

TRACING DEVELOPING DETERIORATION ZONES IN A DAMAGED DAM BY USING ELASTIC WAVE TOMOGRAPHY



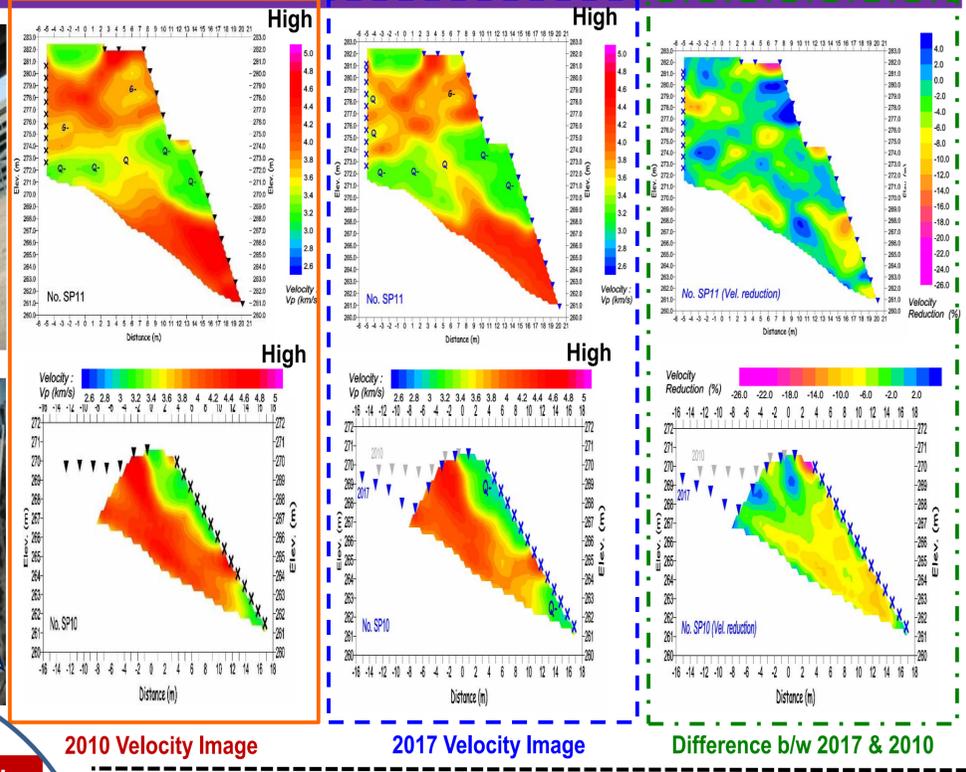
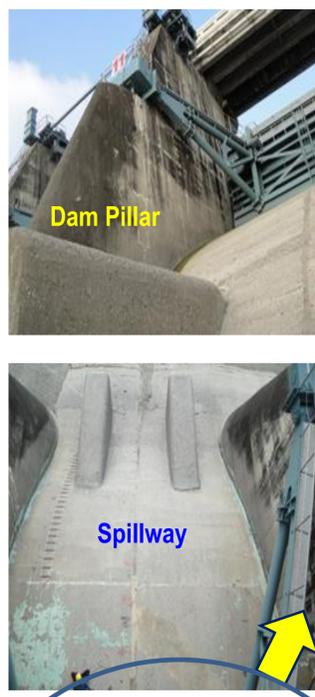
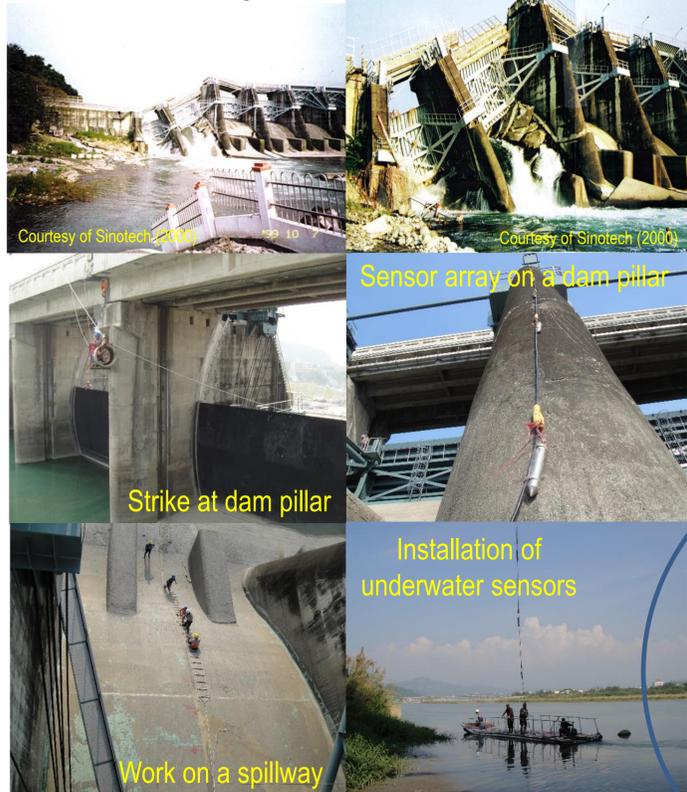
Introduction

The concrete gravity dam built 40 years ago was partially damaged by the M=7.3 Chi-Chi Earthquake in central Taiwan in 1999. The elastic wave tomography method was applied to identify the safety conditions of the repaired dam in 2010. The resulting velocity profiles showed that the filled materials and cracks existed in some dam components. The total structure conditions were accepted as a good to questionable condition. Seven years later, the updating tracing investigation revealed that the previous detrimental zones were spatially extended and associated with time. These testing results were also consistent with the findings from the ground penetrating radar inspection.

