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***Research Article***

# EVALUATION OF SYNTHETIC ACCELEROGRAMS CREATED USING VARIOUS TECHNOLOGIES BASED ON SOIL MODELS

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## ABSTRACT
The paper used two types of synthetic accelerogram technology. The synthetic accelerograms created were analyzed based on grunt models. Grunt models are based on the same physical parameters based on the Strata and Plaxis 3D applications. Developed synthetic accelerograms have been considered to change the seismic effect on grunt models.

***Keywords:*** *Spector, Acceleration, Soil, Velocity, Displacement*

## INTRODUCTION
The main role in the construction of buildings and structures is played by their strength and long service life. Seismic hazard mitigation is a necessary factor in ensuring human safety. Analysis of the physical parameters of grunts reflected during an earthquake in the study of the seismic risk of buildings and structures contributes to the qualitative planning work of the construction. Research on the mitigation and reduction of the consequences of strong earthquakes is one of the urgent tasks of modern Seismology. An important factor in seismic sludge and analysis work is the study of seismic reaction spectra of grunts. There are several ways to create synthetic accelerograms, and in our research we used two methods. The created synthetic accelerograms were evaluated on the basis of grunt models. The primary goal is to create an accelerogram corresponding to the grunt reaction spectrum to ensure seismic strength and non-safety in accordance with international building norms to the structures under construction.

## MATERIALS AND METHODS
1. For the calculation of spectral accelerations, the equation was used (Joinerand Boor, 1997Boore D,M,, Joyner W,B, sieve amplifications for Genera Rosk Cites // Bulletin of the Seismological
Equation for calculating spectral accelerations

$$\text{Log PSA} = b_1 + b_2M + b_3M^2 + (b_4 + b_sM)\log\sqrt{R^2_{jb} + b^2_{\sigma}} + b_7S_s + b_gS_A + b_9F_N + b_{10}F_R + \varepsilon\ \sigma \qquad (1)$$

$M_W$- magnitude,
$R_{jb}$- radius,
$S_S$ and $S_A$- Seismic velocities in grunts ($V_{S30}$),
$F_N$ and $F_A$- Furnace mechanic.

