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Evaluation of Pull out Behavior of Plane and Deformed Steel Bars in Tire Shred – Sand Mixture using Large Scale Embankment

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Abstract: The primary aim of this research is to evaluate Pullout capacity of Deformed and Plane steel bars embedded in tire shred sand mixture. Metallic (strip and grids) and Geo-synthetics are commonly used as reinforcement in mechanically stabilized earth walls.in this research locally available Steel bars are used. Tire shreds sand mixture is used as backfill materials. Pullout resistance is one of the major causes of failure in MSE walls. Pullout resistance depends upon interaction between reinforcement and backfill Materials. By pullout tests we can determine the pullout resistance. Large scale test embankment was constructed at UET laboratory. large scale test embankment has 4ft x 3ft x 5ft dimensions. The wall of test facility was made of steel. Three sides of the test facility were welded to each other. The facing is made of steel plate and is removable. Pullout tests are performed on deformed and Plane steel bars at varying normal Pressure. Normal load is applied through hydraulic jack #4 and #6 dia of Bars of both plane and deformed steel are used. Pullout load is applied through horizontally placed hydraulic jack. The pullout load is measured by the load cell attached to the hydraulic jack. The pullout resistance increases with increase in normal load.

***Keywords**: Pullout, MSE Wall, Deformed Steel bars, Tire shreds, Large scale*

Introduction:

Gravity, Cantilever and Mechanically Stabilized Earth Wall are different types of retaining wall. Retaining walls were constructed to halt the materials from assuming its natural grade. They are constructed for Bridge Ramps, Road work where deep cuts or hillside road location to hold the soil in place. These retaining walls significantly reduce the right of way cost and also fill requirements. (Bowel)

***Figure 1:** Gravity Walls*

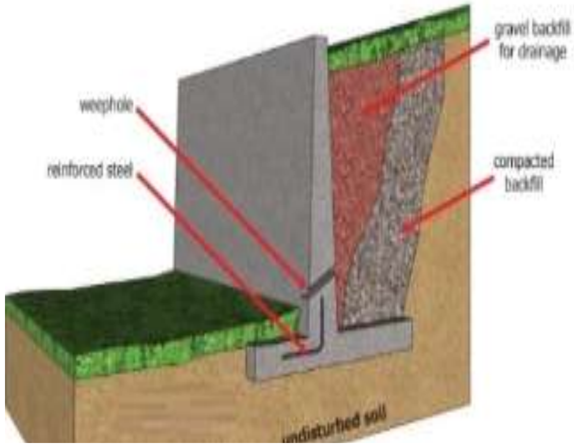

***Figure 2**: Cantilever Wall*

***Figure 3:** Mechanically Stabilized wall*

MSE walls are considered as most economical among all the three types of Retaining walls. MSEW is soil constructed with artificial reinforcement.MSE retaining wall is a composite structure consisting of alternating layers of compacted backfill and soil reinforced elements, fixed to a wall facing.(MSEW) Mechanically stabilized earth wall is consisting of facing element, reinforcement and back fills material. steel grids (welded), steel strips geogrids, and sheets of geotextile are the generally used soil reinforcing elements. Facing is a component of the MSE walls that prevent soil from raveling out between the rows of reinforcement. The panels are typically concrete but they can be of metal, wood, block, mesh or other material (hand book)

Reinforcement layers improve the mechanical properties (tensile strength) of the soil mass. In other words, the soil reinforcement behaves similar to reinforced concrete.(Munfakh 1995). The use of Mechanically stabilized earth wall has become largely accepted as it is economicaltechnology, simplicity and rapidity of construction, less space requirement, less site preparation, reduced right of way acquisition.MSE wall systems has various applications, such as bridge abutments, retaining walls, wing walls, access ramps, underpass and waterfront wall etc

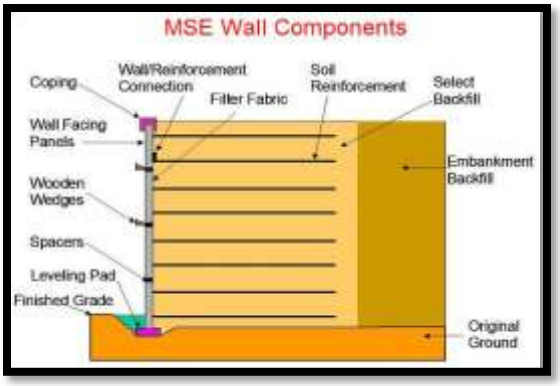

Figure 4: *MSE Walls*

Tyre derived aggregate (TDA) consists of waste tires small pieces and have a basic geometrical shape.Tire shreds consist of small pieces of scrap tires having a basic geometrical shape. the size of tire shreds ranges between 50 mm (2 inches) and 305 mm (12 inches) and are considered for use in civil engineering industry" (ASTM D6270-08).