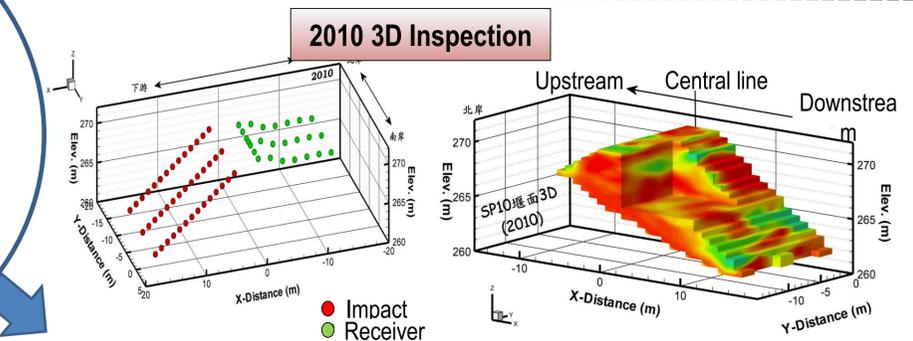
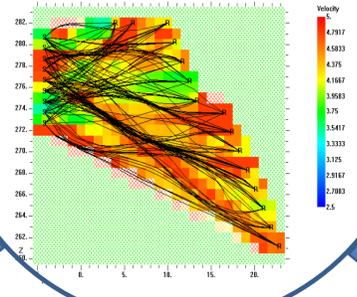
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Dam Inspection

The concrete gravity dam in central Taiwan was constructed for providing drinking water in 1977. The Chi-Chi Earthquake triggered the nearby fault extended to the right bank of the river, lifted the ground surface up to 2.2 m, completely crashed 3 spillways, and structurally damaged the remaining facilities in 1999. An emergency rehabilitation plan was finished in 2000. Currently, the improved dam consisted 2 scouring sluiceways, 15 spillways, and one fish way.

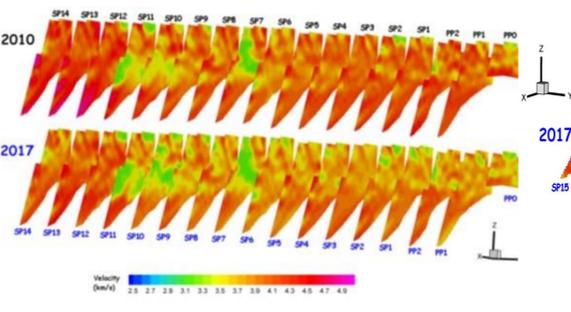


Elastic Wave Tomography



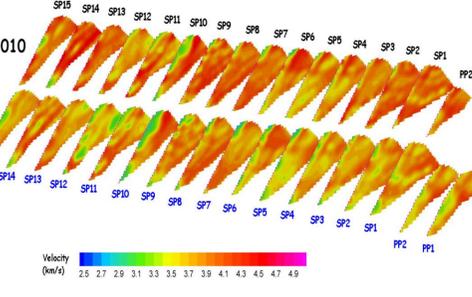
Dam Pillars

Most of concrete conditions are classified as the questionable or good level (3,000~4,500 m/s). In total, the lowest velocity zones (lower bound 3,000 m/s of questionable level Q) are significantly identified on pillars SP7, SP10, and SP11, but the reduction is <6%. The original lowest velocity zones in 2010 expanded into the inner portion of dam pillars, especially PP0, PP2, SP1, SP2, and SP6~SP10, in 2017.



Spillways

Most of concrete conditions are classified as a questionable or good level (3,000~4,500 m/s). The original low velocity zones in 2010, especially SP1~SP12 expanded in 2017, and the total velocity reduction is <12%.



- Overall wave velocities decrease, but quality is identified as a good (G) or questionable (Q) level, approaching the lower bound of questionable level (3,000~3,200 m/s).
- The surface low velocity zone expands deeper up to 2~3 m. Several limited low wave velocity belts spread and form a relatively low wave velocity zone.

Discussions & Conclusions

The conventional and 3D wave tomography results indicate that different degrees of deterioration are found in concrete components with filled materials and cracks, and verified with the follow-up ground penetrating radar investigation. Most of concrete conditions are classified as a questionable (Q) or good (G) level. The detrimental zones are spatially extended and associated with time at 2010 and 2017 inspections. The concrete quality on the lowest wave velocity zones is identified as approaching the lower bound 3,000 m/s of questionable level Q. The follow-up monitoring is suggested to focus on these detrimental spots in concrete dam.