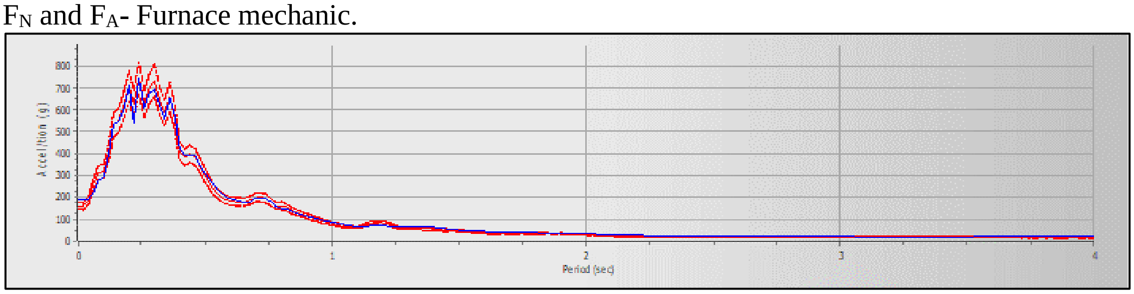


**Figure 1: Spectral acceleration**

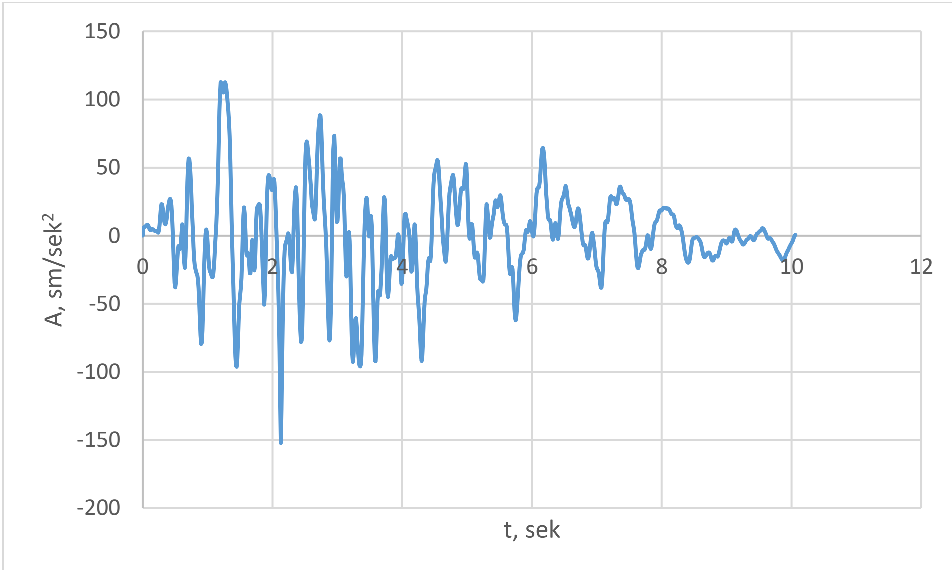


**Figure 2: Cytetic accelerogram based on spectral accelerations**

In our study, the "Generalized mean spectrum" method of real Earthquake Spectra. A generalized spectrum can be obtained taking into account the peculiarities of the joint processing of real accelerograms recorded in the regions and the individual implementation of the interpretation of each earthquake seismograms. The construction of a spectrum envelope of records on Eurocode-8 (design of earthquake-resistant structures), the creation of synthetic accelerograms from the resulting spectrum should be carried out [1]. This is how the law and order of construction work is carried out in the state of California. Possible errors in the determination of seismic effects are due to the imperfection of the methods used in the processing of the initial data. The use of generalized spectra in any building regulations gives qualitative results. Synthetic

**Table 1: Catalogue of earthquakes recorded at Jizzakh seismic station**

| **Dana** | **Width** | **Length** | **Depth** | **Distance, км** | **$M_b$** | | |
|---|---|---|---|---|---|---|---|
| | | | | | **RCSM** | **EMSC** | **IRIS** |
| 29.01.2020 | 38.40 | 70.75 | 60 | 290 | 5.3 | 5.3 | 5.2 |
| 05.03.2021 | 40.89 | 69.50 | 10 | 160 | 4.4 | 4.2 | 4.2 |
| 05.08.2020 | 40.20 | 70.84 | 10 | 250 | 5 | 4.9 | 4,9 |
| 06.03.2021 | 40.24 | 71.88 | 13 | 330 | 4 | - | - |
| 06.11.2020 | 40.16 | 71.72 | 10 | 320 | 4.9 | 5.2 | 4.7 |
| 09.07.2020 | 39.96 | 69.31 | 10 | 120 | 4.7 | 4.3 | 4,3 |
| 12.11.2020 | 41.06 | 73.61 | 6 | 490 | 4.8 | 4.2 | 4.2 |
| 16.01.2021 | 36.43 | 70.64 | 200 | 460 | 5.8 | 5.5 | 5.5 |
| 18.02.2021 | 40.38 | 67.41 | 10 | 42 | 3.7 | - | - |
| 18.11.2020 | 39.86 | 68.90 | 10 | 90 | 4.1 | - | - |
| 09.24.2021 | 40.34 | 70.30 | 5 | 202 | 3.8 | - | - |
| 02.25.2020 | 39.67 | 68.02 | 10 | 50 | 4.1 | - | - |

accelerograms are in most cases created on the basis of generalized spectra for the state of the foundation part of the building and structure. Synthetic accelerograms obtained in this way are significant in that the accelerograms used to generalize are properly interpreted in accordance with grunt seismic conditions [2]. In the research work, earthquake records from kilns with different azmunti were received at one station and taken for processing (Table 1).
In large magnitude earthquake record, the acceleration amplitude and time duration of high vibrations were interpreted by accelerograms recorded in seismostancesOscillation acceleration of grunt oscillation in accelerograms received fading graphs over time (Figure 1).

