Construction of 43 M High Geosynthetic Strip MSE Wall

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PROJECT DESCRIPTION

The world class cities of Dubai and Abu Dhabi in the United Arab Emirates have experienced considerable growth. An hour drive east of Dubai off Highway 102 in the Ras Al Khaimah region, new road construction was needed as part of highway infrastructure expansion to eliminate a network of slow winding narrow roads in the Western Hajjar mountains. The construction of elevated roads with 3 lanes in each direction between Wadi Al Ghor and Link Road between Al Hibab Roundabout and Nazwa Road Phase 1 includes large grade separations in extremely difficult and hardly accessible mountain desert terrain. Tall MSE Walls constructed up to 43 meters in height proved the best feasible solution compared with elevated viaducts.

This project is unique as one of the tallest geosynthetic MSE Walls supporting highway. Back to back walls more than 40 meters in height were constructed as five-tiered structures with 1.5-meter setback between tiers. Walls of such magnitude require tiered cladding and high quality dependable soil reinforcement polymeric strip. The native soil contains high concentrations of sulfides and chlorides requiring geosynthetic soil reinforcement. The design followed AASHTO LRFD for MSE Walls. Figures 1 and 2 provide typical sections and construction photographs.

The mass of an MSE structure is up to 95 percent backfill while the remaining components are wall facing and soil reinforcement. The concern of backfill settlement must correlate with the facing connected to the soil reinforcement. The solution is to use precast concrete facing elements that are independent units surrounded by open joints. The open joints provide flexibility of the facing. In these tall structures, the designed compression of bearing pads in the horizontal joints provide reduction of vertical shear stress in the soil reinforcement connection. Further facing stress control was obtained by using terraces in the wall configuration.

PROJECT CHALLENGES

Challenges included heavy surcharge loads on the existing foundation. Settlement and bearing capacity concerns were addressed to ensure adequate support of the structures. The majority of the walls are founded on highly fractured weathered Gabbro rock with some walls underlain by dense to very dense insitu gravel up to 10 meters thick. Long sections of back to back structures were placed on sloped foundation grades providing varying wall height sections with the need to evaluate excavation limits. The FHWA trapezoidal wall design method was utilized as the foundation soil was either bedrock or very dense Wadi deposits with STP N values above 100. Soil reinforcement length reduction optimized excavation limits and was justified considering adequate bearing resistance of the foundation soil. Global rotation of the structures was not a concern given the competent strength of the bedrock foundation. Back to back wall separations as narrow as 60 percent of wall height required special design considerations. In addition to the above design conditions, the MSE backfill selection was paramount to the success of the project.

MSE BACKFILL

MSE structures have been constructed with a variety of backfill materials with fines contents ranging from 5 to over 50 percent. However, time dependent creep, poor drainage and compressibility of fine materials when used for MSE wall backfill can lead to performance issues. Large constructed fills of the magnitude of this project can undergo elastic compression causing wall deformation. Backfill properties have a significant impact on the long-term performance of the geosynthetic strip MSE Wall including wall facing alignment. AASHTO general wall design guidelines require select structural fill of 34-degree shear strength with a gradation requirement limiting fines content to below 15 percent passing the No. 200 sieve and Plasticity Index below 6. This project used more strict design criteria with requirements of 45-degree soil shear strength and fines content less than 5 percent.

The project was equipped with two large crushing plants that processed local blasted excavated rock from excess cutting operations. The processed material provided ideal MSE backfill that was well drained, durable, not prone to post construction settlement and not aggressive to geosynthetics. The Engineer verified log from the backfill material stockpile provided physical test results of the soil with acceptable pH range 5 to 8 for polyester reinforcement, Cu average of 45, grain size distribution of 50 mm minus, well-graded material with .063 mm (No 230) sieve less than 5 percent, non-plastic and friction angle range 46 to 48 degrees. The quality structural backfill provided the ability to control vertical wall alignment in these tall MSE structures.

SOIL REINFORCEMENT

The compatibility between MSE Wall components is critical. Soil reinforcement consisted of 50 kN tensile strength geosynthetic strips with vertical spacing as low as 40 cm. The strips are composed of high tenacity, multifilament polyester yarns placed in tension and coated with low linear density polyethylene. MSE Wall design required typical polyester creep reduction factor for a 75-year design life. The backfill size impact on installation damage was minimal due to the protection sheath coating. The geosynthetic strip is threaded through the connection recess sleeve embedded in the facing panel to provide a fully synthetic integral mechanical connection. As an important installation method, the strips were tensioned prior to backfill operations. The strip ends, beyond their design length, were pinned with 25 cm long U-shaped staples. Because of the long strip sections, a tensioning trench was used at 7 m intervals to remove slack along the length of the geosynthetic strip. The anchoring process involved creating a shallow trench, tensioning the strip by hand and placing a small soil pile over the strip. Proper wall alignment was maintained with the specified tolerance following these installation procedures.

CONCLUSION

The facing type, soil reinforcement and mechanical connection, along with the quality of the MSE backfill and bedrock foundation, all play an important role in the success of such a critical project.

