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THE PERFORMANCE AND BEARING CAPACITY OF BOTTOM ASHES FILLED EMBANKMENT

Desempeño y capacidad de carga de la ceniza de incineración de residuos

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Key words: model embankment test, municipal solid waste incineration, vertical stress, settlement, lateral.

ABSTRACT

The municipal solid waste incineration bottom ash (IBA) as the fill material in the geotechnical applications is a wise solution where IBA will save the bulk of earth material and can bring huge economic benefits, particularly for the embankments. In this study a series of experimental model tests of embankments filled with IBA and sand were conducted and considered two different slope ratios to investigate the performance of IBA as the fill material. During the testing, the vertical stress distribution, horizontal deformation, and vertical settlement inside of the embankment were monitored. Test results demonstrated that the IBA embankment compared with the sand embankment when slope ratios of 1:1.5 and 1:1.75, enhanced the bearing capacity by 25% and 20%, respectively, and under the same vertical pressure reduced the vertical settlement by 47% and 39.6%. When the embankment shear failure occurred, the lateral deformation inside the IBA embankment was reduced by 27.36% and 23.66%, respectively, compared with the sand embankment, under the conditions of slope ratio of 1:1.5 and 1:1.75, and the lateral deformation distribution along the height of embankment was more homogeneous. These results indicated that the use of IBA as fill material for embankments can be an economical and effective method to save the earth material.

Palabras clave: modelo de prueba de terraplén, incineración de residuos sólidos municipales, estrés vertical, asentamiento, lateral.

RESUMEN

La ceniza de fondo de la incineración de residuos sólidos municipales (IBA, por sus siglas en inglés) como material de relleno en las aplicaciones geotécnicas es una solución inteligente donde la IBA ahorrará la mayor parte del material de relleno terrígeno y puede traer enormes beneficios económicos, particularmente para los terraplenes. En este estudio se llevó a cabo una serie de pruebas de modelos experimentales de terraplenes con IBA y con arena y se consideraron dos relaciones de pendiente diferentes para investigar el rendimiento de la IBA como material de relleno. Durante la prueba, se monitorearon la distribución de tensiones verticales, la deformación horizontal y el asentamiento vertical dentro del terraplén. Los resultados de las pruebas demostraron que el terraplén IBA en comparación con el terraplén de arena, con relaciones de pendiente de 1:1.5 y 1:1.75, mejoraron la capacidad de carga en un 25% y 20%, respectivamente, y bajo la misma presión vertical se redujo el asentamineto vertical en un 47% y 39.6%. Cuando se produjo el fallo de cizallamiento del terraplén, la deformación lateral dentro del terraplén IBA se redujo en un 27.36% y 23.66%, respectivamente, en comparación con el terraplén de arena, en las condiciones de relación de pendiente de 1:1.5 y 1:1.75, y la distribución de la deformación lateral a lo largo de la altura del terraplén fue más homogénenea. Estos resultados indican que el uso de IBA como material de relleno para terraplenes puede ser un método económico y eficaz para ahorrar en material de relleno terrígeno.

INTRODUCTION

As the process of urbanization in China becomes faster, more infrastructures need to be built. In geotechnical projects (embankments, roadbed, retaining structures, etc.) the volume of earth material involved is enormous. These earth materials are usually exploited in the areas around the cities to save transportation costs, leading to the increasing shortage of earth material surrounding the city, but the demand for earth material is growing. To economically deal with this contradiction, provided earth materials for urban infrastructure construction, numerous scholars currently have considered using industrial wastes (coal fly ash, construction debris, municipal solid waste incineration bottom ash, etc.) which either are damped in the ash landfills or posed problems for their disposal to replace earth material as the fill material (Teasoon 2003, Yoon et al. 2004, Ahmad et al. 2010, Lai and Man 2012) Therefore, alternative use of industrial wastes, especially as the fill material for the geotechnical project, are being considered.

At present, many scholars have studied the mechanical behavior of coal fly ash to replace earth material in the roadbed, retaining walls, and slope through a series of in-situ tests and laboratory model tests (Martin et al. 1990, Vegae et al. 2008, Choudhary et al. 2010). Although coal fly ash has been confirmed with good mechanical performance through reinforcement or pre-treatment (Gumuser and Senoi 2014, Nadaf and Mandal 2016), but its leaching and toxicity have not been improved. In the process of natural rainfall, heavy metal ions in coal fly ash would be leached out, polluting the land and groundwater (Wang et al. 2020, Reardon et al. 1995, Tigue et al. 2018). In addition, construction waste has good mechanical properties, which are mostly used to replace earth materials as the fill material in the roadbed, embankment, and other structures (Perez et al. 2013, Silva et al. 2014, Rafaela et al. 2016). The recycled aggregate of construction waste is also composed of amounts of pollutants, and the particles needed to be broken before used, which consume lots of time and processing costs (Buyle-Bodin and Hadjieva-Zaharieva 2002, Zhang and Takayuki 2013). The above reasons have led to the high cost of the current two types of solid waste treatment, and the recycling rate is low in field of geotechnical engineering. Therefore, it is necessary to find a type of economical and environmentally friendly solid waste to replace earth materials as the fill material.