Figure 5: *Tyre shreds*

Size (mm)	Classification
<0.425	Powdered rubber
0.425-2	Ground rubber
0.425-12	Granulated rubber
12-50	Tire chips
50-305	Tire shreds
12-305	Tire derived aggregate
>50 by 50 by 50 but less than 762 by 50 by 100	Rough shred

Table1: *Astm D6270 Civil Engineering Applications Of Scrap Tires*

Using of Tires in the form of tire shreds in backfill have various advantages. Tire shreds are lightweight material, inexpensive, high shear strength and have good drainage property in using backfill material. Therefore, tire shred-soil mixture is considered as the most suitable material for back filling.

Pullout Test:

Pullout resistance is one of the major causes of failure in the reinforced earth walls. The purpose of this test is to evaluate the pullout capacity of Plane and Deformed Steel Bars in tire shred sand mixture as backfill. The data collected can then guide the development of physically correct models that are needed to design reinforced retaining walls and predict their performance in the field.

Many researchers have conducted the pullout tests on reinforcements in soils to clarify the mechanism of pullout in reinforced soil mass (Ingold, 1983, Farag, 1993; Bergado et al., 1992, and Ochiai et al., 1996).For the design of MSE wall both external and internal stability is essential for overall stability of MSE wall. To ensure external stability, MSE wall must have sufficient safety against sliding, overturning, bearing capacity, settlement and global failure modes. Analysis of Internal

stability is essential so that MSE wall has sufficient safety factor against pullout and rupture of the sreinforcement. (Omerbilginetal 2013)When the friction between soils –reinforcement is less than the tensile force in the reinforcement, the reinforcement is pull out of the soil mass and is called pullout failure.
Whenthe tensile strength of the reinforcement material is less than the tensile force in the reinforcement rupture failure occur.

Large Scale Test facility:
Suitable dimensions of large scale test Model wasselected. SAP is used for the analysis and design of Model. Suitable section and orientation of steel sheets and stiffeners was selected against maximum applied normal load.

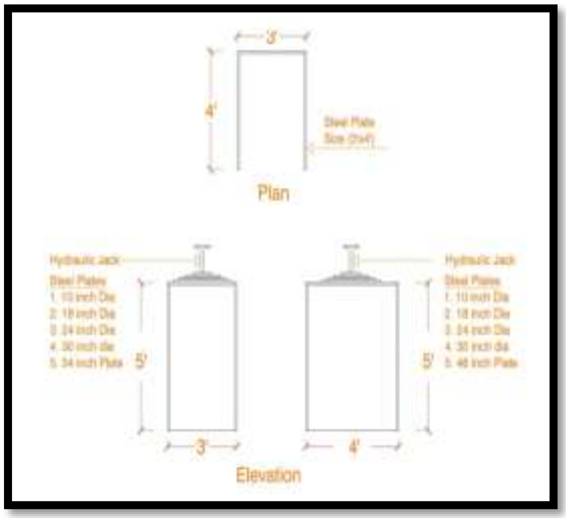

Figure 6: *AutoCAD Drawings of the Large Scale Test Model*

Fabrication of Model and Pullout Machine:
The large scale test model was fabricated locally having dimension of 3ft x 4ft and 5ft in height. Side walls of the test facility were made of steel. Thethree sides of the test model were fixed while the facing is removable to assist the filling and removing of the backfill materials. Holes are provided in the front wall at 6inch spacing both horizontally and vertically.Pullout machine was also locally fabricated and is used for pullout of the steel bars from the large scale test embankment.