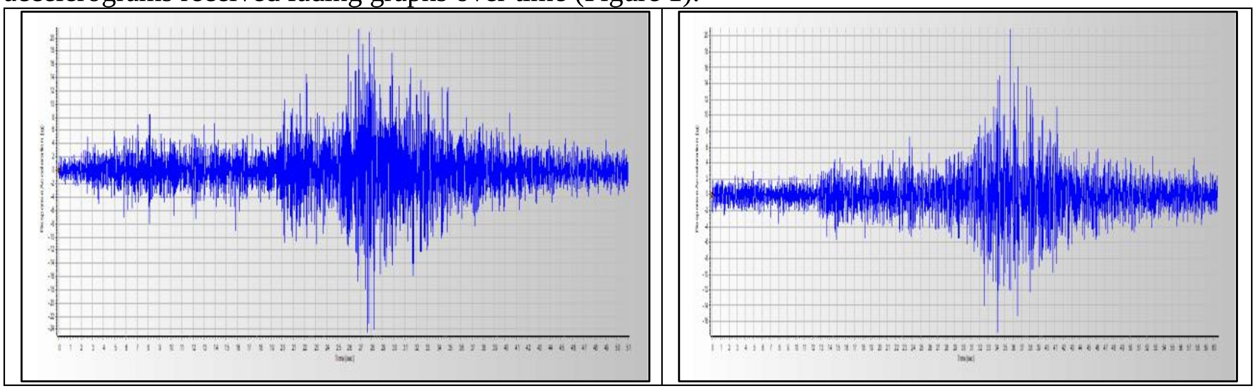

**Figure 1. Graphs of vibration accelerations in grunts of earthquakes recorded at the Jizzakh seismostancy (04.07.2020 - 06.11.2020 y).**
**(*Interpreted using the Seismo Signal program)***

Taking into account the fact that the grunt is composed of multi-composition terrigen sedimentary rocks, the influence of the earthquake hypocenter from different sides serves to increase accuracy in the study of grunt dynamics. Seismic waves acting in different directions in sedimentary grunts give different accelerations to grunts [3]. The acceleration values in these fluctuations increase the quality of creating a synthetic accelerogramBelow are spectra of accelerations of combined real earthquakes obtained as a result of single station records (Figure 3)

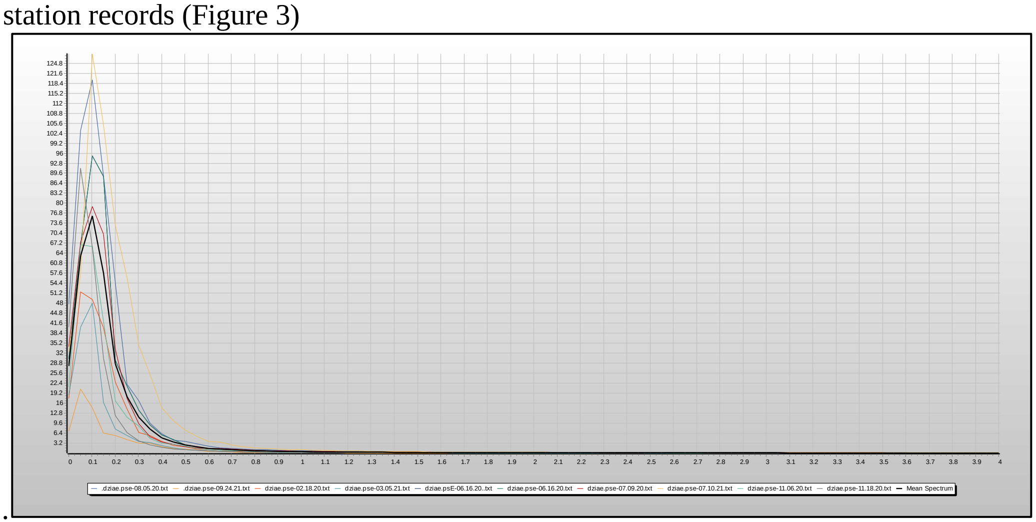

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**Figure 3: Acceleration spectra of several real earthquakes included in the" SeismoSpectr " program**
When creating a synthetic accelerogram, the spectra of real earthquakes were interpreted using the" Generalized mean spectrum " method. This method obtained the mean values of the acceleration of each spectrum during the corresponding times. The accelerograms recorded at local stations located in different

grunt conditions can be processed each in an alloy and a generalized spectrum can be obtained taking into account their physical properties (Figure 5).