The IBA is a by-product of municipal solid waste incineration and is a typical solid waste (Tay and Goh 1991, Sabbas et al. 2003, Zhang and Takayuki 2013). Its physical and chemical properties are affected by local economic levels, incineration control temperature, the type of municipal solid waste, and other factors, with certain heterogeneity (Chimenos et al. 1999, Arm. 2004, Izquierdo et al. 2008, Weng et al. 2010). At present, most of coal fly ash have been filled after stabilization in the landfill, which wasted a lot of landfill space and limited the possibility of resource utilization (Lam et al. 2010, Dong et al. 2010). The particle properties of IBA are similar to sandy soil, which have been regarded as harmless materials and have been confirmed directly used in road construction (Chimenos et al. 1999, Forteza et al. 2004, Reijinders 2005, Cao et al. 2019, Zhu et al. 2020). The laboratory characterization tests of IBA revealed that its physical and mechanical properties are very similar to gravel, and it is a road structural fill with good mechanical properties (Becquart et al. 2009, Izquierdo et al. 2011, Lin et al. 2012, Zekkos et al. 2013, Le et al. 2017, Fujikawa et al. 2020). However, current research has only characterized its physical, chemical and mechanical properties, then evaluated the feasibility of results from the perspective of environmental impact analysis. Most of the full-scale and pilot-scale tests only determined the concentration of heavy metals in the leachate of short-term or long-term use of IBA as the fill material in the geotechnical applications (Windt et al., 2011, Toraldo and Saponaro 2014). However, studies on the deformation, bearing capacity, and integrity behavior of the embankment which uses IBA as structure fill when subject to vertical pressure are overlooked. The IBA as fill material in the geotechnical applications where it may save lots of earth material and can bring huge economic benefits, particularly for the embankments. But prior to practical use, it is essential to understand at least experimentally the effect of IBA as the fill material on the behavior of embankment under vertical pressure.

In this study, the behavior of IBA and sand as the fill material for embankment under two different slope ratios were compared, aiming to investigate out the effect of the IBA as the fill material on the performance of the embankment. During the testing, the vertical stress distribution, horizontal deformation, and vertical settlement inside of the embankment were monitored, when the vertical pressure was applied at the crest of the embankment. Therefore, the basic subgrade engineering characteristics tests on the IBA collected from one municipal solid waste incineration plant (located in Wuhan) were conducted in this study. Then a series of laboratory embankment tests were carried out. Finally, this study revealed the failure modes of the model embankment and the working mechanism under the vertical pressure.

MATERIALS AND METHODS

Test apparatus

The equipment used in the test was an automatic hydraulic system, in which the maximum loading value could reach 25 MPa, as shown in **figure 1**. The model embankment tests were conducted in an open-ended woody tank having dimensions of 2000 mm × 800 mm in plan and 76 mm in depth. The tank inner walls were nailed with wooden boards, and the exterior wall was welded and fixed by angle irons and steel bars, as shown in **figure 2**. To facilitate the observation of the deformation and failure mode of the embankment, a 12 mm thick plexiglass was installed in front of the testing tank. The vertical and lateral deformation of the embankment were collected during the loading process by measuring the distance between steel balls buried in the embankment and the fixed mark on the testing tank, as shown in **figure 3**. The vertical stress inside the embankment was

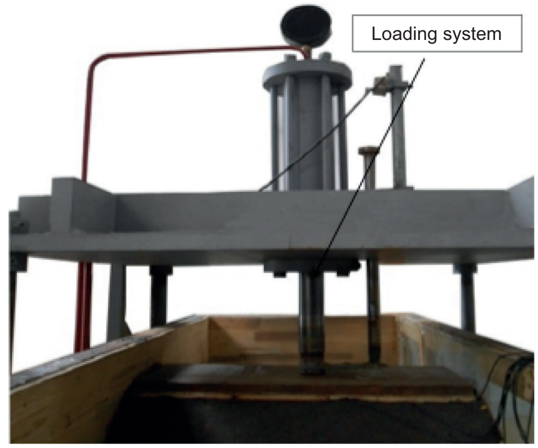

Fig. 1. The device of hydraulic loading.

Fig. 2. Testing tank.

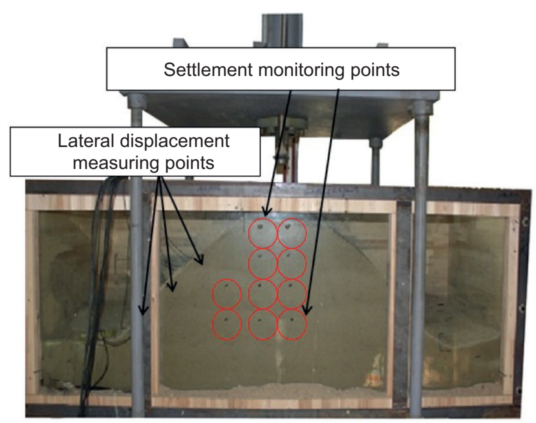

Fig. 3. The model of embankment slope.

measured by earth pressure cells and collected by DH 3816 static strain test system, more information is shown in **Table I**.

TABLE I. PARAMETERS OF TEST COMPONENTS.

Equipment	Model	Range	Quantity
Earth pressure cell	XTR-2030	0 ~ 0.3MPa	8
Strain gauge	DH3816	0~12	1

The IBA procured from one municipal solid waste incineration facility (located in Wuhan City) was used in this study. The feedstocks of incinerators in the municipal solid waste incineration facility were mainly from domestic waste and a small amount from commercial solid waste, as shown in **figure 4**. Before the test, the horns, flakes, needle-shaped rocks, ceramics, and glass fragments were removed, which would affect the test results (Izquierdo et al. 2011). In this test, particles within the range of 0 ~ 20 mm were selected from the IBA. The IBA particles were stored for three months after which the leachates of IBA particles were stabilized (Forteza et al. 2004), as shown in **figure 5**.

