

Typhoon Rainfall and Landsliding in the Pacific Ocean Side of Japan

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ABSTRACT

Japan is an island chain located off the north-western rim of the Pacific Ocean. Generally, in Japan, precipitation occurs mostly during typhoon seasons on the Pacific Ocean side, and in winter (heavy snow) on the Japan Sea side. This paper deals with synoptic descriptions of failures that occurred in various areas, along with rainfall and failure relationships during the typhoons of 2004 in Shikoku. In this paper, the effective amount of rainfall that triggered landslides in the Shikoku Island during these typhoons was identified along with information of occurrence time and landslide-triggering thresholds for Shikoku Island were interpreted.

KEY WORDS: Typhoon; Shikoku, rainfall induced landslides; debris slides; debris flows; triggering thresholds.

INTRODUCTION

Experience shows that landslide occurrences on hill slopes have very close relationship with availability of water. As a result, many types of landslides occur after heavy rainfall in tropical and temperate climatic zones (Jakob and Weatherly, 2003). Landslides triggered by rainfall occur in most mountainous landscape of the world. They pose a significant natural hazard and they have a high damage potential. Many statistically meaningful analyses have been published to demonstrate threshold values of rainfall and landslide triggering (e.g., Caine, 1980; Wilson and Wieczorek, 1995; Crozier, 1999; Aleotti, 2004; Guzzetti et al., 2007). Within the last few years, many studies focusing on rainfall thresholds for triggering landslides with hydroclimatic condition, antecedent rainfall (Crozier, 1999; Glade et al., 2000), and hydraulic conductivity (Terlien, 1998) were conducted. In this context, this paper describes some scenarios of rainfall-triggered landslides that occurred in Shikoku Island, Japan (north western Pacific Ocean side) during various typhoon events in 2004.

It is 225 km long and 50-150 km wide, with more than 80% of land consisting of steep mountain slopes. It is a heavily forested mountainous region of Japan. It has a few plain areas along the coastal lines and elevated peaks in the central part. There are only small villages on the mountains but the mountain bases are considerably populated. The mean annual precipitation of Shikoku ranges from 3,500 to 1,000 mm. Shikoku Island can be roughly divided into three geological zones: Ryoike, Sambagawa-Chichibu, and Shimanto belts from north to south (Fig. 1).

The three zones are bounded by two northerly dipping major faults, the Median Tectonic Line (MTL) and the Butsuzo Tectonic Line (BTL) from north to south, respectively. The Ryoike Belt consists of late Cretaceous granitic rocks, late Cretaceous sedimentary rocks (Izumi Group), and Miocene volcanic rocks (Sanuki Group). Cretaceous granite is widely distributed in the north of Seto Inland Sea. The MTL topographically marks a distinct sharp boundary for Shikoku Range. This range, with a maximum altitude of nearly 2,000 m, is occupied by the Sambagawa-Chichibu Belt. The Sambagawa Belt is composed of low-grade metamorphic rocks. The southern Chichibu Belt is mainly composed of carboniferous to Jurassic sedimentary rocks and low-grade metamorphic rocks. The Shimanto Belt consists of Cretaceous and Palaeogene sedimentary rocks and this belt occupies the two southern peninsulas protruding into the Pacific Ocean. The middle Miocene granitic and partially gabbroic rocks are sporadically distributed along the axes of Muroto and Ashizuri peninsulas.

Owing to the geological and morphological settings, landslides and floods caused by typhoon rainfall are frequent in Shikoku. Also, in 2004, Shikoku experienced extreme events of typhoon rainfall and faced huge losses of life and property. In this paper, rainfall events due to typhoons of 2004 are critically evaluated and landslide events during the rains are also described. The main objectives of this paper are (a) to document the pattern of landslides in response to the typhoon rainfall events of 2004, (b) to derive the intensity-duration relation of rainfall that triggered the landslides during the typhoons of 2004, and (c) to determine the effect of typhoon rainfall on the different geological and physiographical terrain of Shikoku Island.

TYPHOONS IN JAPAN AND SHIKOKU

Typhoons are the most significant meteorological events for natural disasters on earth, which are caused by strong winds, heavy rains, river floods, storm surges, and high waves. It is noticed that the horizontal scale of a typhoon ranges from several 100 km to a few 1,000 km, while that of the cumulonimbus clouds is in the order of 10 km (Tsuboki, 2005). The heavy rain is usually localized in the eye wall and spiral rainbands. From 1951 to 2005, there were 1,468 typhoon events in the northern part of the Pacific Ocean, 163 of which hit the Japanese archipelago. In 2004, Japan was hit by 10 typhoons which are the maximum annual typhoon events within the last 55 years (Fig. 2) and the lowest number of typhoons occurs in February, whereas the highest number is in August (Fig. 3).