The influence of increasing rainfall due to climate change on landslide slopes

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1. Objective

Increase in rainfall that supposed to be induced by the global climate change is obvious in western Japan, according to the analysis of rainfall data observed in various locations including mountainside that are not influenced by local warming due to urbanization. On this point of view, we elucidated the response of landslide slope to this increase in rainfall. Hence, its long term influence on the specific landslide slopes in this area was analyzed using numerical simulation method i.e. finite element method in order to evaluate the landslide slope stability.

2. Method and target areas

Field investigation on landslides slopes and slope failures was conducted to obtain the geologic information, geo-structure, vegetation feature, soil samples and topographic data i.e. cross sections. Accordingly soil shear tests and soil permeability tests are also conducted. The rainfall data at the nearest rain observatory were obtained from the database of Japan meteorological agency. The long term influence on the slope stability in the area is analyzed by the finite element method (FEM) combined with rain infiltration and seepage analysis with the long term rainfall fluctuation data, obtaining factor of safety (Fs = resistance force/ driving force) on real landslide slopes.

The target areas are located in northern Kyushu district, western Japan where they are often suffered from severe landslide disasters. For the FEM analysis, 14 landslide slopes are selected from ones that occurred due to heavy rainfall caused by stationary front in July 2009~2017. The geology in research areas consists of Paleozoic and Mesozoic rocks (mainly schist, granite, slate, serpentine) and volcanic sediment. The vegetation consists of mainly Japanese cypress, cedar or bamboo.

Fig.1 Some examples of landslide occurred in the rainfall disaster in 2017

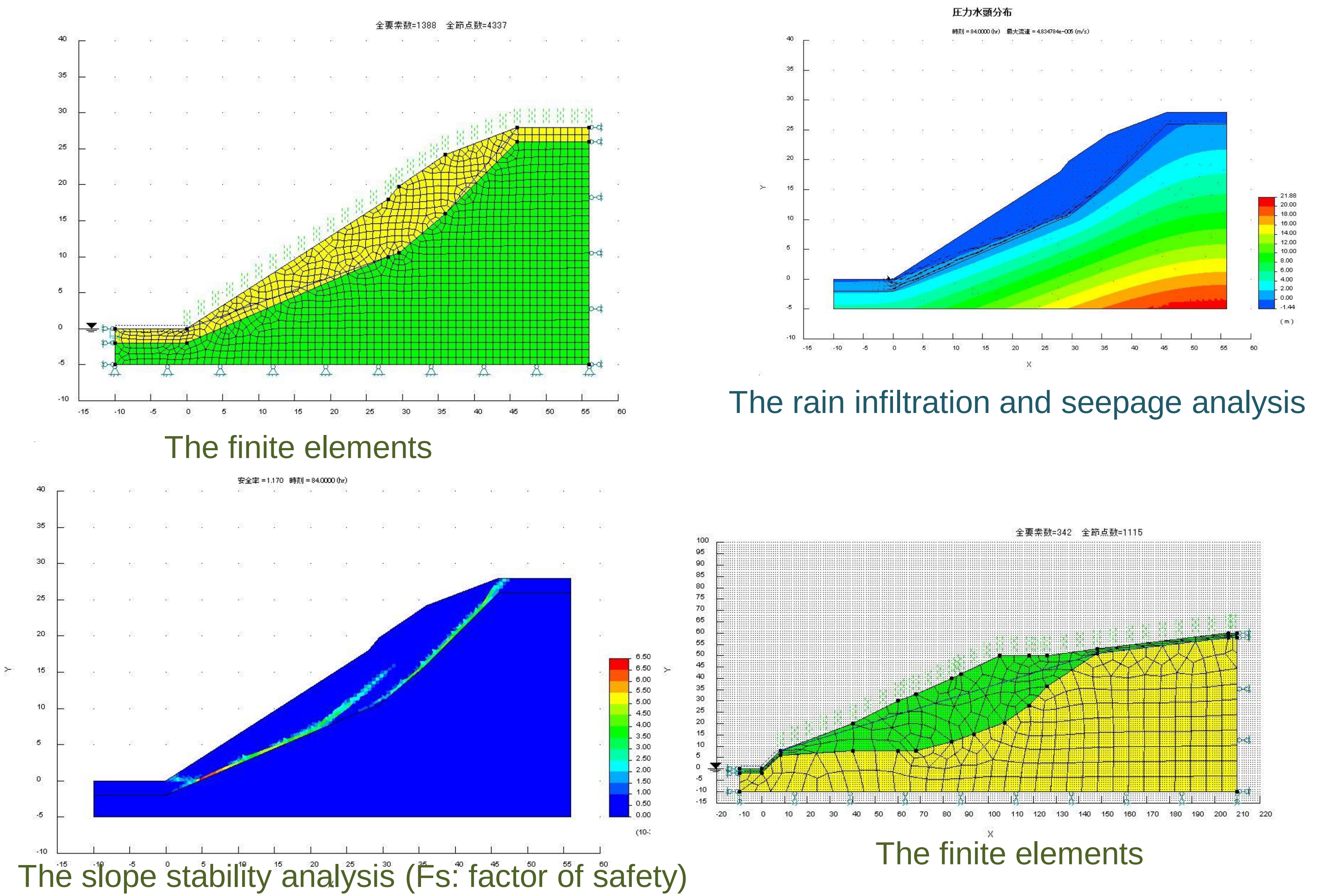
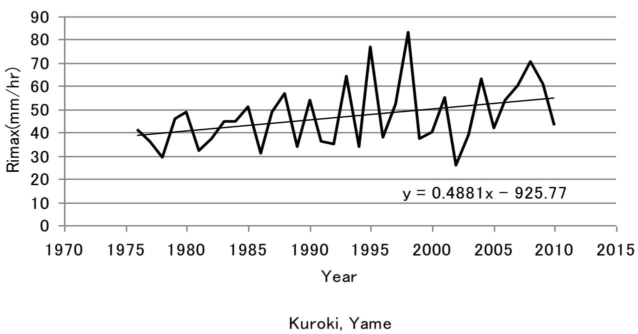
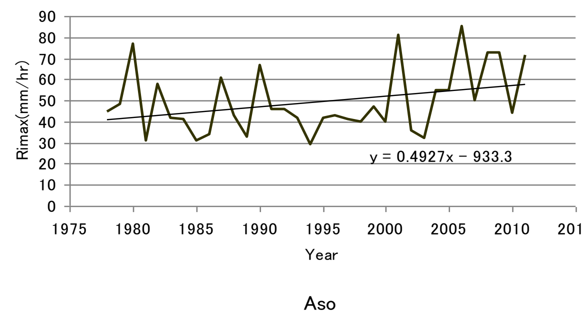