Fig. 4. Fresh IBA after quenching.

The sand used in this study was taken from the river (located in Wuhan city). To ensure particle grading like IBA, the particle size of sand was selected through screening in the range of 0 ~ 20 mm. The

Fig. 5. IBA after screening and storing.

particle size distribution curves of IBA and sand are shown in **figure 6**. The specific physical parameters determined in the laboratory for the IBA and sand are shown in **Table II** which met the requirements for the fill material for embankment in the Chinese specification of "Specifications for Design of Highway Subgrades".

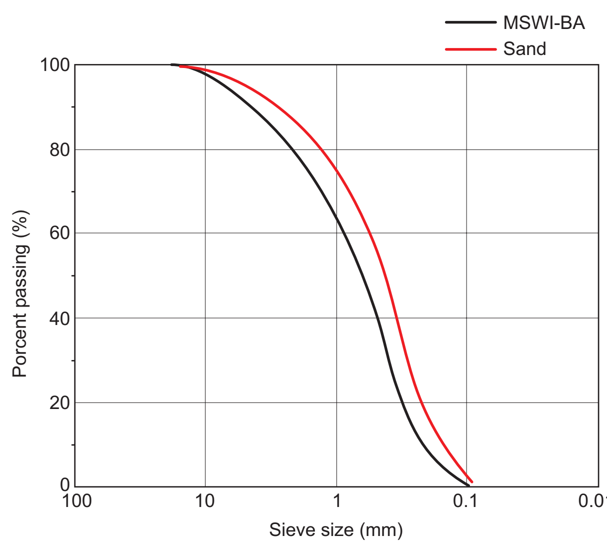

Fig. 6. The grading curves of IBA and sand.

Test methods

The optimal similarity ratio n = 20 was selected for this test. The lubricating oil was applied to the inner side of the testing tank, and the model embankment was preloaded before the test to ensure plane

TABLE II. THE SPECIFIC PHYSICAL PARAMETERS OF IBA AND SAND.

Parameter	Sand	IBA
Coefficient of uniformity, Cu	3.6	3.83
Coefficient of curvature, Cc	1.03	0.79
Optimum moisture content	9.85	17.7
Maximum dry density (g/cm3)	2.02	1.86
Specific gravity, Gs	2.69	2.13
California bearing ratio, CBR	24.7	77.5
Moisture content, (%)	5.6	9.4

strain condition during the testing. Due to the difference between the weight of sand and IBA, the weight of the material was not considered in this test, to facilitate the analysis of the vertical stress inside the model embankment. The layout of relevant data acquisition equipment inside the model embankments, are shown in **figure 7**. Due to the symmetry of the model embankment, the vertical stress and deformation were analyzed directly from the symmetry. The IBA and sand were weighed and then mixed with an amount of the optimum moisture content respectively, after that the mixed IBA and sand were covered with wet geotextile for 1 h to ensure uniform distribution of moisture. The model embankment was built in layers and divided into eight equal layers each 50 mm thick. The compaction device was used by controlling to fall thirty times under the same height of drop to achieve homogeneous compaction of each layer. The dry density of each layer of filler was 90% of the modified proctor density by this procedure. After this procedure, the compacted filler was kept stationary for 24 h and the surface of model embankment was covered with wet geotextile to prevent the evaporation of moisture during the testing.