Figure 7: *Longer side 4ft long*

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Figure 83: *Shorter side 3ft Long*

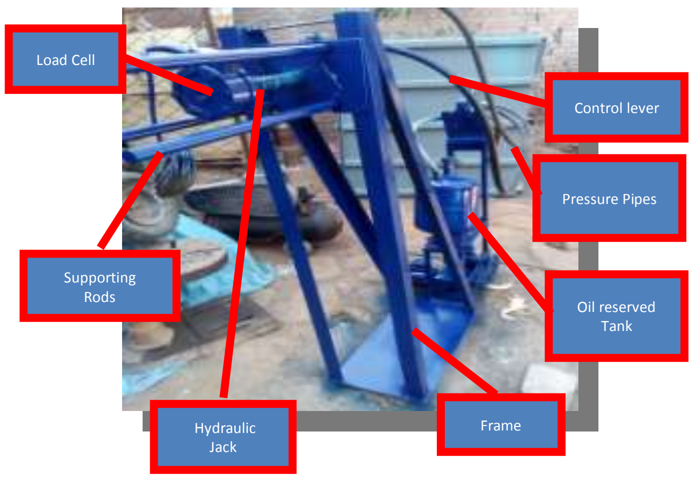


Figure 9: *Pull out Machine*

Selection of Materials:
Two types of back fill materials are used sand tire shred mixture. Sand tire shred Mixture has been used as backfill materials. According to ASTM tire shred size ranges from 50 mm to 305mm.in this research tire shreds of 50mm size is used. Tire shreds is obtained from scrap tires cut into pieces of 2inches. In this research 20% tire shreds and 80% sand is used as backfill materials.

Figure 10: *Tire shred sand mixture*

Reinforcement Materials:
Geo-synthetics and metal strips/grids are generally used as reinforcement in MSE soil. In this research work locally available deformed and plane steel bars are used as reinforcement. The steel bars #4 and #6 are used for pullout test.

The embedded length was kept at 70% of the wall height as per AASHTO standards,the horizontal and vertical spacing of the steel bars is kept 6 inches. The steel bars are placed at different elevation for the pullout test.

Procedure of pullout experiment:

The large scale test model was placed at UET Material testingLab**.** Mixture of sand tire shred is prepared at ratio of 80-20. This mixture is then placed in the large scale pullout test model in layers of 6 inches. Eachlayer is compacted to maximum dry density. Compaction is done by hand hammers.

Figure 11:*Details of Reinforcement*

Deformed and Plane steel bars of #4 and #6 deformed steel bars are placed at each layer at horizontal spacing of 6 inches. A total number of 45 steel bars are placed. Pullout test is performed on the alternate steel bar.

Fi gure 12: *Compacting Plate*

Figure 13: *Layer Wise Compaction of Backfill*

Steel plate having holes is used as facing. The holes in the facing plate facilitate the pullout test.

The normal load is applied through hydraulic jack attached to straining frame in the UET material testing Lab. The normal load is measured by the load cell attached to the hydraulic jack. The normal load from hydraulic jack is applied to steel plates which transfers uniform load to the backfill. Pullout load is applied to the steel bar through horizontally placed hydraulic jack. pullout load is measured by the load cell attached to the hydraulic jack.

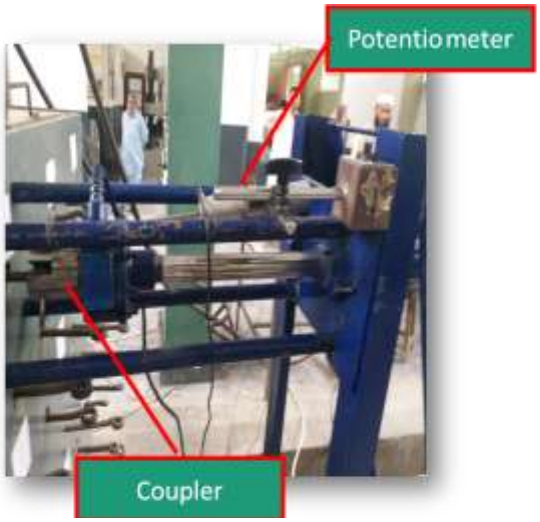
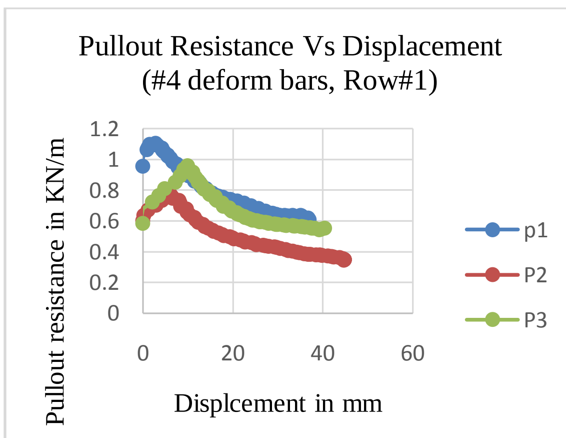


