

TC211-218 Workshop MSE Walls and Reinforced Fills

Seismic Considerations for Reinforced Soil Slopes and MSE Walls Yoshihisa MIYATA, D.Eng. National Defense Academy of Japan

Contents

Current MSE wall Technology

- Outline
- Seismic performance of MSE walls during Kumamoto earthquake (2016)

• Performance Based Design of MSE walls

- Japanese technical standards on road earthwork structure (2015)
- PBD and analysis methods for MSE walls
- PDCA for better technical standard by using performance valuation records

Toward Risk Based Design

- ISO 2394 (2015)
- RBD of MSE walls



MSE wall technology used in Japan



Observed seismic behavior of MSE walls in Japan



Seismic performance in Kumamoto Earthquake 2016



Geotechnical Damage

Slope failure and Landslide

Liquefaction

River dyke settlement

Japan Geotechnical Society (JGS) organized an investigation team to support the recovery of the damaged sites and to study the potential of secondary disasters.

Mukunoki et al (2016) JGS investigation team report, Soils and Found

Investigation of MSE walls

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Target performance levels for MSE walls

Target performance = F (**Importance of structure**, **Magnitude of actions**)

Analysis methods for performance evaluation

Target performance = F (Importance of structure, Magnitude of actions)

PDCA to develop the design standard

Check: Current standards OK?

- Periodical heath monitoring and
- special investigations after extreme event

Action: Improvement of current standards

- Changing of design factors
- Modification of design equations
- · Acceptance of new analysis tools

• What are materials?

- Field observation
- · Full-scale / scaled model tests
- Advanced theory

Check list of MSE walls after extreme events

補強土壁諸元 施設(路線)河陰阿蘇線単県道路改良1号(県道149号 施主 Outline of MSE wall 整理番号 J-30 管理番号 緯度・経度N 32 所在地 施 年月 日子の他 工 年 月 1850 1壁勾記 ■ 垂直 □ 斜 現地発生 Geometry Reinforcement type m 積 805 基礎形式 勾配 1: Soil type 壁前面~路肩(水平距離) 基礎天端~路肩(鉛直距離) 上部法面保護(含切土) ■ 植生 □ 法枠 □ アンカー □ コン → 峠 & 卅 □ 谷埋め・集水地形 □ 傾斜地形 □ 寒冷地 Facing type レクリート吹付け 日その付け 日その付け 日 海岸近傍 他(z地条件 口水辺 口 カルバート隣 □ 多段積み 口西面 ロその他 異常の有無 概要 與來の有態 可有 無 未祥道 可有 魚 未祥道 ック項目 異常の有象 橋梁排水管脱落 1. Appearance: Global deformation 部分崩壊 Leakage mark 広範囲で脱落 壁体脱落部周辺 洗握 洗肥 沈下 滑動 転倒 クラック 目地開き・ずれ その他 広範囲 2. Facing: 脱落部付近 基礎 壁面材 Local deformation 目地部点在 vegetation 補修痕 -</ 洗掘 沈下 すべり 補修痕 補参換 漏出(痕) 沈下 細粒分の吸い出し その他 補修痕 3. Fill: 基礎地盤 広範囲 広範囲 部分崩壊 崩壊形状から Compression 補修痕 傾斜・転倒 クラック ずれ Internal erosion □ ↑ 1 ■ ★ ★ ₩</ 防護柵基礎 無 □ 未確加 無 □ 未確加 無 □ 未確加 倾斜 クラック 目地開き・ずれ 変色・錆汁(痕) その他 笠コン 4. Adjustment RC: 補修療 無 口 未確認 44.1% 20 クラック 沈下・陥没 段差 異常振動(空 その他 1</ 多数確認 大規模に陥退 多数確認 崩壊箇所で脱落 補修痕 上面道路 小崩壊 浸食 5. Surcharged ※E 決下 クラック スレーキング 高含水比 その他 緑体度 1< 嵩上げ盛土等 崩壊 補修痕 embankment: 開き 損傷 変形(端部調整材 その他 隣接構造物境界 有 ■ 無 □ 未破計 有 ■ 無 □ 未破計 19th International Conference on Se and Geotechnical Engineering 有■ 無 有■ 無 □ 未破計)他 補修痕

6. Drainage: Clogging, Damage

7. Footing: Scour, Settlement, Stability

8. Base foundation: Scour, Stability

9. Road facility: Pavement stability

10. Boundary to neighboring facility:

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Progress in design concept

ISO 2394: General principles on reliability for structures

Risk base design

For accepted risk Full probabilistic model + Social model $P_f \cdot C \leq R$ ISO 2394 (4th, 2015)

Performance based design

For required performance Semi probabilistic model $\phi S \ge \gamma Q$ (Safety) + D $\le D_{max}$ (Service)

ISO 2394 (3rd, 1995)

Specification based design

For equivalent specification Deterministic model S ≥ FQ (F supports safety and service)

ISO 2394 (1st ,1973) (2nd, 1985)

A risk based design: LCC design

Summary

- ✓ MSE walls is a prevailing technology due to its high peformance.
- Over 700 site investigations show that MSE walls performed well during the Kumamoto earthquake (2016).
- Japanese technical standard on road earthwork structure (2017) accepted performance based design. MSE wall design is being developed by PDCA approach.
- ✓ Future design of MSE wall should be RBD. A design to minimize the lifecycle cost with risk is useful for selecting the best structure system and determining of reinforcing conditions.