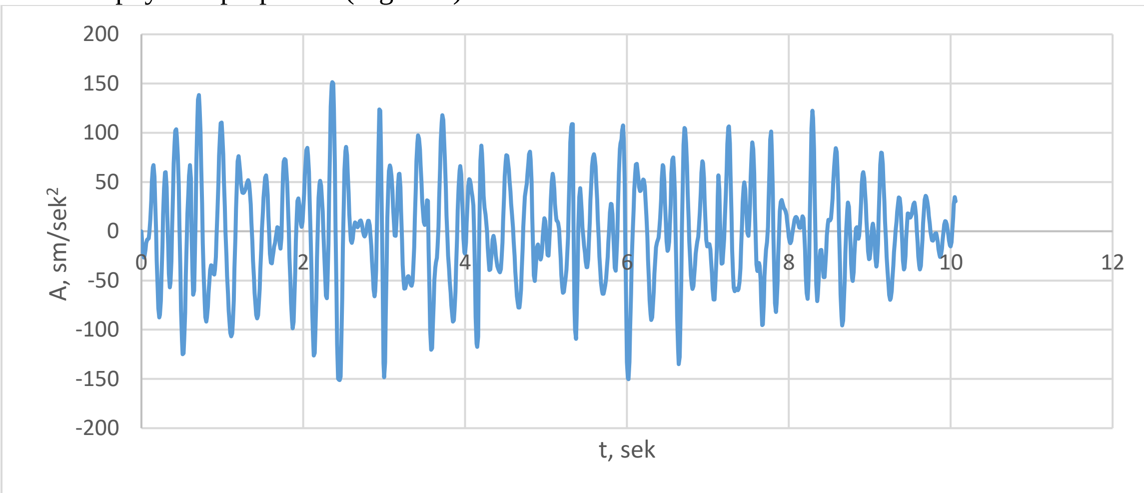


**Figure 5: Synthetic accelerogram based on a generalized spectrum of Real earthquake records**

**RESULTS AND DISCUSSION**

The creation of accelerograms in the construction of buildings and structures that meet international requirements in some cases creates imbalances. Differences in generalized spectra are not caused by differences in the seismogeological conditions of different regions, but by errors in the statistical processing of records of strong earthquakes and a number of assumptions that turn out to be incorrect. One of the errors in the MSK-64 scale is the use of seismic scale intensities obtained by the traditional least squares method. Currently, the method of "generalized medium spectrum" should be carried out depending on the grunt seismic conditions of each area. Possible errors in the assessment of seismic effects may be due to the imperfection of the methods used to process the initial data.

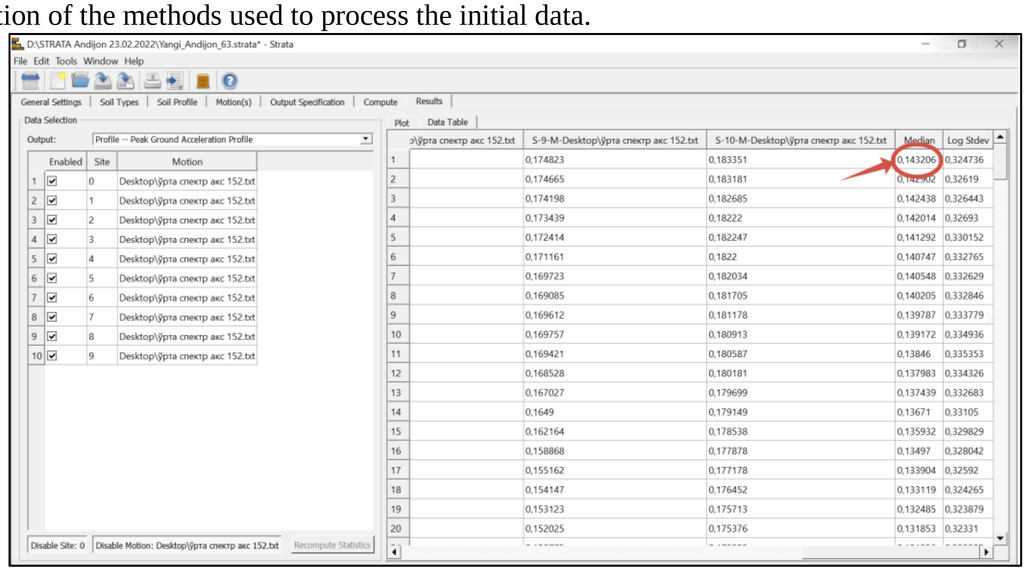


**Figure 7. Peak acceleration map from a synthetic accelerogram based on the middle spectrum**

**Assessment of seismic impacts on a free surface**

The Monte Carlo method implemented in the STRATA program was used to account for the uncertainties of the ground models and input accelerograms. Data on the geological structure and physical properties of soils are the initial data for modeling the reaction of soil to seismic effects. This modeling is based on the

thin layer method, as well as the finite element method. This simulation allows us to take into account the resonant properties of the soil column and assess the influence of soil conditions on the amplitude, frequency spectrum and duration of vibrations. In determining peak acceleration values under the created grunt model, a synthetic accelerogram based on the mid-spectrum derived from the umualized spectra of 12 real earthquakes was developed and incorporated into the program as a seismic effect.
A synthetic accelerogram based on the equation for determining peak acceleration values (Joiner and Boor, 1997) under the created grunt model was developed and incorporated into the program as a seismic effect.

