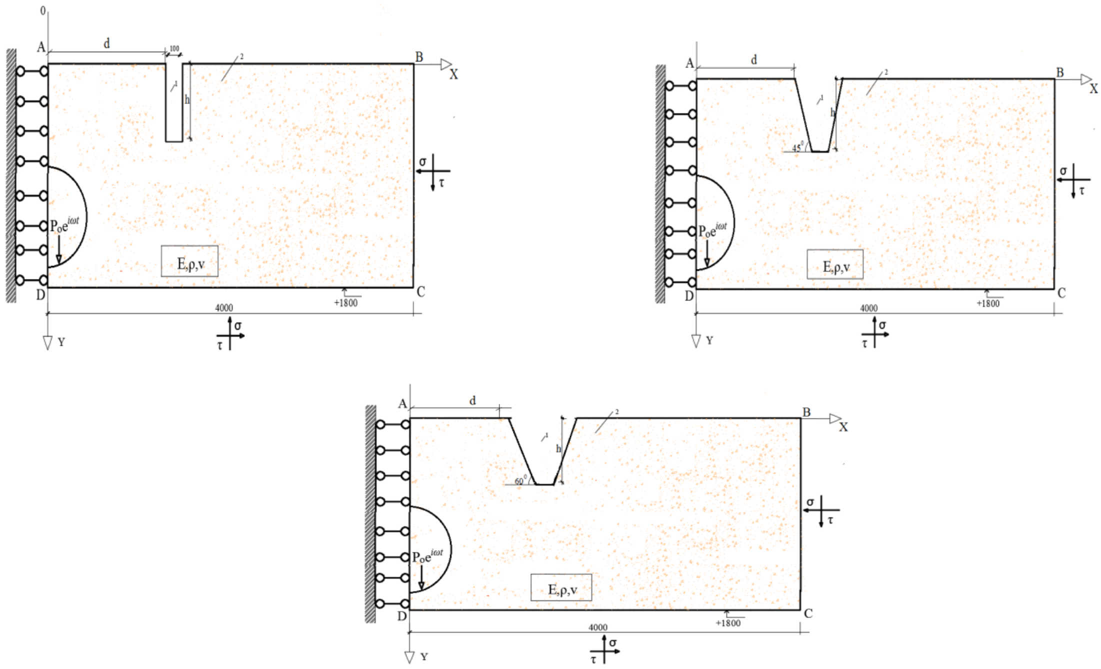

Fig. 1. Design schemes considered for trenches with inclined sides

With harmonic load with circular frequency ω

$$[P(t)] = \{P\}e^{i\omega t} \qquad (3)$$

the reaction of the system will be as follows

$$\{u(t)\} = \{\overline{u}\}e^{i\omega t}, \quad \{\dot{u}(t)\} = t\omega\{\overline{u}\}e^{i\omega t}, \quad \{\ddot{u}(t)\} = -\omega^2\{\overline{u}\}e^{i\omega t}, \qquad (4)$$

those, the system also oscillates with the angular frequency ω, where $\{\overline{u}\}$–vector of constant complex amplitudes of the system's displacement.

After substitution of (3) and (4) in (1), the equation of motion of the system becomes independent of time and takes the form of a system of complex algebraic equations

$$[\overline{K}]\{\overline{u}\} = \{\overline{P}\}, \qquad (5)$$

In thisplace: $[\overline{K}]$ – modified complex stiffness matrix determined by the formula. $[\overline{K}] = [K] + i\omega([C] + [\Gamma]) - \omega^2[M]$ (6)

It is known that $\omega = 2\pi f$ (f - the vibration frequency).