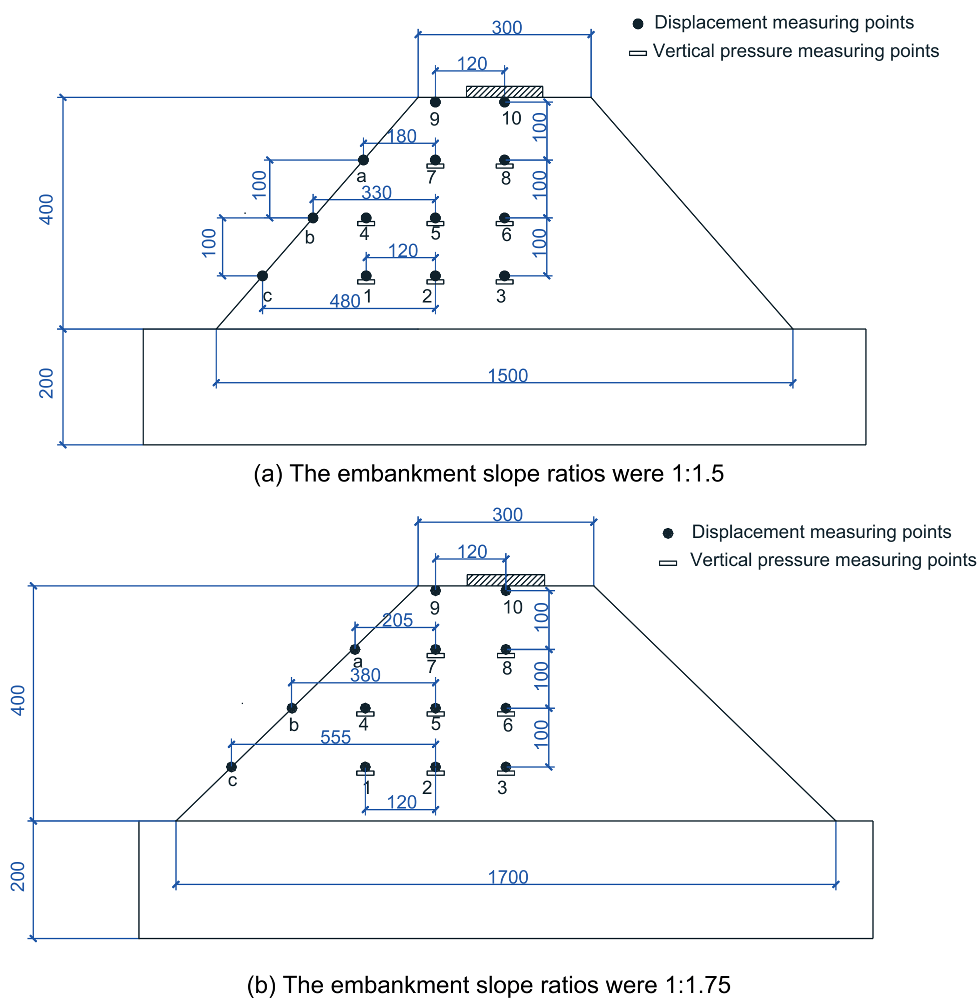

Fig. 7. The Cross-section of the model embankment.

Tests adopted step loading, each step load was 0.5 MPa, and the vertical pressure was applied to the crest of the model embankment via the rigid loading plate having dimensions of 800 mm × 300 mm in plan and 40 mm in thickness. Therefore, the step loading increments were equivalent to an increment in vertical loading of 6.5 kPa applying to the crest of the model embankment. After each step loading was completed, the model embankment should be fully settled by keeping the vertical pressure for 10 min until the model embankment was destroyed. When the deformation increases sharply or the model embankment has cracks that penetrate the model embankment under the same vertical pressure increment, it is judged that the model embankment was destroyed. Due to limited sampling, the upper part of the IBA embankment in this test was filled with IBA, while the lower part was filled with sand. In the control test, the sand was only used as the fill material for the model embankment. According to the Chinese specification of "Specification for Design of Highway Subgrades", the test was carried out with slope ratios of 1:1.5 and 1:1.75. The detailed scheme of conditions is shown in **table III**.

TABLE III. CONDITIONS OF EMBANKMENT SLOPE MODEL TESTS.

slope ratios	Height (0 ~ 0.2 m)	Height (0.2 m ~ 0.4 m)	Condition
1:1.5	sand	sand	1
	IBA	sand	3
1:1.75	sand	sand	2
	IBA	sand	4

RESULTS AND DISCUSSION

Effect of IBA on stress distribution

To investigate the effect of IBA as the fill material on the stress distribution inside the model embankment, pressure values when the vertical pressure was applied at the crest of the embankment were obtained. **Figure 8** shows the pressure values at the positions 7 and 8 (**Fig. 7**) under the vertical pressure of 19.5 kPa.

From **figure 8,** the vertical stress distribution is similar, and for all conditions, the highest vertical pressure was measured at the central axial of the model embankment. The sand embankments (Condition 1 and Condition 2) had higher pressures at the central axial, but the lower values of vertical stress were seen at 120 mm from the central axis, than the

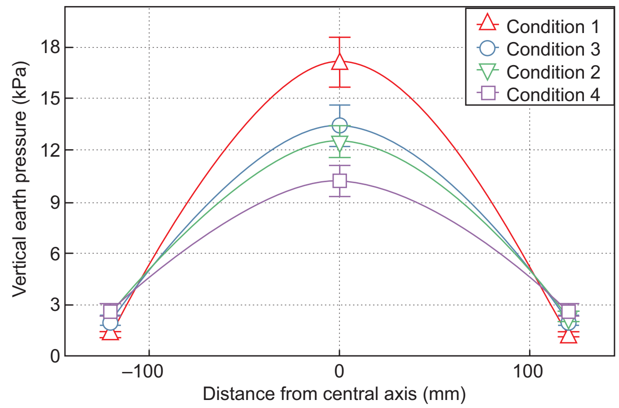

Fig. 8. Vertical stress distribution at 100 mm depth for a 19.5 kPa applied vertical pressure.

IBA embankments (Condition 3 and Condition 4). On the contrary, the IBA embankment (Condition 3 and Condition 4) showed the lower values of vertical stresses at the central axial of the model embankment and the vertical stresses at 120 mm from the central axial were higher, indicating the more homogeneous vertical stress distribution in the IBA embankment. These phenomena indicated that IBA as embankment filler could effectively reduce the vertical pressures in the embankment.The results are proportional to the stiffness of the fill (Li et al. 2019). Because the IBA particles were randomly shaped and the surface was rougher, as the compaction process completed the interlocking, and fixing effects would occur among IBA particles. On the other hand, the cementation reaction that occurred between IBA particles (Zekkos et al. 2013, Fujikawa et al. 2020). These all increase to the stiffness of IBA, thus the more homogeneous the distribution of vertical stresses in the IBA embankments.

The effect of IBA as the fill material on the vertical stress along the embankment height was studied by collecting the vertical pressure at that of the central axis. **Figure 9** shows the variation of the vertical stress inside the embankment against the vertical pressure at different depths from the crest of model embankment.