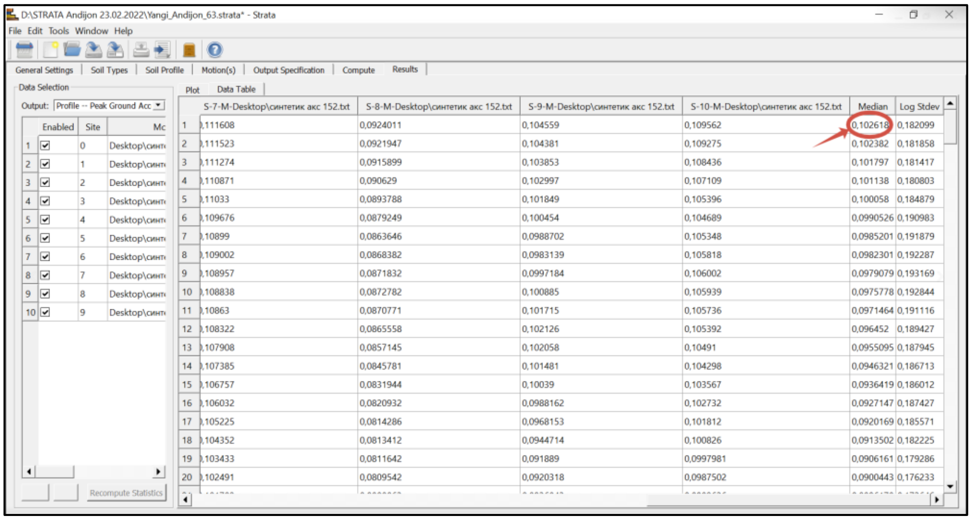

**Figure 9. Peak acceleration map from a synthetic accelerogram based on the Joiner and Boor equation**

As a result, differences between the values of the grunts peak acceleration of both accelerograms given as seismic effects were induced using the program. The results of calculated synthetic accelerograms based on the generalized mean spectrum and Imperial equations of the peak acceleration values of the grunts scattered over construction sites using the above methods are presented in Table 2.

| № | Grunt model | Mid-spectrum $PGA_1$, (g) | Spectral acceleration $PGA_2$, (g) | Difference between seismic intensity gain PGA, (g) |
|---|---|---|---|---|
| 1 | Liner Elastic | 0,14 | 0,10 | 0,04 |

**Evaluation of synthetic accelerograms as seismic waves in infinite space using the Plaxis 3D program in the finite element method.**

Evaluation of seismic impact and seismic effect change in construction sites with scattered subsiding soils by preparing DSM piles using FEM (Finite Elements Method) in spatial space. In this case, numerical methods cannot be directly applied to solve the problem of propagation of seismic waves in an infinite half-space. To perform this task, we replace the infinite half-space with a finite parallelepiped in the area of our interest.

At the same time, boundary conditions of the following form are imposed, with the continuation of the parallelepiped representing the effect of the abandoned part on the faces of the abandoned sides, i.e., passing the waves incident on the boundary without returning them.

$$\left.\begin{aligned} \sigma_x &= a\rho V_p \dot{u} \\ \tau_{yz} &= b\rho V_s \dot{u} \\ \tau_{zy} &= b\rho V_s \dot{u} \end{aligned}\right\} \left.\begin{aligned} \sigma_y &= a\rho V_p \dot{u} \\ \tau_{xz} &= b\rho V_s \dot{w} \\ \tau_{zx} &= b\rho V_s \dot{u} \end{aligned}\right\} \left.\begin{aligned} \sigma_z &= a\rho V_p \dot{w} \\ \tau_{xy} &= b\rho V_s \dot{u} \\ \tau_{yx} &= b\rho V_s \dot{u} \end{aligned}\right\} \tag{2}$$

where, σ and τ are normal and shearing stresses; $\dot{u}$ and $\dot{v}$ - projections of the velocities of the boundary points on the axes; $V_P$ and $V_S$ are Velocity of P and S waves; α and β are dimensionless parameters; ρ is the density of the material.

Geometric relations can be formulated as follows:

$$\varepsilon = Lu \tag{3}$$

$L^T$ is the transposition of the differential operator, which is defined as follows:

$$L^T = \begin{bmatrix} \frac{\partial}{\partial x} & 0 & 0 & \frac{\partial}{\partial y} & 0 & \frac{\partial}{\partial z} \\ 0 & \frac{\partial}{\partial y} & 0 & \frac{\partial}{\partial x} & \frac{\partial}{\partial z} & 0 \\ 0 & 0 & \frac{\partial}{\partial z} & 0 & \frac{\partial}{\partial y} & \frac{\partial}{\partial x} \end{bmatrix} \tag{4}$$

