Influence of Surface Rupturing and Shallow Subsurface Structure on Near-Fault Pulse-Type Motions during the 2016 Kumamoto Earthquake

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INTRODUCTION

The 2016 Kumamoto earthquake with MJ7.3 occurred in the midnight of April 16th (hereafter referred as the main shock) and massive shaking with the JMA intensity of 7 hit to densely populated area of Mashiki-machi leading to devastating damages to lots of wooden houses. Features of near-fault ground motions recorded in Mashiki-machi are summarized as follows: (1) Pulse-type motions with predominant period of 1 s. were recorded adjacent to surface rupturing. (2) Amplitude level was larger than the Takatori motion during the 1995 Kobe earthquake. (3) Principal axis was close to east-northeast direction parallel to Futagawa segment. (4) Spatial variation of recorded ground motions is large in short distance within 1 km.

Discussion has been made for why the pulse-type near-fault ground motions with large amplitude were generated, e.g., rupturing in deep and shallow part of seismic fault, site amplification in shallow and deep part of subsurface structure. Quantitative evaluation of amplification mechanism of pulse-type near-fault ground motions is important for predicting input ground motions to structures adjacent to seismic faults. In this study, strong ground motions in Mashiki-Machi are theoretically synthesized using the finite source model by Hikima (2016) based on waveform source inversion analyses. Then, amplification mechanism is discussed based on numerical approach focusing on effects of rupturing in deep and shallow part of seismic fault and the shallow and deep part of subsurface structure.

METHODOLOGY

The thin layer method (TLM) is used as a theoretical evaluation method of ground motions. The TLM is thoroughly verified in the "Benchmark Test Project" in Japan (Hisada et al., 2012), as a practical and theoretical method for ground motion evaluation in the horizontally flat strata. Velocity structure in Mashiki-Machi is referred from the PS logging data at the KiK-net Mashiki site for the shallow part and the "preliminary nationwide velocity structure model" for the deep part. Source process evaluated by Hikima (2016) has two segments for the Futagawa faults stretched from the Hinagu faults. Although the finite source model deals with frequency range from 0.05 to 0.8 Hz, ground motions are calculated in the frequency range up to 2 Hz considering importance of frequency component around 1 s. in observed pulse-type ground motions from the engineering's point of view.

EFFECT OF SURFACE RUPTURING AND SUBSURFACE STRUCTURES ON GROUND MOTION AMPLIFICATION

Observed ground motions at the KMMH16 site during the main shock were simulated by the TLM. Theoretically synthesized ground motions fairly reproduced the observed ones. Frequency component around 1 s.is rather underestimated, partly because the finite source model do not guarantee the higher frequency component over 0.8Hz.

Effects of surface rupturing on ground motion amplification are discussed. Theoretical ground motions are calculated for hypothetical source models deleting the sub-fault row in the shallow part of finite source model. Peak ground velocities become small especially in longer period range than 2 s when shallow

sub-fault area is ignored.
Next, ground motions are evaluated focusing on effects of subsurface structures on amplification characteristics by replacing low velocity strata to the profile of the seismic bedrock. In ground motions in the bedrock model, the predominant period component around 1 s. diminished despite that variation of peak ground velocities is small.

Keywords: The 2016 Kumamoto earthquake, Near-Fault, Pulse-Type Motions

