# Engineering Assessment of Aging Degradation for Small Sediment Control Structures

Sangjun IM[1*], Won CHOI[2] and Song EU[1]

[1] Department of Forest Sciences, Seoul National University, Korea
[2] Department of Landscape Architecture & Rural System Engineering, Seoul National University, Korea
[*]Corresponding author. E-mail: junie@snu.ac.kr

## INTRODUCTION

Landslides and associated debris flow are major drivers of natural disasters in Korea. Sediment-related disaster prevention structures, such as erosion control dam and check dam, have been implemented for steep torrents on forested watersheds. About 15,000 erosion control dams (ECDs) have been installed to date since ECD project has first employed in 1985. ECD is structurally small in size, with typically 5~7 m height and 30~50 m width, and is receiving sediment mixture from small forest watersheds (< 300 ha). This structure could be made of concrete and stone materials, even as open-type dam uses steel materials as a debris barrier.

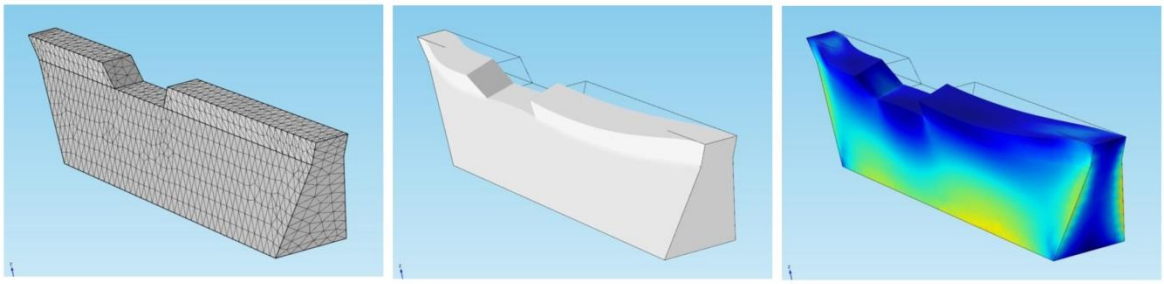
Time dependent deterioration of ECDs is random and irreversible phenomenon in nature. Although ECD materials are inherently durable, engineering strength of dam could be lost partly or completely due to aging degradation. Aging process can slowly and progressively change the engineering characteristics of materials over a period of time. Age-related degradation can lead to changes in structural performance and resistance capacity of ECDs. Freezing and thawing, leaching, cracking due to temperature variation, corrosion of concrete structures, and cement debonding are the main sources of aging deterioration of ECDs.

Various approaches have been conducted to quantitatively examine the engineering performance of aging concrete structures. Time-based reliability analysis was traditionally utilized to evaluate resistance decrease over time. Symptom-based reliability was also employed to predict the safety and performance for existing structural components in future condition. Other studies have quantified degradation effects on stability with fragility curve (or conditional probability of failure). In this study, a numerical approach is applied for performance evaluation to aging concrete ECDs. Finite element technique is embedded in the resistance analysis with static and dynamic loads.

## ANALYSIS AND RESULTS

Numerical analysis of aged ECDs has been done using the finite element method coupling with aging degradation function. The linear and nonlinear earthquake response analyses of concrete ECDs with various boundary conditions were conducted using one-dimensional analysis program Shake91. Structural safety factors (settlement, overturning and sliding) of the ECDs were assessed by considering their seismic loads. The three-dimensional linear structural analyses considering the concrete reduction factor following to the aging and the crack length of the dam crest based on worst scenario were also conducted using finite element method COMSOL.

Age-related degradation of structural materials is a complicated process. Corrosion is one of the main reasons for time-dependent deterioration of aged concrete materials. In this study, aging degradation function for concrete was derived from previous studies and field survey data. Impact force induced by debris flow was estimated from small debris flow flume experiment, and input into the model as an external force.



(a) 3D modeling (meshing) (b) Displacement (a) Von Misses stress

**Fig. 1** Structural analysis of concrete ECD

## CONCLUSIONS

Aging is a natural phenomenon that leads to change in engineering strength over operating time. This deterioration can reduce the resistance capacity of structure materials and give rise to serious problem of ECDs in Korea.

In this study, aging degradation effects of concrete ECDs has examined using finite element method and static and dynamic loads. Impact force derived from debris flow was input as static load and seismic wave was considered as dynamic load. Strength degradation over time was quantified according to concrete corrosion and cracking, and embedded into the finite element analysis under various operational conditions.

The numerical results showed that concrete corrosion have little influences on structural resistance of ECDs. But, cracking due volume changes led by temperature variation and cement debonding can cause to significant effects on resistance capacity, which may result in the decrease of structural performance that captures debris flow in torrent streams.

Engineering performance monitoring and structural maintenance (such as inspection and repair) are essential to reduce the risk of structural failure, and enhance structural functionality over operational period. This study provides with engineering techniques to accurately assess the structural performance of landslide disaster mitigation/prevention structures.

## ACKNOWLEDGEMENTS

This study was carried out with the support of ´R&D Program for Forest Science Technology (Project No. 2017061B10-1719-AB01)´ provided by Korea Forest Service(Korea Forestry Promotion Institute).

**Keywords**: Aging Degradation, Erosion Control Dam, Performance Capacity, Reliability Analysis, Finite Element Method