Fig. 2 FEM analysis examples (coupling analysis of infiltration-seepage and slope stability: Asakura-Kurokawa and Yame-Kuroki-Kasahara)



The Yame-Kuroki, Kasahara deep-sheeted landslide



The Aso-Hakoishi shallow landslide

Fig.4 The case of Yame-Kuroki, Kasahara deep-sheeted landslide: “rainfall increased Fsno_rinc=0.9” and “rainfall in the disasters Fsrealrain=0.7” ; 22% safer if there were no rainfall increase. **The case of Aso-Hakoishi shallow landslide:** Fsno_rinc=1.02, Fsrealrain=0.990

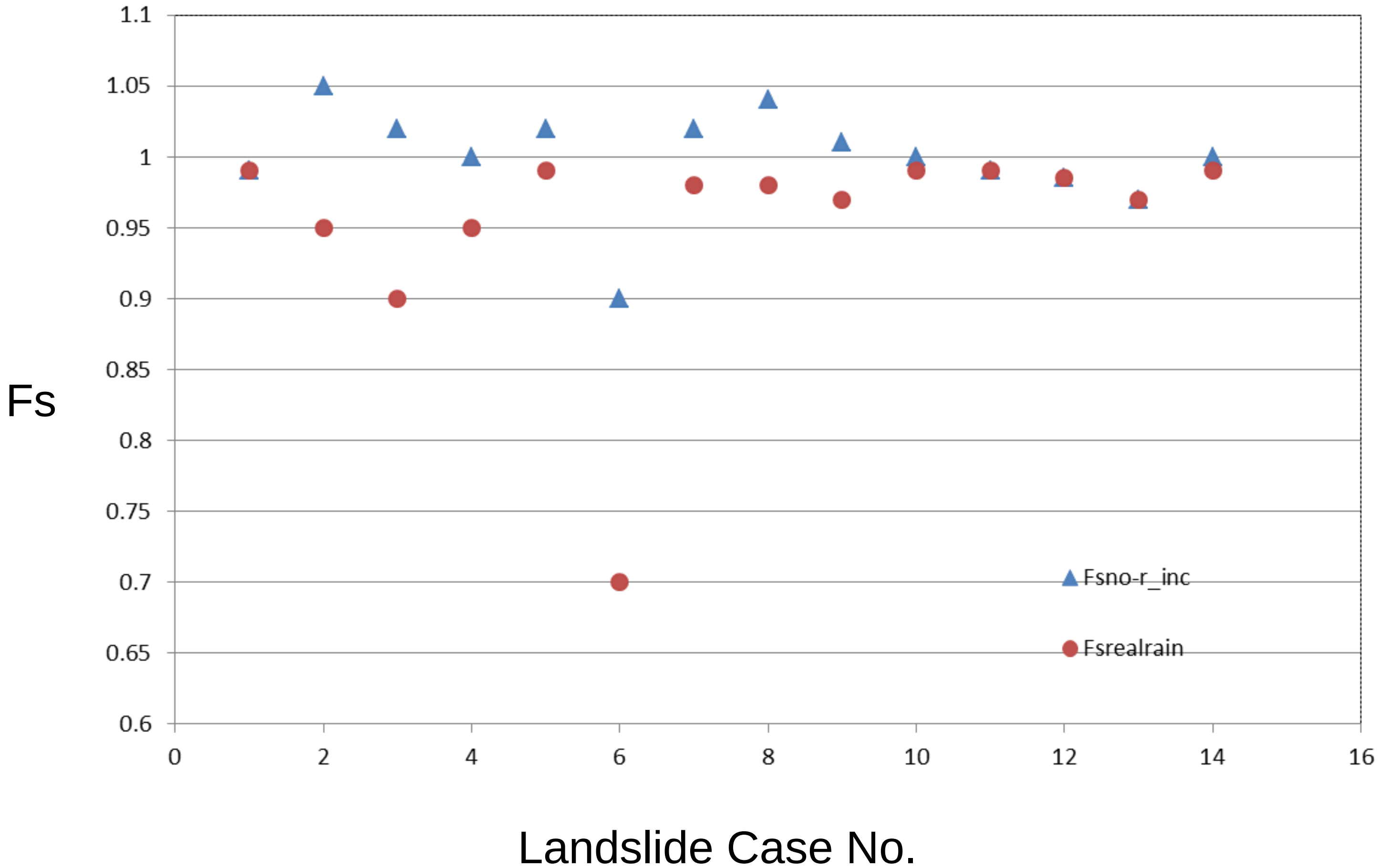


Fig.10 Results of the FEM slope stability analysis with rainfall infiltration/seepage analysis

(The difference between “rainfall increased Fsno_rinc” and “rainfall in the disasters Fsrealrain” is obvious by statistical significance level=5%, P=0.0475)

4. Conclusion

The influence of increasing rain in landslide occurrence i.e. slope instability was estimated by approximate average 5% (1% to 12%, in extremely case 22%) of reduction in Fs, and it deemed enough high on the slope stability point of view.

The increase of “rainfall rainfall intensity Ri”, “daily rainfall Rd” due to climate change with the increasing rate such as 20mm/hr or 50mm/day in 40 years, surely has strong influence on almost landslide slopes in aspect of slope stability.

Therefore, with this rain increase rate, it is possible for many forest slopes or natural slopes to become unstable and cause landslide disasters.

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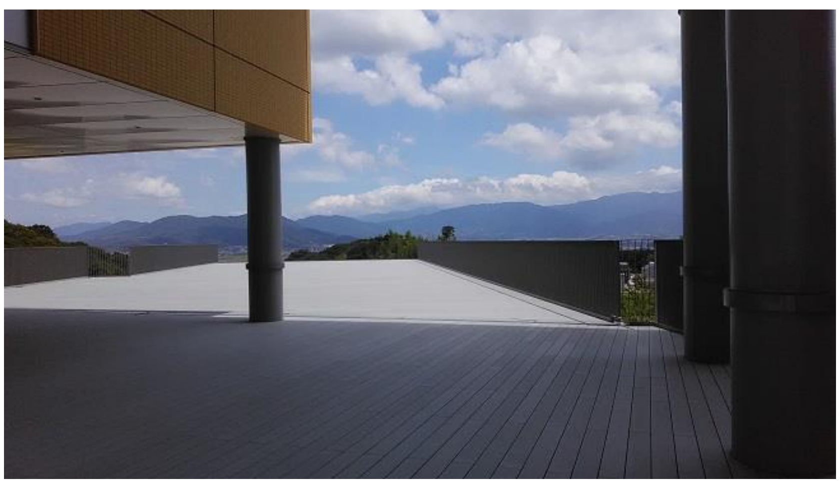

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