Prediction of Variation in Reservoir Sedimentation by Gravimetry Technique

Yu-Shen HSIAO[1,*] and Yun-Chen SHIENG[1]
[1]Department of Soil and Water Conservation, National Chung Hsing University, Taiwan
*Corresponding author. E-mail: yshsiao@nchu.edu.tw

INTRODUCTION

The study is aimed at accurate and fast estimation of variation in reservoir sediment due to torrential rains by gravimetry technique. The related theories and software for this study are preliminarily completed, and some experiments by using simulated data have been carried out. The simulated study area is in Tseng-Wen reservoir (Fig. 1), which is located in mountain areas of Chiayi County, south of Taiwan. Tseng-Wen reservoir forms the largest reservoir in Taiwan, and the total capacity is around 708,000,000 m^3. Several practical gravity surveys around Tseng-Wen reservoir will be carried out by a FG-5 absolute gravimeter during typhoon seasons in order to validate the simulated results in this paper. The purpose of the research is to develop a fast and accurate method to estimate the sediment variations in reservoirs, and subsequently bring contributions to soil and water conservation.

METHODOLOGY

A method for computing terrain corrections (TC) is used in this study for predicting variation of reservoir sedimentation. TC is a procedure removing the gravity effect of topographic variation at a gravity observed station *P*. If station *P* is near a reservoir, the TC values could be obviously changed due to the variations of water or deposits before and after tremendous rains or landslides. We can estimate the amount of reservoir storage or sediment variations by analyzing the differences between two TC values both computed at station *P*. Then the amount of water or deposit in the reservoir after the typhoon disaster can be precisely estimated.

Fig. 1 The location (The black rectangle) of Tseng-Wen reservoir in Taiwan.

DESIGN OF EXPERIMENT AND RESULTS

We design three different levels of water surfaces, which are 275 m (high), 265 m (medium), and 255 m (low), and also three different levels of deposit surfaces, which are 251 m (high), 248 m (medium), and 245 m (low). The cases divided by different conditions of water and deposit levels are shown in Table 1. We also select three simulated gravity

observed stations 1~3, which are 100, 200, and 300 m away from the dam area of Tseng-Wen reservoir.

The simulated TC differences ΔTC (gravity differences) between cases 2~9, and case 1 at stations 1~3, are all summarized in Fig.2. It is apparent that the TC differences (ΔTC) between every 2 cases increase rapidly with increasing water and sediment volumes, and decrease gradually with increasing distance from the gravity station to reservoir. In general, gravity variations derived by terrain corrections (TC) method are approximately 0.01 ~ 0.20 mgal, depending on different reservoir conditions. The gravity changes observed at three gravity stations are obvious if a great quantity of water or sediments exists; on the contrary, a small amount of water or sediment variation results in almost the same ΔTC at all gravity stations. The results reveal that the mounts of ΔTCs are easily detected by an absolute gravimeter (resolution: 0.001 mgal), but relative one (resolution: 0.1 mgal). Absolute gravimeters are also able to well predict the slight sediment changes. Overall, gravity observation at nearest station is still strongly suggested for future practice surveys.

Table 1 Cases with different conditions of water and deposit levels for Tseng-Wen reservoir.

Case	Water level	Deposit level
Case1	low	low
Case2	medium	low
Case3	high	low
Case4	low	medium
Case5	medium	medium
Case6	high	medium
Case7	low	high
Case8	medium	high
Case9	high	high

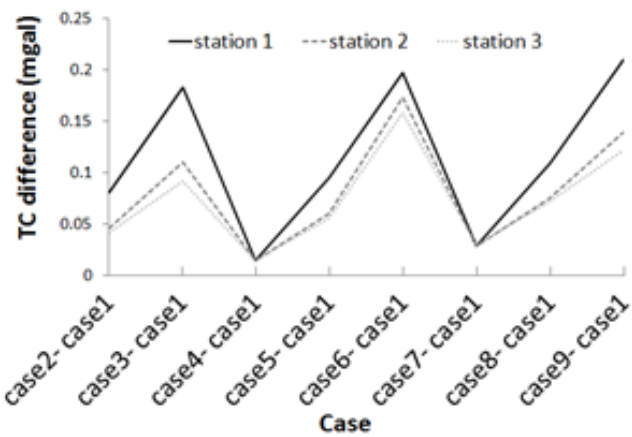

Fig. 2 The TC differences (ΔTC) between cases 2~9, and case 1 at stations 1~3

CONCLUSIONS

W investigated the TC value changes (gravity changes) due to simulated reservoir conditions, including high, medium, and low water and deposit levels. The principal conclusions in this study are (1) the gravity changes observed at three gravity stations are obvious if a great quantity of water or sediments exists, (2) that slight water or sediment change results in little gravity variation at three gravity stations, (3) that after the analysis of TC, absolute gravimeters are more suitable for estimating the amounts of water or sediment variations while doing practical gravity surveys.

Keywords: gravimetry, reservoir sediment, soil and water conservation.