Effect of Surcharge Load on MSE Wall Reinforced with Tire-Derived Aggregate

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***Abstract*: MSE wall is used extensively nowadays especially in United States of America for the construction of highway wall. In this research a wall is reinforced with tire-derived aggregate also called Crumb Tire Rubber (CTR) in order to analyze the stability of the overall structure. Whereas, the soil that was used for research purpose is Indus River Soil, which is not only economical but also helps in desilting the Indus River System. Various element tests were conducted including Sieve Analysis, Pycnometer Test, Compaction Test or Direct Shear Box Test to obtain different parameters. The parameters were used in two-dimensional software i-e PLAXIS 2D for numerical analysis of MSE wall. After that, additional vertical downward load of 25 kPa to 100 kPa were applied to analyze the effect of load on the deformation of the MSE wall and finally represented in graphical form in this research. Conclusively, horizontal, vertical and total displacements were observed to be decreasing with the increase in the percentage of CTR. In addition to that the horizontal, vertical and total displacement proliferate with the increase in the height of MSE wall, which becomes notable when the superimposed load increases from 25 kPa to 100 kPa.**

***Keywords*: Crumb Tire Rubber, Displacement, Indus River Soil, PLAXIS 2D,**

I. INTRODUCTION

One of the modern methods to construct earth wall is by reinforcing the natural soil with the various reinforcement material in order to support its own weight and is famously known as Mechanically Stabilized Earth (MSE) Wall. It is a method of artificially reinforcing earthen materials so that they can carry superimposed load. The strength and behavior of MSE wall rely on different reinforcing material such as anchorage system, metal bar, and wire mats welded together in order to enhance the overall properties of the soil mixture. Besides, 60,000 MSE walls higher than 35 ft are in service at the U.S. highway system [1]. In addition to that, approximately 9,000,000 ft^2 (850,000 m^2) were added into the U.S. transportation system annually, which accounted for more than half of all types of retaining wall usage [2]. Furthermore, it collapses under the external burden because of the various causes that are properties of soil mass (shear quality and internal friction), properties and proportion of blended soil-rubber material and phreatic level. In addition, strengthening materials other than rubber for building such kind of vertical wall is costly and scarcely available in Pakistan, which gives an opportunity to utilize material which is promptly accessible that is used tire rubber.

Fig 1: Failure of MSE wall.

Besides, Waste Tire are used rubber tires. These end-of-life tire which is never again appropriate for use on automobiles after completing its service life, can be utilized to fill another monetary need. To reduce the adverse effect of rubber tires and to save the ecological cycle, scrap tire can be utilized in MSE wall by blending it with sand. Stockpiling of tire are banned and burning of tire causes environmental pollution since these types of solution provide short term relief. Rubber is long-lasting and resistant which cannot be dumped without affecting environment. Therefore, it should be used in a constructive and sustainable way so that the adverse effect of unusable rubber tire can be minimized, in addition to that, rubber's characteristics can be used to increase the properties of the soil mass. The manufacturing of scrap tire rubber is available in vast quantity in the world and available in ample quantity in Pakistan as well. The dumping of tires at the dumping site has shown the adverse effects on the environment and since it has been disposed-off in the past which amounts in bulk resulting in increased risk that it may catch fire and it may burn as long as months, increasing the pollution in the ground as well as in the air.
Besides, the aim of this study is to examine the variation in the properties of the MSE wall with the addition of Crumb Tire Rubber.

Moreover, the goal of this study is to analyze the stability of the vertical wall by adding a Crumb Tire Rubber in the soil mixture. Furthermore, component testing of blended mixture sand-rubber will be done in lab alongside the numerical investigation of the MSE wall using Finite-Element programming PLAXIS 2D. In this study, the reliability of the MSE wall is also observed by comparing the impact of scrap rubber tire mixture.
Moreover, in Pakistan particularly in Sindh, Indus river soil is available in vast quantity as the soil from the upper riparian travel and settle at different parts of the river. In this research Indus River Soil is used for our research purpose. The benefits of using this soil include desilt of the Indus River, available easily in large quantity and saves transportation cost.

II. MATERIALS & METHODS

A. Tire-Derived Aggregate

It is utilized as a fortification in the soil. Various extents of CTR, for example, 3% to 15% by mass was added in the earthen material. It was acquired from Korangi 04 close by Murtaza Chowrangi Tire Elastic Production Line, Karachi, Pakistan. The average length and thickness of the rubber material is 5 mm and 0.75 mm respectively.