As displayed in **figure 9**, it can be inferred that the vertical stress inside the embankment has a positive correlation with vertical pressure at the initial loading stage but a nonlinear relationship, and the vertical stress decreased with the increasing depth of the embankment. The vertical stress inside the embankment drastically decrease with increasing vertical pressure after the model embankment failure occurred. The vertical stress values inside the sand embankment of Condition 1 and

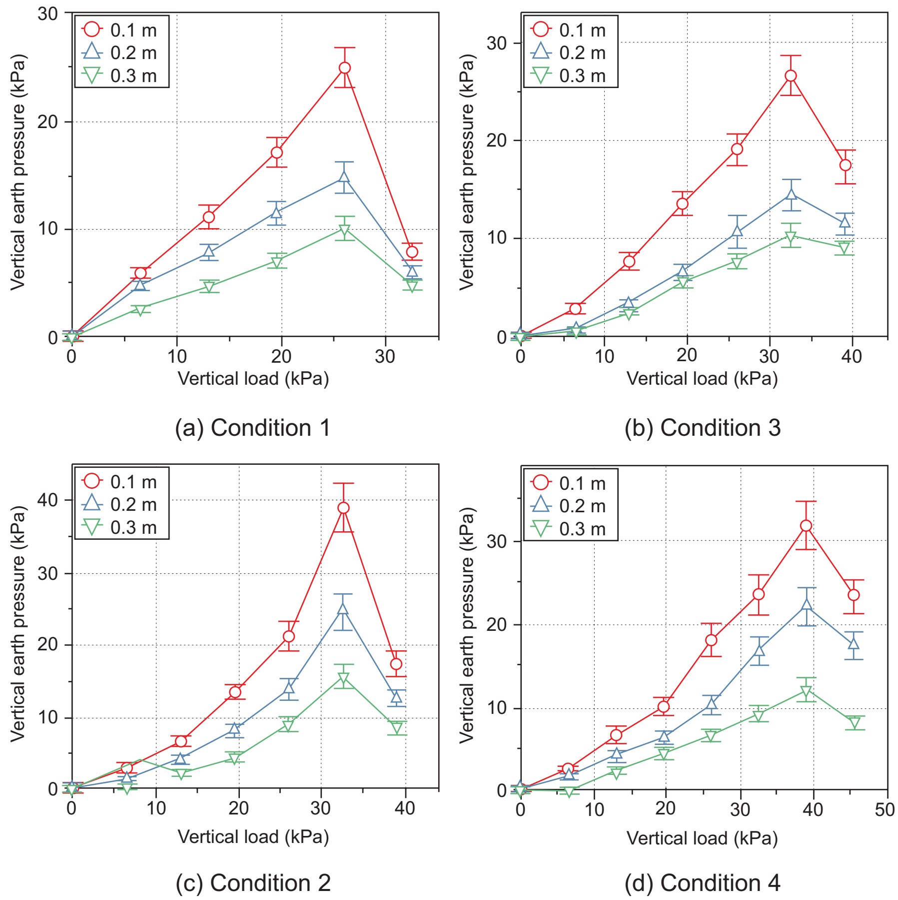

Fig. 9. Vertical stress vs vertical pressure relationship at different depth.

Condition 2 was reduced by 73.78% and 32.20% respectively. The IBA embankment of Condition 3 and Condition 4 reduced the vertical stress values respectively 55.56% and 26.86%. The decrement of vertical stress with IBA as fill material (Condition 3, Condition 4) was smaller than that with sand as fill material (Condition 1, Condition 2) under the same slope ratios. It can be drawn that compared to the sand embankments within the detection range of earth pressure cells, the deformation and failure areas of the IBA embankment were greatly reduced, and there was still certain residual strength after the failure occurred.

Vertical load versus settlement

To analyze the effect of the IBA as embankment fill material on the vertical pressure-vertical settlement response, the variation of the settlement against the vertical pressure at different depths from the crest of embankment are presented in **figure 10**.

From **figure 10**, it is clear that the settlement of the embankment increased with the increasing vertical pressure. The settlement ratio also increased with the increasing vertical pressure, generating more settlement. Meanwhile, the shear cracks appeared at the crest of embankment which gradually extended to fissures penetrating the model embankment, then the model embankment tend to fail. The IBA embankment show a better mechanical behavior than the sand embankment. The test results show that the settlement of the IBA embankment was less than that of the sand embankment under the same vertical pressure and slope ratios. When the vertical pressure was loaded to 26 kPa, the IBA as the fill material for embankment allowed the settlement decrement of 45.33% and 39.66% than sand embankment for same configuration (Condition 1 and Condition 2), respectively. The increment of settlement would increase to different degrees when the embankment shear failure occurred. Among them, the settlement at the crest in Condition 1 and Condition 2 increased by 354.88% and 225.38%, respectively, while that