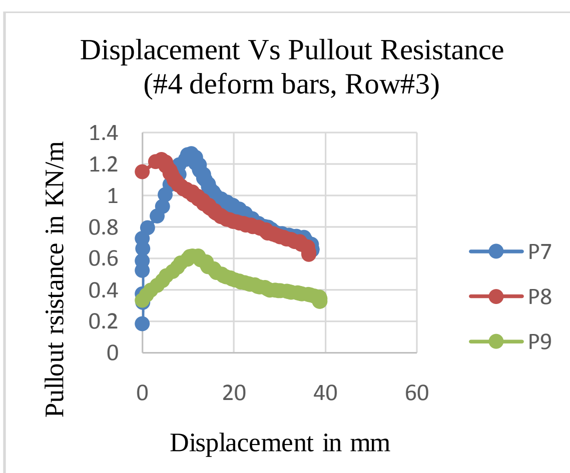
Figure 14: *Pullout Testing of Steel Bars*

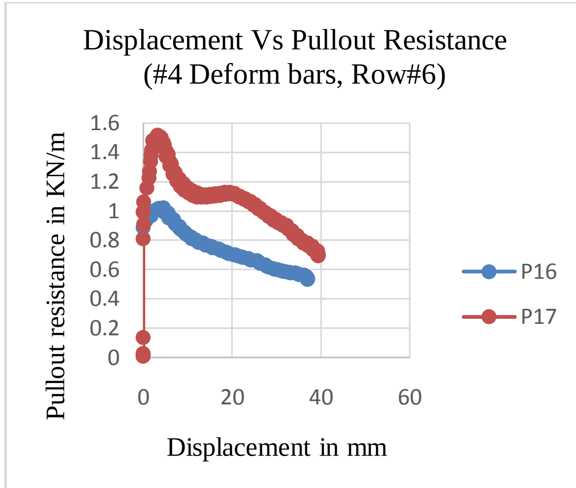
Result and Discussions:

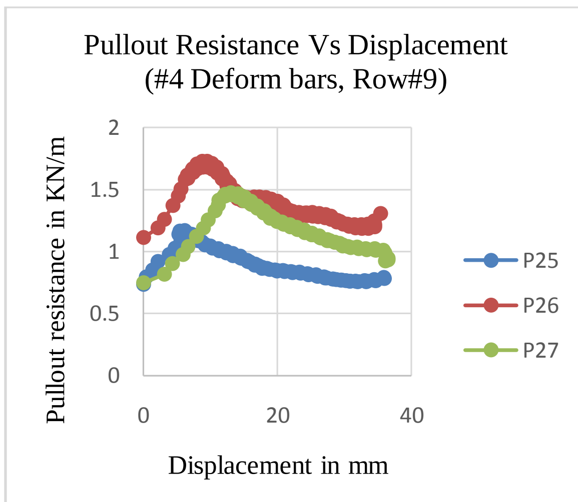
No.4 Deformed Steel Bars:

Results of #4 deformed steel bars embedded in large scale embankment of tire shreds sand mixture of ratio 20-80 with 20Kpa normal load are as under. The pullout resistance increases as we go from top to bottom due to increase normal stress due to self-weight of sand tire shred mixture.