We determine the displacement, velocity and acceleration of the nodes formed in soils considering physical and mechanical properties of the material [4].
The system of master equations depending on the time of movement of the system under an influence of dynamic load is as follows:

$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = \{F\} \tag{5}$$

where the order of the system of differential equations is 39,039, [M] is the Mass Matrix, $\{u\}-$ is a displacement vector, $[C]$ $-$ is the Damping Matrix, which also considers the boundary conditions, $[K]$ $-$is Matrix Hardness, and $\{F\}-$ is the Load Vector. Displacement $\{u\}$, velocity $\{\dot{u}\}$ and acceleration $\{\ddot{u}\}$ may change over time.
Here the foundations of linear elasticity theory have been applied. In principle, however, all models can be used for dynamic analysis. To implement the problem digitally, we use the Plaxis 3D [5,6] software complex, which contains possible variants of the physical equations of the material. Plaxis is solved in the finite element method using 3D software. Numerical methods cannot be directly applied to the solution of the problem of the propagation of seismic waves in infinite half-space. To accomplish this task, we replace the infinite half-space with the finite parallelepiped of the sphere of interest to us. At the same time, boundary conditions are imposed on the faces of the discarded sides of the continuation of the parallelepiped, which represent the effect of the discarded part, that is, passing the waves falling on the border without returning them. The created model 12,231 nodes are divided into 5,091 finite elements. The forms of finite elements are chosen as false tetrahedra [7].

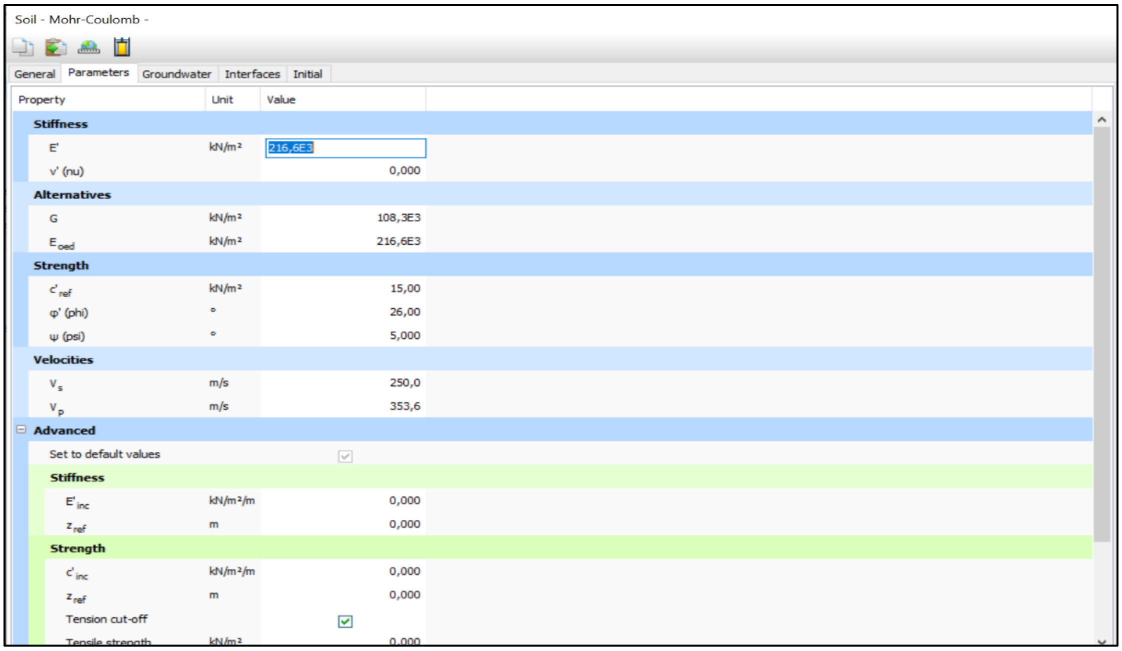


**Figure 10: Grunt parameters to be included in the created model**

Two different acceleregrograms were included in the same-dimensional model selected after grunt parameters were introduced. After computational work using Plaxis 3D software, we will be able to determine the values of velocity, acceleration and displacement on the x-axis at any time of seismic impact at node 10816 (Fig.11).