B. Indus Riverbed Soil

The Soil utilized in this study is an A-3 group of soil as per AASHTO Standards. The sample of 50 kg of soil mass was taken for testing purposes from the Kotri River close to Jamshoro. The maximum and minimum dry density of soil is 1.63 and 1.29 gm/cc respectively along with the void ratio of 0.682. The value of the cohesion of the soil is 0.14 kg/cm^2 and that of internal friction is 33.89 degrees.

C. Research Methodology

This exploration study possesses different stages. A literature review of different researchers was altogether examined, then the area to be looked into was chosen. Materials utilized in this examination were gathered from various mentioned sources after the determination of research work. The materials chosen were A-3 sand from Kotri River and Crumb Tire Rubber from Karachi. CTR is utilized as a stabilizer in the soil in this research. 1mm to 10mm length of CTR was utilized in the soil as a stabilizer. In addition, the various percentage by weight ranging from 3% to 15% of CTR was utilized in the sand. So as to acquire the uniform blend of the soil-rubber mixture, while blending was done cautiously. Different component tests were performed on the soil, CTR and soil-CTR mixture. Besides, additional surcharge load of 25 kPa to 100 kPa was applied at the highest point in the elevation of the MSE wall to examine the impact of increasing vertical load and is presented in a graphical structure. Besides, the outcome of various tests of soil was acquired and examination was made according to the results. The beneath table shows the details of the test that were received.

III. RESULTS

A. MSE wall

The Mechanically Stabilized Earth Wall was exposed to the additional load of 25 kPa to 100 kPa. Parametric fluctuation like displacement in horizontal, vertical and both combined was examined and introduced in graphical structures.

i. Unreinforced MSE wall

It was exposed to additional vertical load of 25 kPa to 100 kPa. At that point, the displacement has been seen at various loads as demonstrated as follows.

a) Displacement in Horizontal Direction

The horizontal displacement at the various height of the MSE wall strengthened with scrap tire rubber has been noticed and accumulated as chart as appeared in Fig 2.

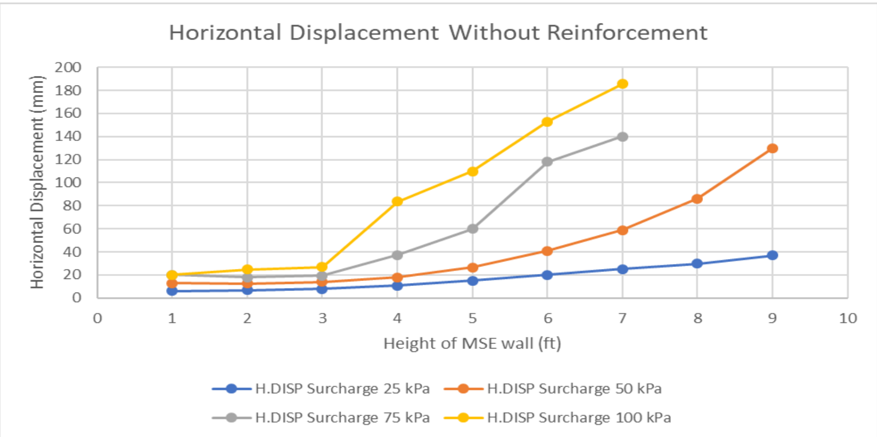

Fig 2: Displacement in horizontal direction with additional vertical load on unreinforced wall.

It is apparent from Fig 2 that displacement in horizontal direction increments with the surge in the vertical component of the MSE wall. This impact gets noticeable as additional load increments from 25 kPa to 100 kPa.

b) Displacement in Vertical Direction

The vertical displacement at various tallness of vertical wall build with scrap rubber tire-soil mixture has been observed and accumulated as chart as appeared in Fig 3.

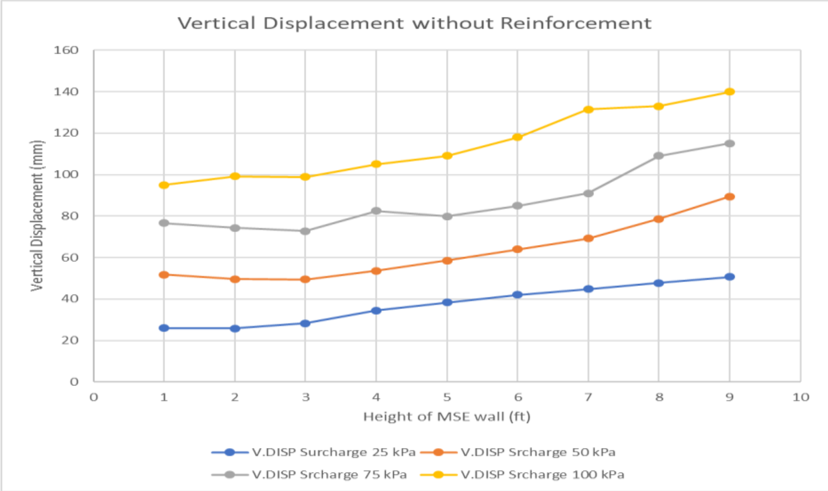

Fig 3: Displacement in vertical direction with additional vertical load on unreinforced wall.

