Two dimensional determination of peak acceleration distributions during earthquakes

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Abstract. In this study, the two dimensional peak acceleration values between the bedrock and the ground surface is examined by using the soil bedrock model formed for a profile in the Bornova Plain in the east of İzmir Bay. For this purpose, two dimensional soil bedrock model was created for profile using microgravity and Extended Spatial Autocorrelation (ESPAC) method results. The S-wave velocities obtained from the ESPAC method were used to determine the density for microgravity modelling. After the density determination process, microgravity data on the profile were obtained by forward Talwani modelling. The obtained model is divided with gridding the data at regular intervals. In the study area, a recorded earthquake data used for deconvolution by soil-bedrock model known strong ground motion station BYN , and then transfer to the interface of bedrock in addition to obtain required bedrock data. Then, the calculated site-specific bedrock earthquake data was transferred from the bedrock surface of the grid model to the soil surface and layer boundaries. By combining these peak acceleration values for the profile, the two dimensional peak acceleration distribution for the profile was calculated.

1. Introduction
Turkey has suffered a great deal with the 1999 Kocaeli earthquake. After this event, the earthquake – soil-structure common interaction has gained more importance. In order to minimize earthquake damages and consciously build structure design, we need to determine the parameters that will be used for earthquake –soil-structure in a healthy way. Some parameters in earthquake engineering change the parameters of earthquake waves as they travel between the layers between the engineering bedrock and the soil surface. The most important of these parameters are the changes in earthquake duration,
frequency content, and amplitude. These changes can be defined by using the density and depth of the engineering bedrock and the P and S velocity values, densities and layer thicknesses of the soil forming layers [2].

In order to provide a practical way to design earthquake resistant structures, these changes are defined in the Eurocode 8 regulation for an average depth of 30 m. In some cases, the same regulation uses the on-site design description, especially where the soil is thicker than 30 meters and/or S-velocity values are less than 250-300 m/s [1]. In some circumstances it will be necessary to calculate the soil transfer function, which will define the joint effect of the layers between the engineering bedrock and the soil surface. The soil transfer function gives us detailed information about a depth the earthquake wave will be affected. The engineering bedrock and soil of the region should be studied. The geological units in the study area of the engineering bedrock should be investigated and defined by in-situ studies to determine the density of this layer and its depth from the soil surface. In order to define the effects of earthquake waves on focusing and repetitive reflections, the topography of the interface between the engineering bedrock and the soil should be investigated in small scale lenticular structures and thin layers that may have high S velocities and density differences in the soil.

Soil dynamic parameters can be determined with higher accuracy by using multidisciplinary methods together. Determining the dynamic parameters of the soil is a necessity before construction. Earthquake-resistant building design is one of the most important tasks in reducing the damages of earthquakes. Determining the soil characteristics of the structure, revealing how the soil and the structure behave during an earthquake, and constructing the structure in accordance with the soil characteristics constitute an important step in the fight against earthquake. In this study, microgravity, SPAC, and 1D equivalent static earthquake load analyzes were used to determine 2D peak acceleration distribution on a profile for İzmir Bornova Plain.

2. Study Area and Geological Features
The basin of the İzmir and its region contains the Upper Cretaceous Bornova Melange [4]. Limestone mega-olistoliths older than the matrix of the mélange are found in a random order within the matrix of the Bornova Melange. These limestones are known as Işıklar limestone in Altındağ and at its region [5]. Bornova Melange (complex) is composed of platform-type limestone and diabase blocks and conglomerate lens/channel fillings within the matrix consisting of sandstone/shale-calcareous shale intercalations [3]. The Neogene aged lacustrine sediments overlie the Bornova Melange with an angular unconformity. Yamanlar volcanics cover the existing units unconformably. The Quaternary aged soil area unconformably overlies all existing units.

3. Applications
Applications in the study area can be divided into 5 stages. These stages are;
- Microgravity Modeling (Determination of Bedrock)
- Deconvolution of Earthquake Data
- Model Gridding (1000 m)
- Convolution of Earthquake Data
- 2D Acceleration Distribution
Scintrex CG-5 gravity device was used for gravity measurements at approximately 500 m sampling intervals depending on the terrain and urbanization conditions along 10 km profiles in the Northwest-Southeast direction. Within the scope of measurement planning, fixed station with absolute gravity value determined in Dokuz Eylül University Campus was used as the main base station. All measurements are finalized by connecting to this station. A total of 7 profile measurements were taken. In order to obtain healthy tilt angle values, low standard deviation values and low error values, 5-15 repetitive readings with a minimum duration of 60 seconds were performed. Within the scope of this study, calculations will be made on the results of 1 profile in the westernmost part of the area.

Stage I was obtained in 2017 and published by Pamuk et al. 2017[6]. As a result of the microgravity and SPAC measurements, the models for the A-A model section were made and the calculations made in this study were performed on this model [6]. The microgravity Bouguer Anomaly Map (Raw) and the microgravity Bouguer Anomaly Map (residual) are shown in Figure 2.
After the completion of the modeling steps, the Mw = 6.2 Midilli earthquake at 12:28:37 GMT on 12.06.2017, which was recorded at the BYN strong motion station located in the middle of the A-A’ profile, was selected for the calculations. Primarily, the soil model for the substation is determined (Figure 3).
Using the determined soil model and recorded earthquake data, earthquake data was transferred to the seismic bedrock interface. Deconvolution of the selected earthquake record is shown in Figure 4.

The earthquake data which was then transferred to the seismic bedrock interface was moved upwards from the seismic bedrock interface to the ground surface with a grid of 1000 m along the A-A' model. Peak acceleration values of all interfaces were determined during this transport operation and 2D peak acceleration distribution of the earthquake was determined as a result of interpolation of these values (Figure 5).
Figure 5. Peak acceleration distribution of the model A-A ((Mw = 6.2 Midilli earthquake at 12:28:37 GMT on 12.06.2017)

4. Results and Discussions
Compared with the predominant period values, it is seen that it is generally compatible. The sections with high predominant period values were characterized by low gravity values. When the residual Bouguer gravity anomaly map was examined, the gravity values ranged from -7 to 11 mGal. These values are between -7 and -3 in the middle parts of the study area where the ground thickness is expected to be deeper than the surrounding area. A partial increase in the values is observed as is approach from the sea. The gravity values increased as expected in the northern and southern parts of the study area, where the topography increased and the soil thickness decreased.

The study area is generally represented by a 3-layer model. Accordingly, the first layer was modeled as soil, the second layer was modeled as an engineering bedrock and the last layer as seismic bedrock. In the middle of the study area where the soil thickness is greater, the maximum acceleration values increase. In areas where S wave velocities are higher than 760 m / sec, acceleration values are observed to be between 0.008-0.0024g. In addition, there is an increase in acceleration values on both sides of the area due to the basin effect.

In the ESPAC study at the northernmost of the area, The S wave velocity is calculated as 3000 m / s after 1200 m depth and this unit probably points to the Menderes Massif. This unit, which corresponds to the seismic bedrock, could not be reached in other ESPAC studies.

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