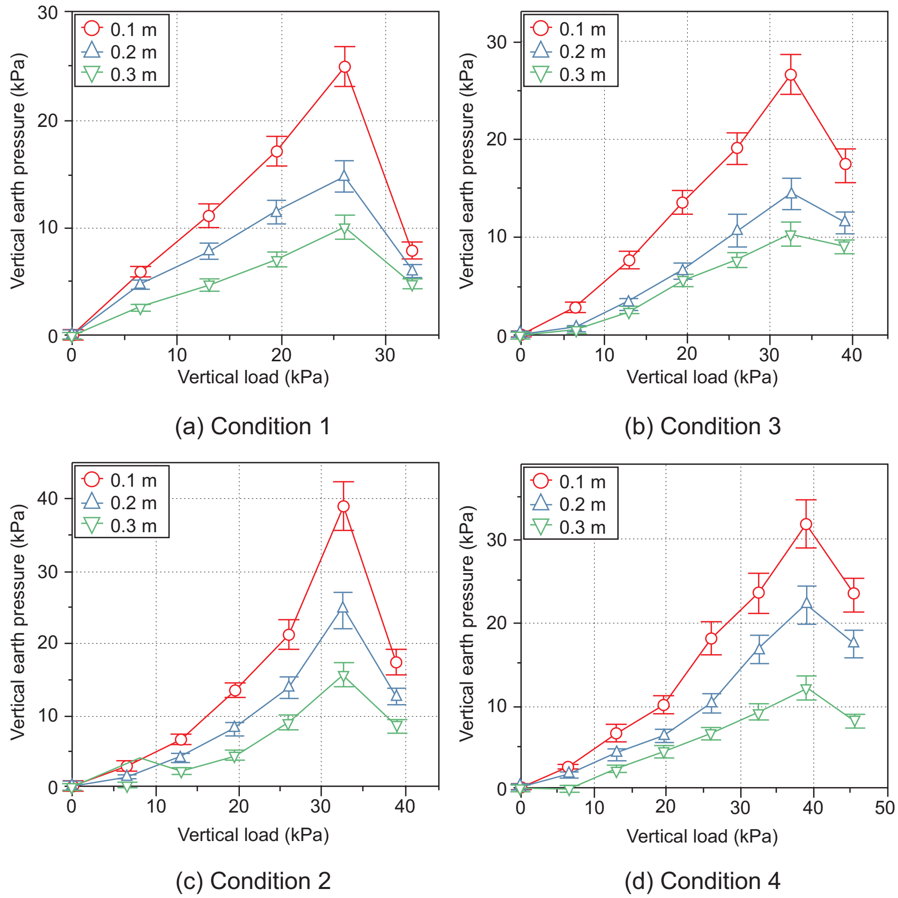

Fig. 10. Settlement vs vertical pressure relationship at different depth.

of Condition 3 and Condition 4 only increased by 181.48% and 71.42%, indicating that the IBA as fill material for the embankment could effectively improve the performance.

It is also observed in **figure 10** that the bearing capacity was 26, 32.5, 32.5, and 39 kPa for Condition 1, Condition 2, Condition 3, and Condition 4. Compared with the sand embankment, the IBA embankment increased the bearing capacity by 25% and 20% when the slope ratios were 1:1.5 and 1:1.75, respectively. The bearing capacity of the embankment increased with the decreasing slope ratios of the embankment. However, the improvement effect of the IBA as fill material on the bearing capacity of the embankment decreased with the decreasing slope ratio.

The relevant results of the model embankment test are listed in **table IV**. It is clear to show that IBA as the fill material for embankment (Condition 3, Condition 4) could greatly reduce the lateral displacement of the model embankment compared to that of the sand embankment (Condition 1, Condition 2) under the same slope ratios. The lateral displacements of the embankment middle height were attained from the results of model embankment tests when the model

TABLE IV. SUMMARY OF RESULT FROM EMBANKMENT MODEL TESTS.

Measurement	Condition 1	Condition 2	Condition 3	Condition 4
Slope radios	1:1.5	1:1.75	1:1.5	1:1.75
Bearing capacity (kPa)	26	32.5	32.5	39
Yield settlement (mm)	13.3	13.3	15.52	10.5
Lateral displacement (mm)	29.4	23.8	22.2	18.7

embankment shear failure occurred (**Table IV**). In the case of the same configuration, the IBA embankment could reduce the lateral displacement by 24.4 % and 21.4 % than that of the sand embankment when the slope ratios were 1:1.5 and 1:1.75, respectively. Indicating that lateral displacements were reduced under the same slope ratios because of the good mechanical properties of IBA.

Analysis of lateral displacement of the embankment slope

Lateral displacements of the embankment increased rapidly when the shear failure occurred. Therefore, the embankment depth-lateral displacement curve is given in **figure 11** when the shear failure occurred to the model embankment.

From **figure 11**, it can be seen that the changing trends of lateral displacements of the four conditions were similar, that increased then decreased with the increasing depth of embankment. For all conditions, the largest lateral displacements were measured at the middle height of model embankment. It was considered that the interface friction between the surface of model embankment and loading plate and base and the distribution of stress inside the model embankment would play a significant role in the largest lateral displacements at the middle height of the embankment (Li et al. 2017, Li et al. 2019). Compared with the sand embankment, lateral displacements inside the IBA embankment were reduced by 27.36% and 23.66% when the slope ratios were 1:1.5 and 1:1.75, respectively, and the distribution along the embankment slope depth was more homogeneous.

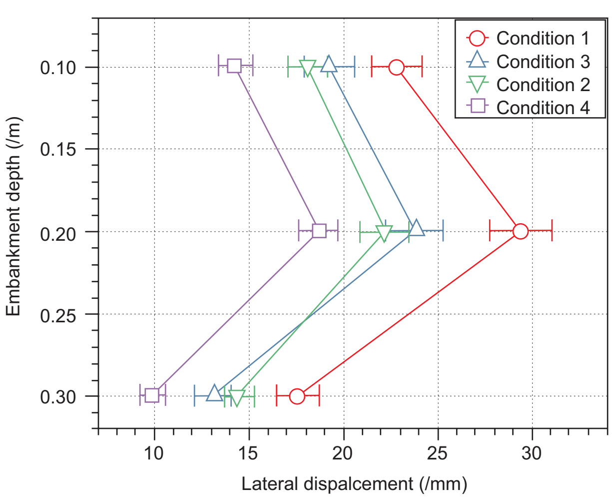

Fig. 11. The embankment depth vs horizontal displacement relationship.