With the correct numbering of nodes and elements, the matrix formed using the well-known procedure of O. Zenkevich will have a strip-like form, since the matrices of masses, stiffness and damping of the system are symmetrical, strip-like.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 8, Issue 9 , September 2021

Owing to the possibility of using a complex variable in the FORTRAN translation language, the solution of equation (5) is performed without the procedure of dividing it into real and imaginary parts. After solving equation (5) by the Gaussian elimination method, the complex vector of constant amplitudes of the system is determined

$$[u] = \{u_1, u_2, u_3, \ldots, u_N\}. \tag{7}$$

Here N- the number of degrees of freedom of the discretized region (ABCD). The actual oscillation vector is determined by the formula

$$\{u(t)\} = \mathrm{Re}\{\bar{u}\}e^{i\omega t} \text{ or } \{u(t)\} = \mathrm{Re}\{u\}\cos\omega t - \mathrm{Im}\{u\}\sin\omega t .$$

The algorithm and the program of calculations were verified by solving known problems and comparing the result with the experimental data given in [11].

III. RESULTS

Suppose that a trench 1m wide and 7m deep is dug at a distance of 8m from the metro (Fig. 1). The first is a rectangular trench (vertical) as above. This compares to a trench on both sides tilted at a 45^0 angle; and a trench on both sides, inclined at an angle of 60^0. Their effectiveness is compared in Figure 2-4. The differences between the results for different trench cases can be considered quite small. These results indicate that for most situations, a sloped trench can be used instead of a rectangular trench to achieve similar results. The plots obtained taking into account these trenches are shown in Fig. 2-4.

For comparison, the changes in the amplitude modulus on the soil surface are given by dashed lines obtained taking into account the trench on both sides by 45^0, 60^0 and 90^0, and by continuous lines without taking into account trenches.

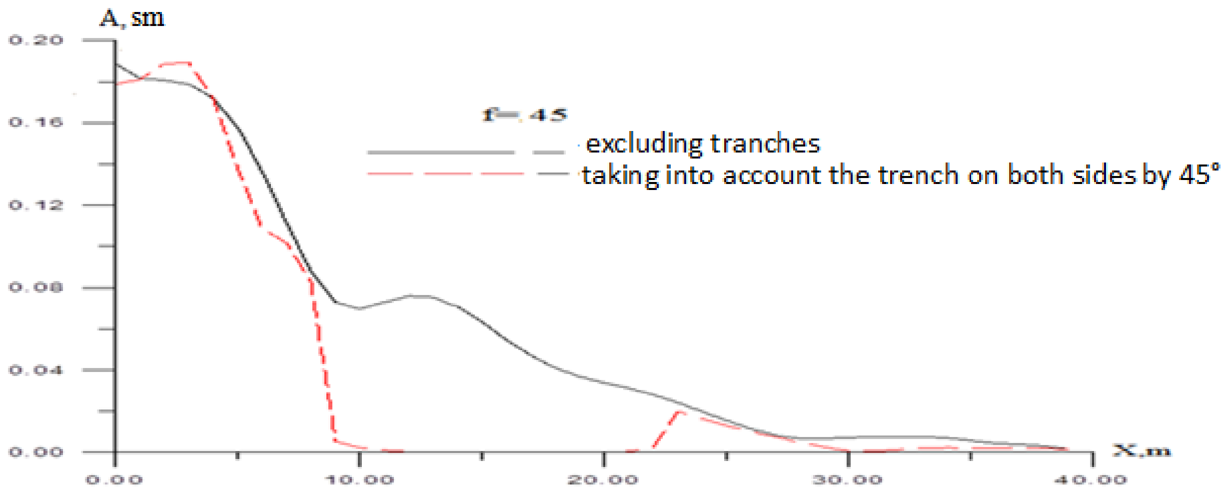

Fig. 2. Influence of the trench on both sides 45^0on the envelope of the vibration amplitudes of the points of the soil surface at f = 45Hz.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 9 , September 2021