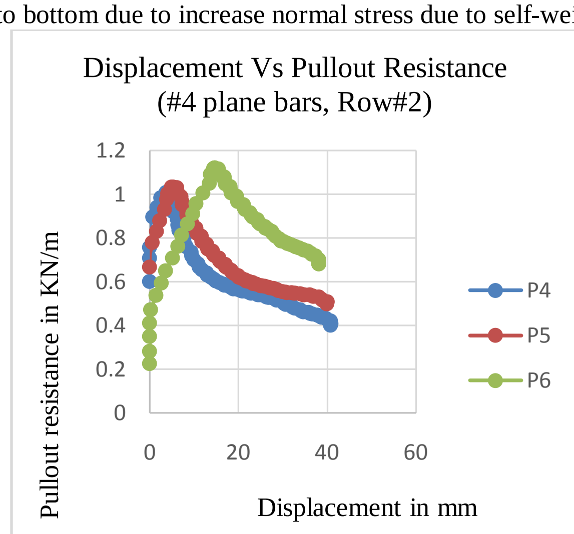


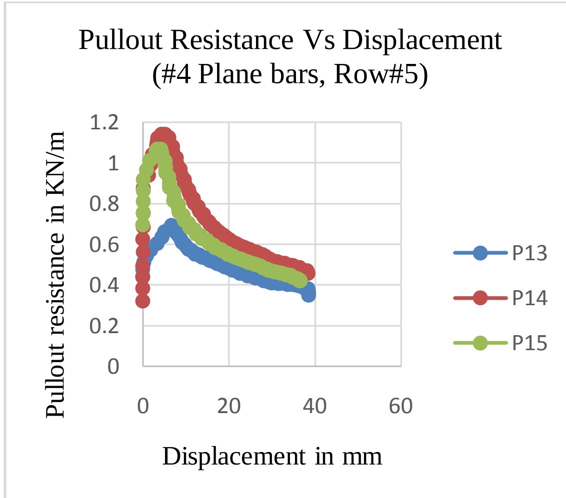




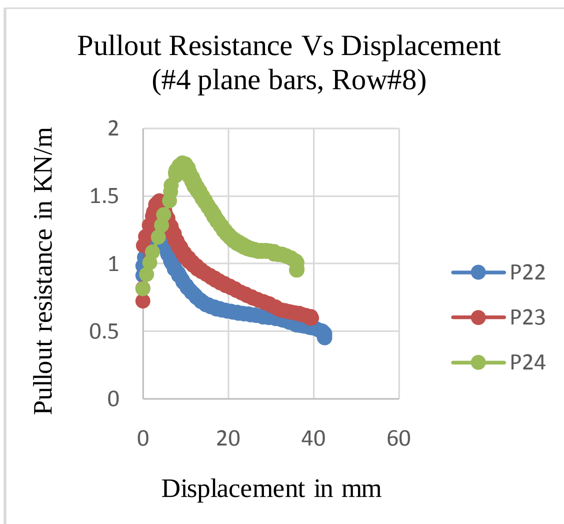
No. 4 Plane Steel Bars:

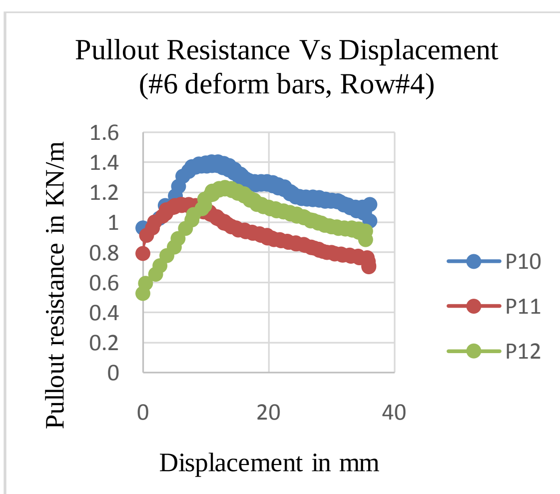
Results of #4 Plane steel bars embedded in tireshreds sand mixture of ratio 20-80 are as under. the pullout resistance increases as we go from top to bottom due to increase normal stress due to self-weight of sand tire shred mixture.