Working mechanism and failure modes

Compared with sand, IBA as the fill material for the embankment could greatly improve the performance of the embankment slope, including the bearing capacity, stiffness, and stability of the embankment. The results are closely related to the stiffness of the fill material (Li et al. 2019) due to the surface of IBA particles were coarser than that of sand particles, and the size and shape of the particles were random. Under the action of vertical stress, the interlocking and fixing effects occurred between the particles, making the relative movement of the particles more difficult. On the other hand, the presence of active silica, aluminium, and calcium ions in the fine IBA particles generated a volcanic ash (cementation) reaction, that agglomerated the IBA particles into weak concrete blocks (Zekkos et al. 2013, Fujikawa et al. 2020), as shown in **figure 12**. These could mobilize the strength in larger volumes of fill further away from the influence of the loading plate, reduce the vertical stresses measured under the loading plate, and spread the vertical stresses over larger volumes of fill (Li et al. 2019).

Fig. 12. IBA cemented into weak concrete blocks (Geotechnical toll for scale).

The failure modes of sand and IBA embankment subjected to vertical pressure are shown in **figure 13**. The failure modes of IBA embankment were like those observed in sand embankment, but the failure zone of IBA embankment far less than that of sand embankment. This phenomenon, caused by interlocking, fixing, and cementation effects between IBA particles, leading the vertical stresses acting in the fill mass, was spread over larger volumes of fill, as well as the strength in larger volumes of fill was

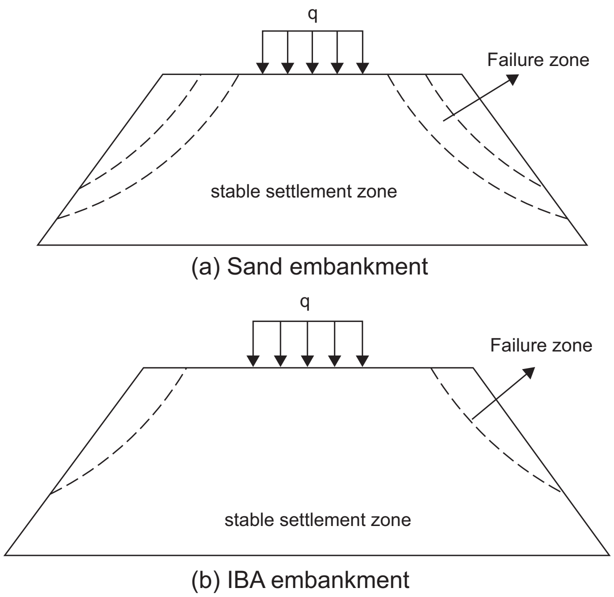

Fig 13. Failure mode of model embankment (Li et al. 2017).

mobilized. Thus, the larger volumes of fill bearing the vertical pressure, led to the shear strength of embankment improvement, forcing the shear failure to develop towards regions with poor shear strength. Thus, the stable settlement zone was increased which ultimately improved the performance of the embankment.

These phenomena are like Li et al. (Li et al. 2017, Li et al. 2019).

Figure 14 shows the shear fissures at the embankment in different conditions when the model embankment failure occurred. Compared with the sand embankment, the shear fissures of the IBA embankment were fewer, and most occurred in the part of the sand fill, while the areas of undamaged embankment were larger. The reason was that the surfaces of the IBA particles were rough, which gave full play to the interlocking, fixing effects. Another reason was the cementation reaction that occurred between IBA particles. Therefore, the generation of