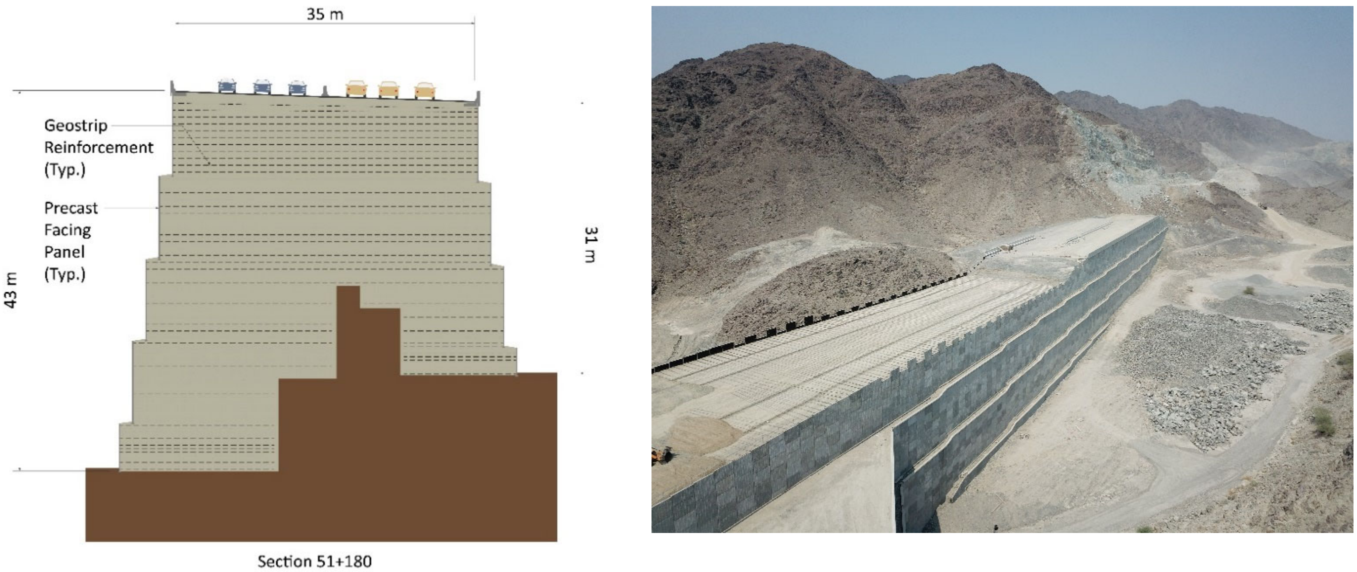

Figure 1. 43 M high Geosynthetic Strip MSE Wall in construction.

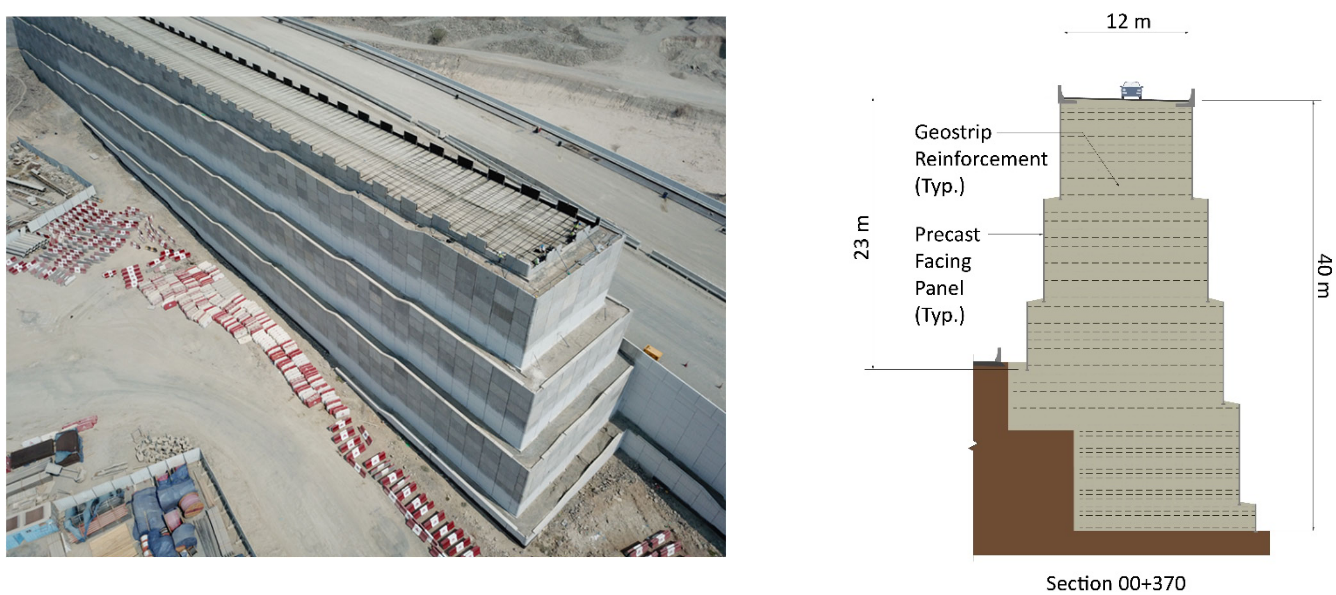

Figure 2. Truck Escape Ramp with geosynthetic strips shown in top tier.