It is obvious from the Fig 3 that the displacement in vertical direction increments with the expansion in the vertical component of MSE wall. The impact is noteworthy as additional load increments from 25 to 100 kPa.

c) Total Displacement

The various height of total displacement of vertical wall without scrap tire rubber has been observed and incorporated as chart as appeared in Fig 4.

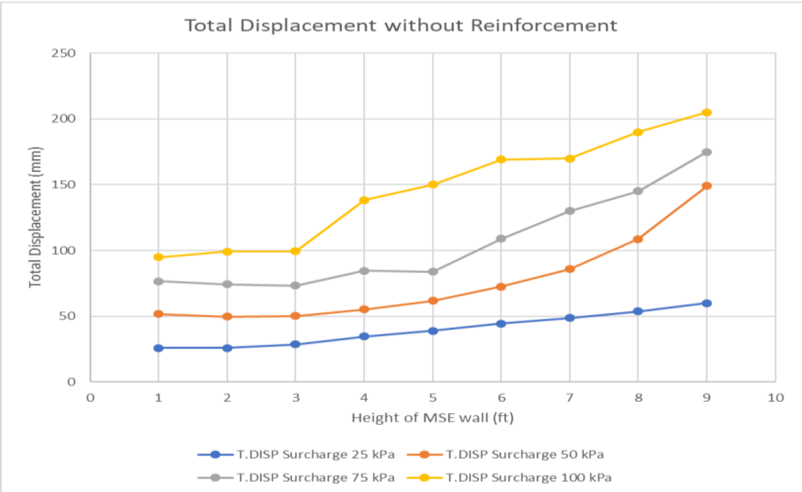

Fig 4: Total displacement with additional vertical load on unreinforced wall.

From the Fig 4 it is perceptible that total displacement increments with the increase in the tallness of MSE wall. The impact gets conspicuous as additional vertical load increments from 25 kPa to 100 kPa.

ii. Reinforced MSE Wall

The scrap tire rubber chips blended sand wall was exposed to an additional mass of 25 to 100 kPa. At that point, the displacement has been seen at various surcharge load as demonstrated as follows.

a) Displacement in Horizontal Direction

The displacement in horizontal direction at various height of the MSE wall strengthened with scrap tire rubber has been noticed and accumulated as chart as appeared in Fig 5.

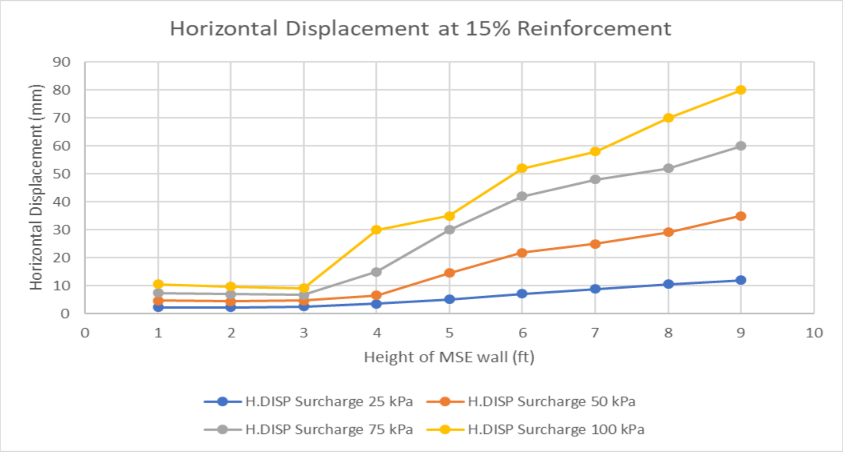

Fig 5: Displacement in horizontal direction with additional vertical load with reinforcement.

It is apparent from Fig 5 that displacement in horizontal direction increments with the expansion in the vertical component of the MSE wall. This impact gets noticeable as additional vertical load increments from 25 to 100 kPa.

b) Displacement in Vertical Direction

The displacement in vertical direction at various tallness of MSE wall fortified with scrap tire rubber has been noticed and accumulated as chart as appeared in Fig 6.

