Study of Sediment Hazard Zone in the Residential Area Endowed with Cultural Heritages

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In order to study countermeasures for landslides and debris flows due to heavy rainfall and earthquake, several researches concerning to sediment hazards are conducted, focused on Kyoto City with national treasures and important cultural properties. The results obtained in present study are summarized as follows.

In chapter 1, the overview of sediment hazards in Japan is introduced, and the engineering issues of the countermeasures are clarified.

In chapter 2, one dimensional governing equations of debris flow are shown, and their characteristics are discussed. Debris flows should follow Reynolds similarity because it is considered as a laminar flow in a view of mechanics. However, hydraulic model tests for debris flow are planed based on Froude similarity. In present study, Reynolds of debris flow is discussed based on the momentum conservation equations and the constitutive equations proposed by Egashira et al., and numerical simulations are conducted to examine those characteristics. The results obtained by present studies are summarized as follows.
(1) Debris flow follows Reynolds similarity in a view of dynamics.
(2) The important parameters such as Reynolds numbers shown in Eqs. (2.28) and (2.29) are obtained based on the momentum conservation equation and the constitutive equations. The Reynolds number of a debris flow can be described as a function of Froude number. Therefore, debris flow follows both Reynolds and Froude similarities simultaneously under the condition shown in Eqs. (2.35) and (2.36). This means that those similarities are satisfied in case that the model is designed so that the topography is not distorted and the ratio of mass density of sediment to water/muddy-water.
(3) Numerical simulations for depositional and erosional processes of a prototype and the models are conducted under the conditions shown in (2), and then it is confirmed that debris flows satisfy Froude similarity. The Courant number of the model also needs to be the same value to a prototype in order to obtain the results which satisfy Froude similarity.

In chapter 3, roles of studies on landslides and debris flows are discussed. The view point of studies on sediment-induced disaster mitigation ranges widely, from social to natural science. Especially non-structural countermeasures such as warning systems and hazard maps have been developed through collaboration between the associated research fields. To maintain focus, a restricted range of topics was chosen for the present discussion based on many researches such as numerical simulations, empirical methods and so on. To summarize, studies associated with dynamics of landslides and debris flow have been introduced to show how they can support design of countermeasures against sediment-induced disasters, as follows.
(1) The countermeasures carried out in Japan are briefly introduced to show the roles of corresponding studies, and are supported significantly by the related research.
(2) The governing equations from mass point system to depth averaged continuum field are introduced to treat landslides and debris flow, including formulas for the bed shear stress and erosion rate of bed sediment, and reviewing the associated studies. In particular, it is recommended that governing equations, which can evaluate the inherent flow characteristics caused by internal solid friction, rapid sediment erosion/deposition and the corresponding change of bed elevation, should be employed in the numerical simulations.

In chapter 4, sediment hazardous area in historical city is analyzed, based on governing equations of debris flow. In order to investigate present issues of countermeasures against flood and sediment hazards with attention focused on residential area endowed with cultural heritage in Kyoto, data analyses, survey of method to predict hazard zone and hazards zone mapping are conducted. The results are summarized as follows.

In prefectural Kyoto area, water induced flood and sediment disasters take place probably anywhere and every year. In Kyoto city area, residential region spreads actively to northern and western mountain-sides during latest 90 years. A simple equation of motion for soil block is useful for estimating hazard zones. There are residential regions endowed with cultural heritage in the potential hazard area.

Present study is preliminary and many problems should be analyzed: Especially in these study topics, it is very important how to treat with local phenomena using simple, general methods. Proper countermeasures for residential region with cultural heritages will be reconsidered taking into account the law to protect cultural heritages and places around them, scenery and so on. In this study, proposal of sediment hazardous area in historical city can help the planning of land use, though we do not evaluate flow characteristics of debris flow such as kinetic energy, fluid force and impact force. In order to mitigate those disasters by means of direct and indirect countermeasures, it is necessary to include characteristics of floods and sediment movement under the high resolutions. Specially, it is considered that there are several additional problems for the countermeasures of historical city, even if the countermeasures successfully are conducted in urban area against the plan size of external force. Because the city included historical scenery is constituted of cultural heritages such as architecture, painting, sculpture and craft product. Therefore, it is very important how to prevent such cultural heritage from natural disasters. In conducting the countermeasures, cultural environments should not be changed. There are several problems to be solved for countermeasure, which is proper to each historical city.

In chapter 5, the summaries of obtained results of present study are described.