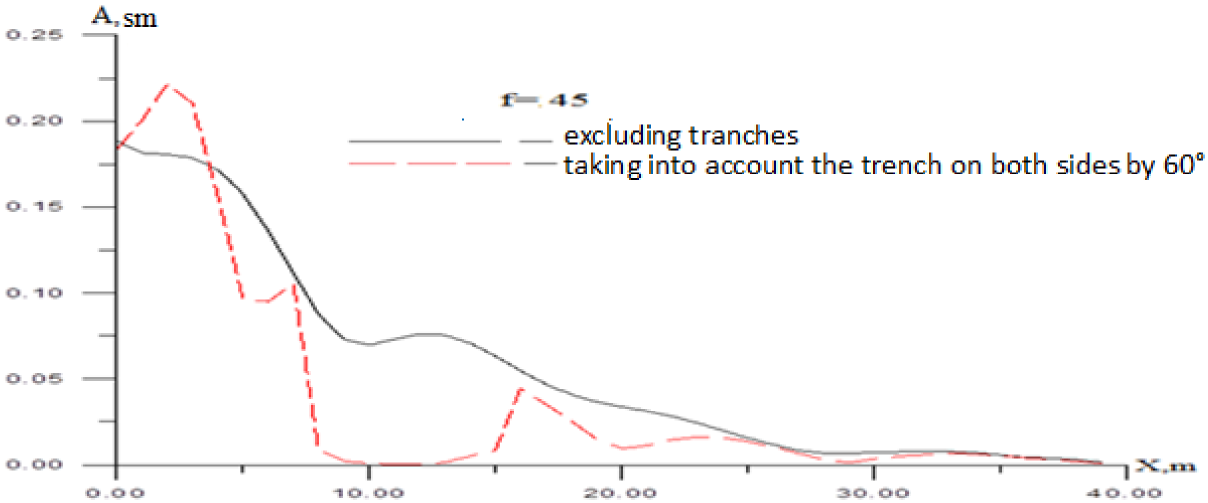

Fig. 3. Influence of the trench on both sides 60^0on the envelope of the vibration amplitudes of the points of the ground surface at f = 45Hz.

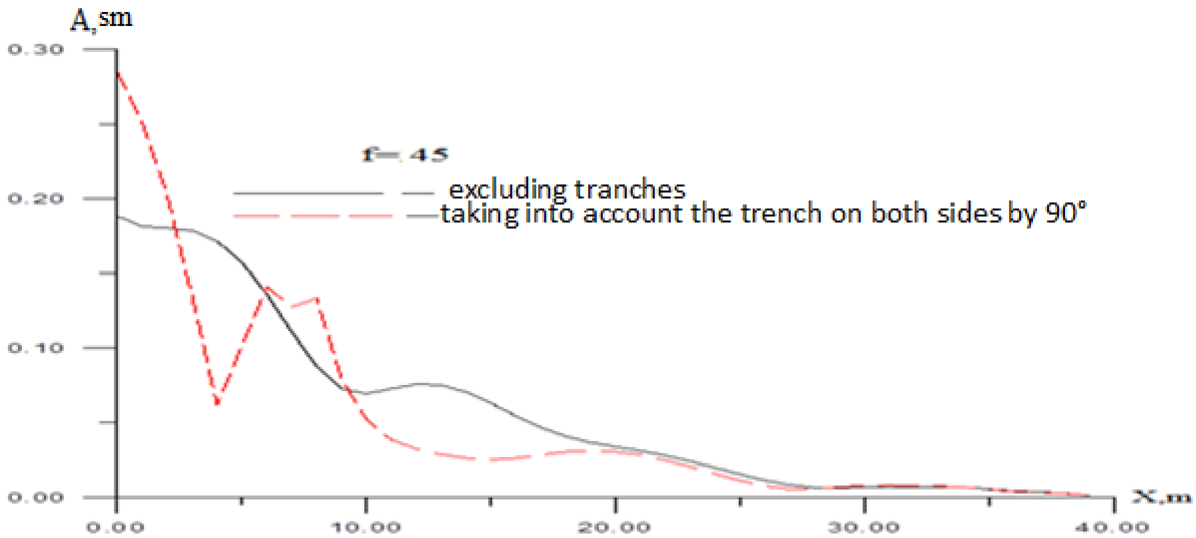

Fig. 4. The influence of the trench on both sides of the 90^0on the envelope of the vibration amplitudes of the points of the ground surface at f = 45Hz.