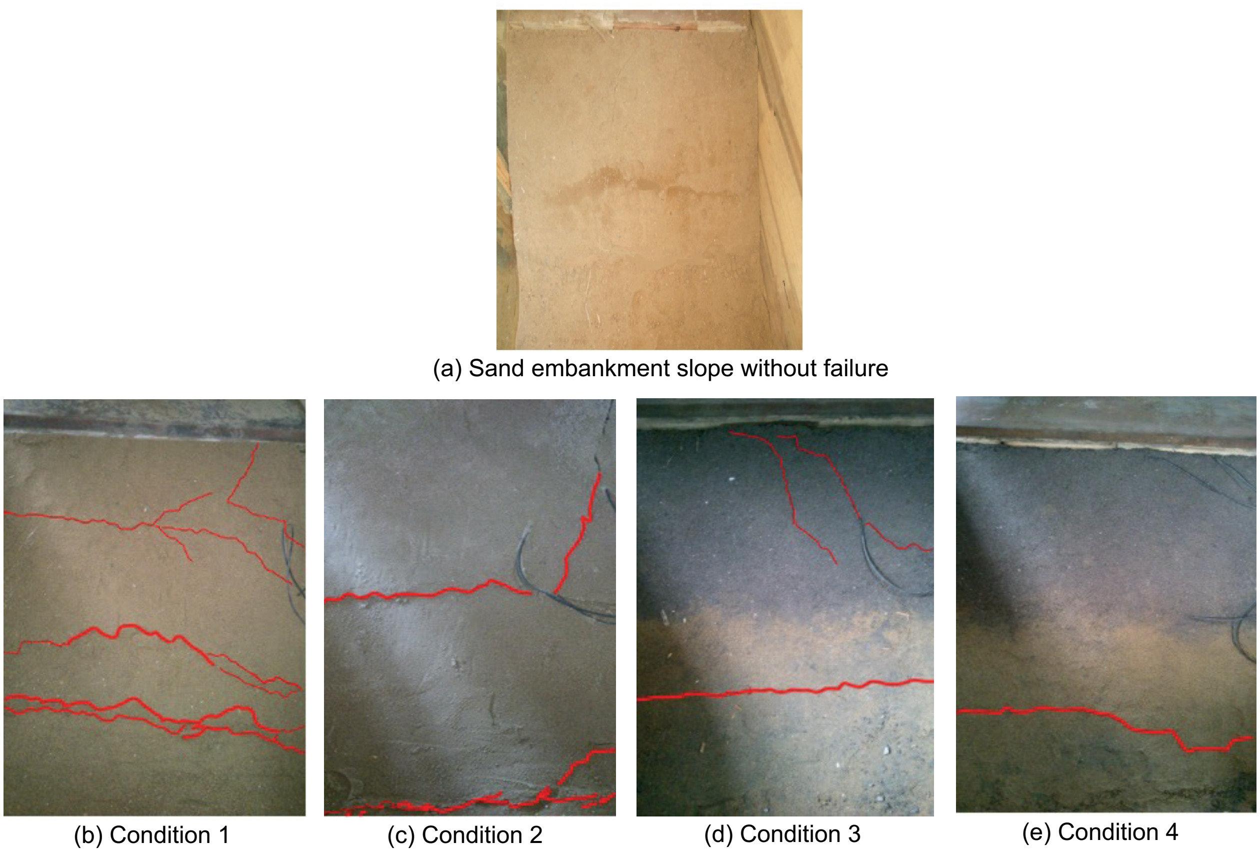

Fig. 14. Shear fissures of the embankment slopes after shear failure.

relative displacement between particles was limited, thus the generation of shear fissures of the embankment was inhibited.

In summary, compared with sand, IBA as the fill material for embankment could greatly reduce the settlement and vertical stress caused by vertical pressure and improve the bearing capacity of the embankment. However, IBA as the fill material for embankment improved the performance more significantly under the condition of larger slope ratios. The cause was that the embankment has weak resistance to failure, small stiffness, and poor stability when the embankment slope ratios were larger. Under the effect of vertical pressure, the embankment produced larger distortion, and relative sliding surfaces were generated inside the embankment. Thus, led to the interlocking and fixing effects between particles were fully exerted to resist the deformation and failure of the embankment. On the contrary, the embankment has a larger rigidity and bearing capacity when the slope ratios were small, thus the embankment has a certain resistance to deformation and failure. These reasons led to the internal relative surfaces being less and the interlocking and fixing effects between the IBA particles could not be fully exerted. As a result, the IBA fill could improve the performance of the embankment slope more significantly when the slope ratios are larger.

CONCLUSIONS

In this study, the engineering mechanics behavior of the IBA embankment, including the distribution of vertical stress, settlement, and lateral displacements of the IBA embankment under vertical pressure were studied. The failure modes and working mechanism of the IBA embankment were revealed and compared with the sand embankment. The main conclusions are as follows:

The interlocking and fixing effect would be produced between the compacted IBA particles. On the other hand, the volcanic ash (cementation) reacted in the fine IBA particles which agglomerated the IBA particles into weak concrete blocks. These effects cause IBA as the fill material for embankment with higher local shear strength than sand.

The improvement of IBA as the fill material was reduced with the decreasing slope ratios. When the slope ratios were 1:1.5, the IBA embankment could increase the bearing capacity by 25% and reduced the settlement by 47% compared with the sand embankment, but when the slope ratios were 1:1.75, the increment of the bearing capacity was only 20 %, and the decrement of settlement was less than 40%.

The IBA as the fill material could effectively reduce the vertical stress inside the embankment, and create a more homogeneous distribution of vertical stress, that will lead to lower vertical settlement and lateral displacements inside the embankment.

The obvious shear fissures were presented on the surface of the embankment when the model embankment failure occurred. The IBA embankment discovered fewer shear fissures, and the shear fissures most occurred in the sand filling part. Therefore, the undamaged area of the IBA embankment was larger, and the residual strength was higher.

The effect of IBA as fill material for embankment on improving performance and saving earth materials has been firmly established in this study. While integration of the study into large-scale application may pose a challenge to engineers, due to the lack of practical engineering references and research on the performance after reinforced with reinforcement materials. Thus, a further study is required to investigate the reinforcement effects and performance of the IBA embankment reinforced with different reinforcement materials.

DECLARATIONS

The corresponding author is responsible for co-authors declaring that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflicts of Interest, the corresponding author is responsible for co-authors declaring their interests, and declare that there is no conflict of interest regarding the publication of this article.

AVAILABILITY OF DATA

The corresponding author confirms that all the content, figures (drawings, charts, photographs, etc.), and tables in the submitted work are either original work created by the authors listed on the manuscript or work for which permission to re-use has been obtained from the creator.

The data used to support the findings of this study are available from the corresponding author upon request, and the readers can access the data supporting the conclusions of the study.

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