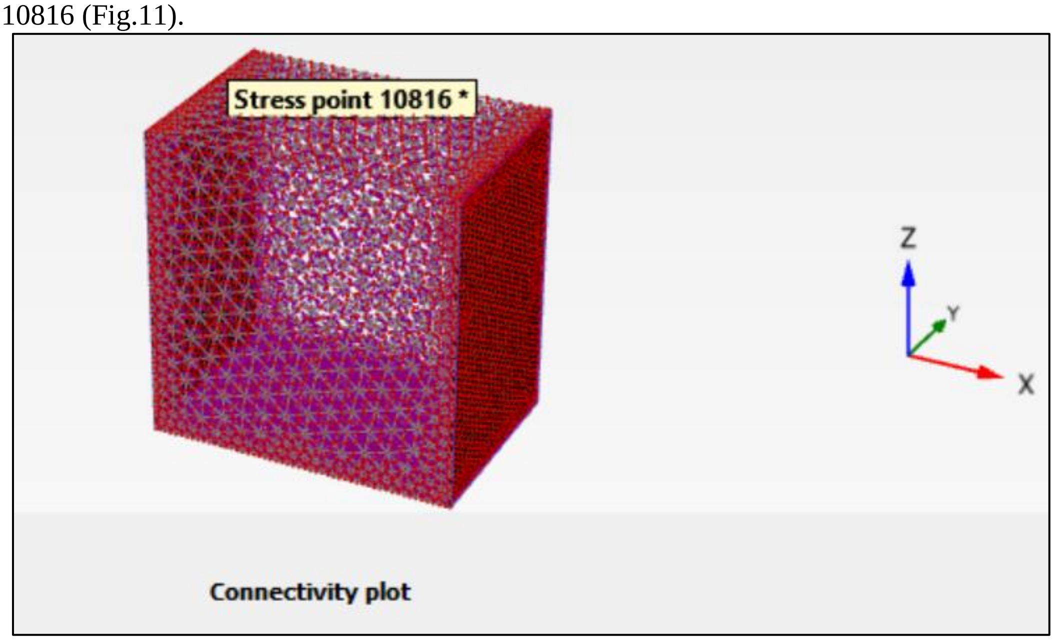


**Figure 11: 3D model of gurnt separated into nodes to evaluate the synthetic accelerograms created**

Axelegrograms developed as a result of an earthquake in the field were included.