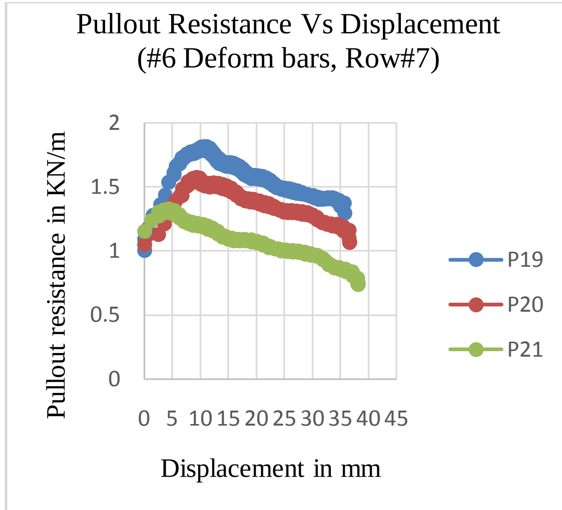




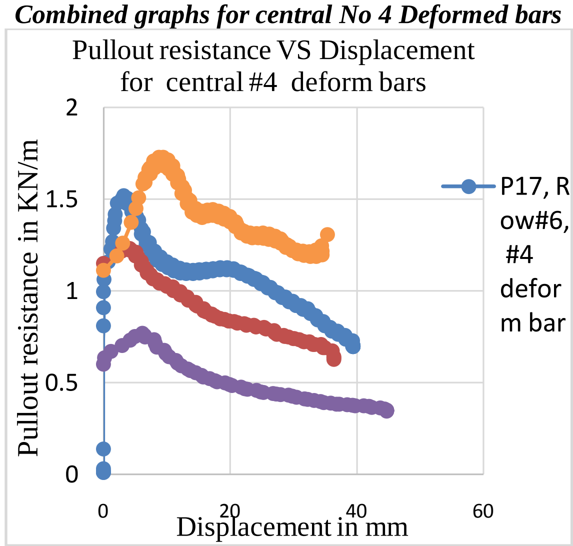
No. 6 deformed Steel Bars:
Results of No.6 Deformed steel bars embedded in tire shreds sand mixture of ratio 20-80 with 20kpa normal load are as under. The pullout resistance increases as we go from top to bottom due to increase normal stress due to self-weight of sand tire shred mixture.



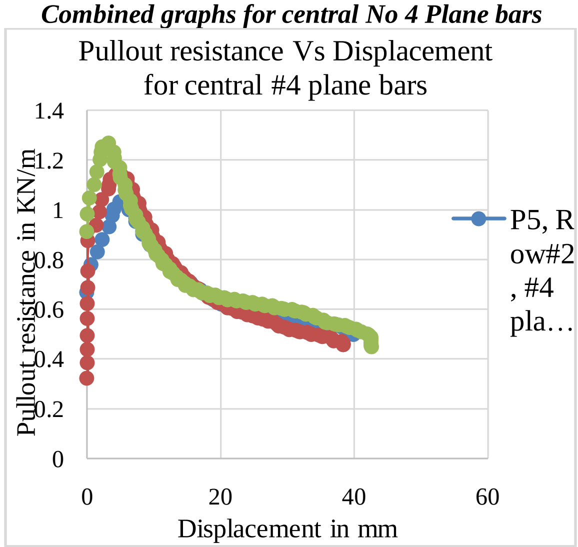




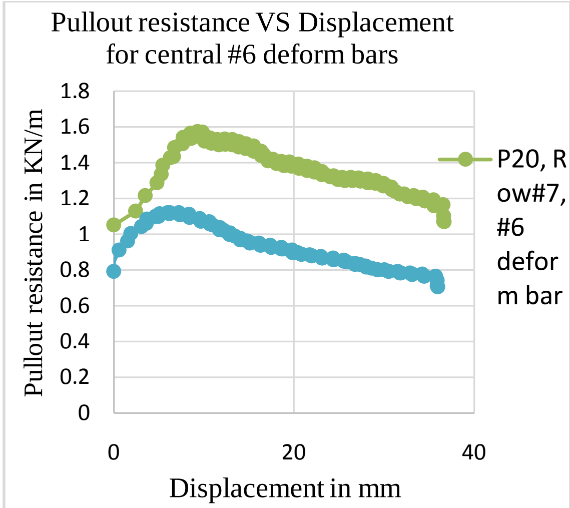
Combined graphs for central No 4 Deformed bars



Combined graphs for central No 4 Plane bars



Combined graphs for central No 6 Deformed bars



Conclusion and Recommendations:

Conclusion:

- The use of locally available deformed steel bars as reinforcement in mechanically stabilized earth shows good results and should be promoted for economy
- The pullout résistance of bottom bars are more than the top bars due to increase in normal stress.
- Pullout resistance of plane bars is slightly less than deformed bars.

Recommendations and future Research

- In this research work 20/80 tire shred sand mixture is used. Different ratios of tire shred sand mixture should be used in future work
- This research work is performed with 20kpa normal load, research with 60kpa 80kpa normal load should be performed

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