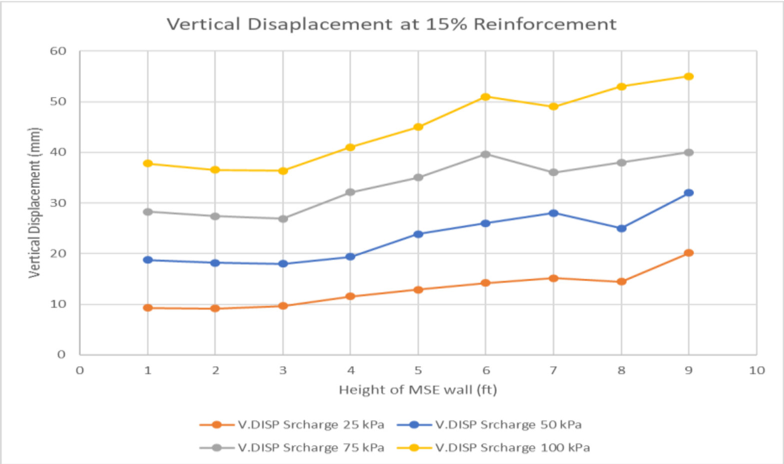

Fig 6: Displacement in vertical direction with additional vertical loading with reinforcement.

It is obvious from the Fig 6 that the vertical displacement increments with the expansion in the vertical component of wall. The impact is noteworthy as additional load increments from 25 to 100 kPa.

c) Total Displacement

At various height, the total displacement of wall with scrap rubber tire chips has been observed and incorporated as chart as appeared in Fig 7.

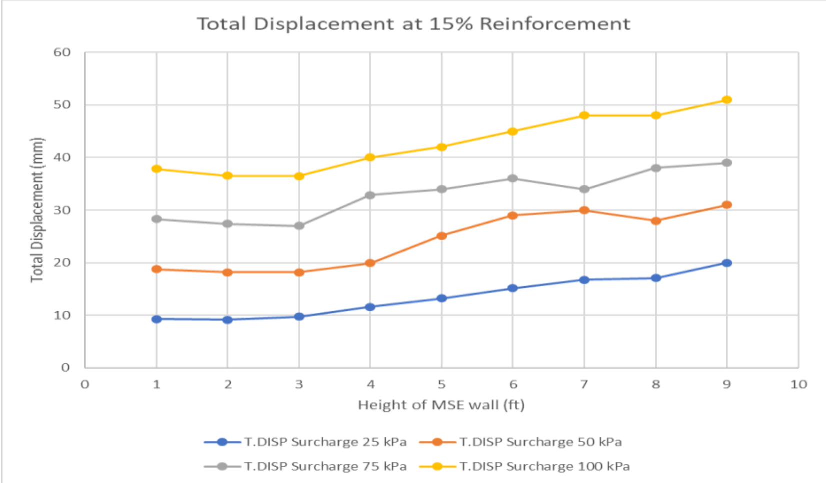

Fig 7: Total displacement with additional vertical load with reinforcement.

It is perceptible from the Fig 7 that total displacement increments with the increase in the tallness of wall. The impact gets conspicuous as additional vertical load increments from 25 to 100 kPa.

IV. CONCLUSIONS

Following observation can be made based on this research.

1) The displacement in horizontal direction increments as the height of the MSE Wall increases, which becomes conspicuous when the additional vertical load increments from 25 kPa to 100 kPa.
2) The displacement in vertical direction increments as the height of the MSE Wall increases, which becomes more visible when the additional vertical load increment from 25 kPa to 100 kPa.
3) The total displacement increments as the height of the MSE Wall increases, which becomes conspicuous when the additional vertical load increments from 25 kPa to 100 kPa.

V.RECOMMENDATIONS

Following are the recommendation that can be included are as follows.

1. Further examination utilizing silt and cay such as mud can be used as a base material to see how scrap elastic tire rubber support in these sorts of soils are recommended.
2. Further investigations ought to be attempted to comprehend the impact of CTR fortification on consolidation and penetrability qualities.
3. Since the tire elastic length is a significant parameter in CTR blended sand, a progressively point by point and exhaustive examination ought to be attempted to observe MSE wall at different lengths of rubber.
4. Thickness of scrap tire rubber can be fluctuated.
5. Different level of rubber availability in the soil mixture can be utilized in the wall.
6. The type of soil other than A-3 sand (AASHTO Classification) can be utilized in the blend.
7. Effect of elastic rubber on other than vertical structure can be examined, for example, bank and abutment and so on.
8. Various geotechnical program, for example, FLAC can be utilized.
9. Various properties of soil can be examined, for example, seismic performance with the incorporation of CTR.

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