In fig. 2 shows the change in the envelope amplitudes at the free boundary along the coordinate at a frequency, in the case when the trench is inclined at an angle of 45^0 on both sides. The trench is located 8 m from the axis of the tunnel. In front of the trenches, there is no increase in amplitude in relative to the amplitude obtained without taking into account the trench. At a distance of 10 m from the tunnel, and behind the trench, the amplitude decreases by 96.6%. At a distance of 20 m from the tunnel, the amplitude is halved. At a distance of 30 m from the tunnel, the amplitude of vibration waves becomes lower than 89%.

At this frequency, when the trench on both sides, inclined at an angle of 60^0 (Fig. 3), after passing the obstacle at a distance of 10 m, the amplitude of vibration waves decays 98.7% faster, and at a distance of 20 m - 72%, at a distance of 30 m the difference is 53%.

Figure 4 shows the results when the trench is tilted on both sides at an angle of 90^0. In front of the trench, the amplitude increases due to reflection from the wall of the slot. And behind the trench, the amplitude decreases by 25%.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 8, Issue 9 , September 2021

At a distance of 20 m from the tunnel, the amplitude decays 9.5% faster. At a distance of 30 m from the tunnel, this difference becomes insignificant.

IV. CONCLUSION

From this study using the finite element method, it was shown that an idealized open trench is a very effective mitigation measure to reduce earth vibration. For homogeneous soil, the results are consistent with an established rule of thumb. Trenches with inclined sides are of more practical interest. Calculations show that the performance of a trench on both sides of an inclined (45° or 60°) trench is more efficient than a vertical trench.

REFERENCES

[1]. Thompson Dj. Railway noise and vibration: mechanisms, modelling and means of control, Oxford: Elsevier, 2008.

[2]. Lombaert G., Degrande G, Francois S., Thompson Dj. Ground-borne vibration due to railway traffic: a review of excitation mechanisms, prediction methods and mitigation measures. Proceedings of the 11th International Workshop on Railway Noise, Uddevalla, Sweden, 9-13 September 2013.[Notes on Numerical Fluid Mechanics & Multidisciplinary Design 126, 253-287, 2015.

[3]. Jones C.J.C. Using numerical models to find antivibration measures for railways. Proc. Instn Civ. Engs, Transp. 1994; 105: -p. 43-51.

[4].Massarsch K.R. Vibration isolation using gas-filled cushions. Soil dynamics symposium to honour Prof. R Woods (invited paper). Austin, Texas: Geo-Frontiers; 2005. -p. 1-22.

[5]. Takemiya H., Fujiwara A. Wave propagation/impediment in a stratum and wave impeding block (WIB) measured for SSI response reduction. Soil Dynamics and Earthquake Engineering 1994; 13: 49-61.

[6]. Thompson Dj., Jiang J., Toward M.G.R., Hussein M.F.M., Dijckmans A., Coulier P., Degrande G., Lombaert G. Mitigation of railway induced vibration by using subgrade stiffening. Soil Dynamics and Earthquake Engineering, 2015; 79: 89-103.

[7]. Woods R. Screening of surface waves in soils. J Soil Mech Found DivProc ASCE 1968; 94(SM4): 951-79.

[8]. Richart F.E., Hall J.R., Woods R.D. Vibration of soils and foundations, Prentice-Hall, Englewood Cliffs, New Jersey, 1970.

[9].YuldashevSh.S., MatkarimovP.Zh. Vibration propagation in soil from vehicles and vibration protection systems. Tashkent, “Science and Technology Center ”, 2014. -188 p.

[10].Lysmer J., Kyhlemeyer L. "Finite Dynamik Model for Infinite Media" Jour Engineering Mechanics Division, ASCE, Vol 95, No EM 4, August, 1969.-p. 859-887.

[11].Saidov S.M., YuldashevSh.S. "Solving the problem of vibration propagation from the passage of trains" Materials of the international scientific and technical conference "Modern problems of soil mechanics and complex rheological systems." - Samarkand. 2013.book №2, -340 p.