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ON TWO DISTINCT TYPES OF SEISMIC SHAKING WE MAY EXPERIENCE

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ABSTRACT

We briefly discuss the two noticeable different types of seismic shaking: (1) vibration with rather long duration that may be generated by interlocking earthquakes, seismic clusters or earthquake swarms; and (2) abrupt vertical shock experienced but probably seismologically incorrectly recorded near epicenters of shallow earthquakes.

1. INTRODUCTION

There are still many unknowns in the seismic rupture processes. Examples include those related to two distinct types of rather extreme seismic shaking[1)] with (1) very long and (2) impulsive duration. The former shaking (1) may arise from interlocking earthquakes, seismic clusters as well as earthquake swarms, and for instance, the off the Coast of Fukushima Prefecture earthquake at 23:36 JST on 16 March 2022 itself (JMA magnitude 7.4, epicentral latitude and longitude of 37.697°N and 141.622°E, focal depth 57 km) has seismological records of long shaking of about two minutes. Considering its foreshock (JMA magnitude 6.1, epicentral latitude and longitude of 37.680°N and 141.605°E, focal depth 57 km) that occurred just two minutes before, at 23:34 JST, the total duration for this (series of) earthquake(s) might be regarded as extraordinarily long four minutes. Although extraordinarily long, the shaking generated by (interlocking) earthquakes seems to be relatively correctly, like what we feel by ourselves, recorded: The vibration in the vertical direction is weaker than that in the horizontal direction in the far field as in the case of “ordinary” earthquakes.

In order to comprehend more thoroughly the generation mechanism of this and other seemingly complex rupture processes associated with interlocking earthquakes, seismic clusters and earthquake swarms, we are conducting laboratory two-dimensional experiments for simultaneously observing global, large-scale material behavior and local, smaller-scale development of ruptures and waves in linear elastic brittle solids. The solid specimens involve sets of digitally prepared small-scale cracks that model large-scale geological fault planes, and they are subjected to external quasi-static and dynamic impact loads. The specimen in Fig. 1, for example, has zones of damage (weak zones) consisting of small-scale cracks in specific places. Intuitively, the pre-existing weak zones with a dip angle of 30 degrees are expected to accelerate rupture development, but the snapshots experimentally taken by a high-speed video camera show that both upward quasi-static primary and downward dynamic secondary ruptures are “captured” in the weak zones. Thus, pre-existing weak zones may decelerate and even arrest rupture development, and further experiments suggest that local geometrical changes may indeed control the global and local (interlocking) rupture behavior[2)].

2. MISSING DATA

The latter impulsive shaking (2) is abruptly experienced near epicenters of shallow earthquakes. The strong vertical shock, such as the one felt onboard a ship at sea or seaquakes, has been reported verbally for some earthquakes. However, the sudden and strong shock arising straight from beneath seems to have been incorrectly recorded in seismograms. Unfortunately, although experienced repeatedly, the existence of the strong vertical shock can be inferred only indirectly through several dynamic studies of the unique near-field seismic structural failures found on the surface and in the underground[1]. Therefore, we are currently trying to uncover the physical properties of the shock by investigating recent earthquake swarms around Noto Peninsula that draw much attention and other small earthquakes that might attract much less attention like the one at 19:10 JST on 9 July 2022 (JMA magnitude 3.6, epicentral latitude and longitude of 35.595°N and 139.640°E, focal depth 33 km). The sudden vertical shock recorded in the very beginning of the 9 July quake is stronger than any other ensuing horizontal and vertical shaking, and this recorded sudden vertical shaking is similar to what we actually feel in the case of an earthquake occurring just below.

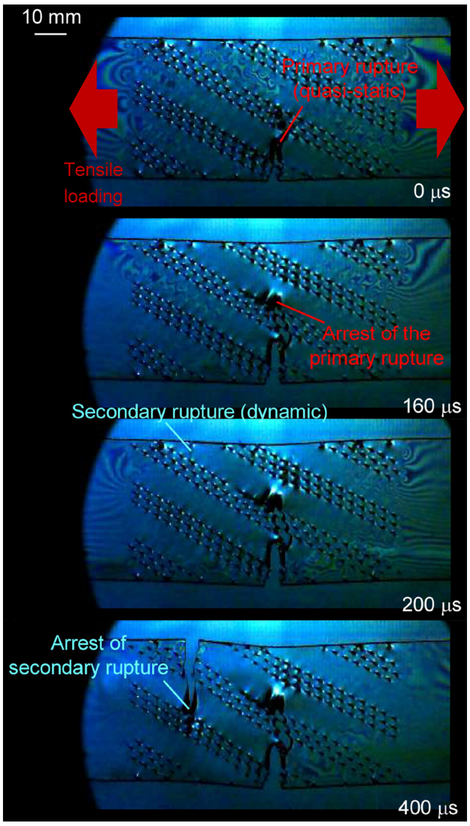

Fig. 1 Complex development of ruptures in a specimen with pre-existing zones of damage having small-scale inclined but parallel cracks (weak zones) under uniaxial tensile loading. The primary rupture is upward quasi-static while the secondary one is downward dynamic, but both are "captured" inside the weak zones. The constant strain rate of the external load is 1.2×10^{-2} /s (modified after Uenishi and Nagasawa[2]).

3. CONCLUSIONS

The velocity response spectra of this small earthquake on 9 July 2022 indicate that the vertical component prevails for frequencies below 10 Hz, i.e. even in a lower frequency range. This does mean that there exists an earthquake where the sudden vertical shock is stronger than the horizontal shaking for all structures with eigenfrequencies below 10 Hz. However, the difficult issue for seismographs to detect larger amplitudes and frequencies over 10 Hz, especially over audible 16 Hz, still remains unsettled.

REFERENCES

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