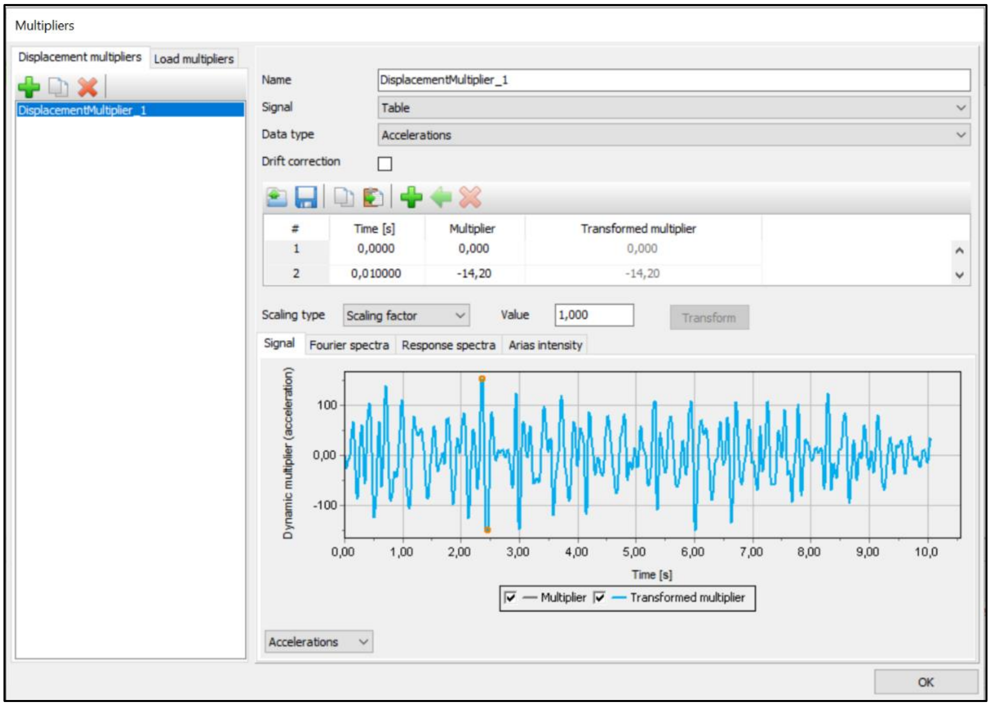


**Figure 12: Synthetic accelerogram included in the Plaxis 3D program (created on the basis of the middle spectrum)**

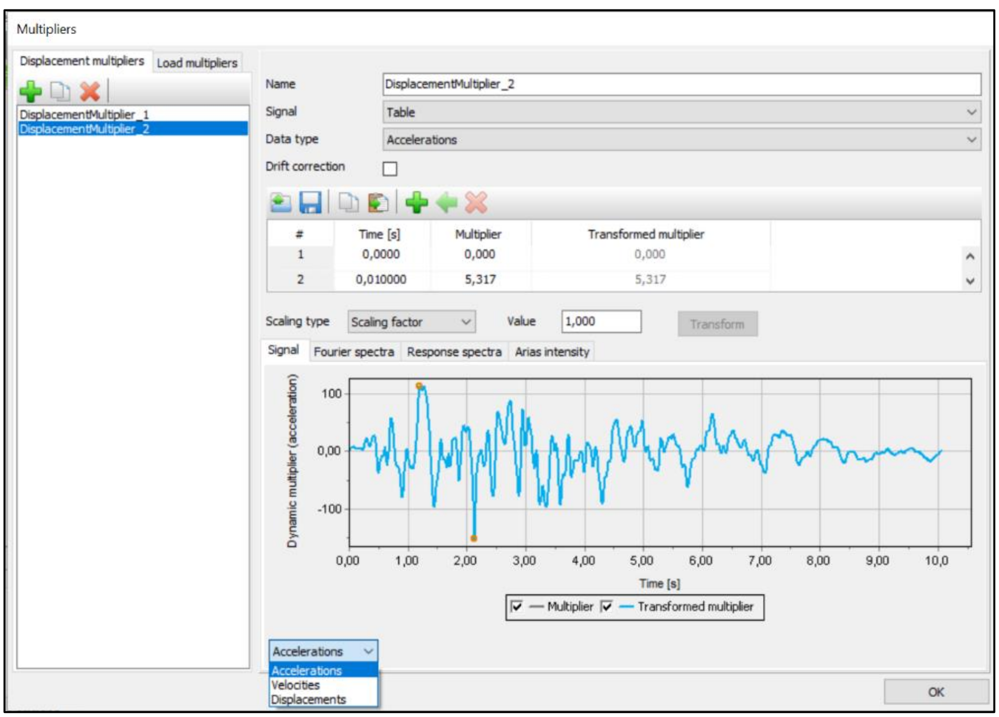


**Figure 13: Synthetic accelerogram included in the Plaxis 3D program (based on Imperial equations**

The following table 3 lists the differences between the maximum values of acceleration, speed and displacements at the selected node (Table 3).

**Table 3: the differences between the maximum values of acceleration, speed and displacements at the selected node**

| Mid-spectrum | Spectral acceleration | Difference | Mid-spectrum | Spectral acceleration | Difference | Mid-spectrum | Spectral acceleration | Difference |
|---|---|---|---|---|---|---|---|---|
| ***Acceleration,, ax (sм/s2)*** | | | ***Velocity, vx (sm/s)*** | | | ***Displacement, ux (sm)*** | | |
| $a_{x1}$ | $a_{x2}$ | $\triangle a_x$ | $v_{x1}$ | $v_{x2}$ | $\triangle v_x$ | $u_{x1}$ | $u_{x2}$ | $\triangle u_x$ |
| *299,6* | *250* | *49,6* | *24,0* | *19,0* | *5,0* | *1,26* | *1,12* | *0,14* |

## CONCLUSION

There are several different ways to create synthetic accelerograms, which we used in our study from two methods. Method 1 is a medium spectrum method generalized from real earthquake records. 2 is a method of spectral accelerations based on The Joiner and Boor equation. The created accelerograms were evaluated using two different programs. The analysis of synthetic accelerograms created in Grunt models was evaluated through the Liner Elastic grunt model of the Strata program. The result was found that in a synthetic accelerogram created taking into account generalized mean speters, the peak acceleration value of gruntdar is PGA=0.14 g, and in a synthetic accelerogram based on spectral acceleration, the peak acceleration value of grunt is PGA=0.10 g.

The Plaxis 3D program includes accelerograms created using generalized medium Spectra and spectral accelerations as seismic effects. The developed grunt model is divided into finite elements, with finite elements in turn separated into nodes. The synthetic accelerograms created using two different methods were determined by the X-axis of the grunt model at 10816 knots with the values of velocity, acceleration and displacement. The acceleration difference is $\triangle a_x$ =49.6 sm/s$^2$, the speed difference is $\triangle v_x$ =5.0 m/s, the displacement difference is Tash $u_x$ =0.14 cm.

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