CHAPTER VI

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE STUDIES

7.1 Discussions

This study determines the potential application of stone dust used for cement and bentonite mixtures. The stone dust for specific size range is mixed with cement to determine the mechanical properties of each mixture. The cement mixtures are divided into two stages. The ranges of stone dust sizes for stage I are 4.75, 2.00, 0.85, 0.425, 0.25, 0.15 and 0.075-mm. Results from stage I testing reveals the detail of the effect of aggregate sizes on the mixture strength. In stage II the stone dust is separated into coarse and fine particles, where only one separator is selected which can be installed between the rock crusher and the stockpile. Two sets of size separations are selected. Set I, particles within the ranges of 4.75-0.25 mm are considered coarse, while those within the range of 0.25-0.075 mm are classified as fine. Set II, particles sized 4.75-0.15 mm are considered coarse, and those within the range of 0.15-0.075 mm are classified as fine. The coarse particles are used for cement mixture, while the fine particles are used for the bentonite mixture.

From the test results of stage I, it can be seen that the compressive strengths are highest for particle sizes of 0.85-0.425 mm and decrease with decreasing particle sizes. The mixture with particle size larger than 0.85 mm tend to show low strength. This is probably due to limestone with small particle sizes has a bonding higher than those with larger particle sizes. This agrees with the test results obtained by Prokopski et al. (2020) that a high concentration of fine grains in a sample may affect its strength.

The compressive strengths and elastic modulus for stage II, for cement mixtures show that the coarse particles from set I (4.75-0.25 mm) have greater strength as compared to those from set II (4.75-0.15 mm). This is supported the results obtained elsewhere (Yalley and Sam, 2018). This is because concrete with higher fine content absorbs more water during hydration leading to the decrease of its strength. As a result, the separation in set I is suitable for substituting clean sand. It is supported by the test results obtained from this study that the strength of concrete rises from 17.1 MPa when mixed with clean sand to 28.8 MPa when mixed with coarse particle from set I. Only the fine particles from set I (0.25-0.075 mm) are therefore considered for the bentonite mixture.

The small particles can fill the pore spaces between cement particles in the paste better than the larger ones which is known as filling effect. The fineness of stone dust has influence on the observed compressive strength values (Cai et al., 2020; Thongsanitgarn et al., 2011). Porosity is an important factor that affects the behavior of specimens, lower porosity leading to greater uniaxial compressive strength and Young's modulus (Srikanth and Mishra, 2016; Ghafoori et al., 2016). A smaller grain size might affect however the strength of specimen. This is supported by the test results obtained by Prokopski et al. (2020) that small particles usually have finer particle size distribution compared to coarse ones. The portion of cement is replaced by stone dust, resulting in a more densely packed mineral concrete component and reduced porosity of the concrete, thus increasing the strength of specimen.

Compaction, direct shear, consolidation, and swelling tests are conducted on mixtures of bentonite and fined stone dust to obtain the optimal ratio. The test results show that the increase of the stone dust weight ratio increases the dry unit weight and decreases the optimum water content. This agrees reasonably well with the test results obtained by Bilal and Ahmad (2020), Thanh Duong and Van Hao (2020), and Pastor et al. (2019). The mixtures containing 60% stone dust exhibit the highest shear strength and friction angle, while yielding the lowest cohesion, settlement, and swelling behavior. This is attributed to the effective filling of small void spaces by the fine particles, resulting in an increase of shear strength. Lower bentonite contents contribute to a reduction of swell capacity. A mixture of 40% bentonite and 60% stone dust may be suitable because it shows the highest maximum dry unit weight, shear strength, and can decrease the cost of the bentonite materials. As suggested by

Johannesson and Nilsson (2006), Borgesson, Johannesson, and Gunnarsson (2003), and Butcher (1993) that for effective compaction the bentonite weight ratio for the mixtures should not be less than 30%. This is primarily to prevent bridging and voids occurring between aggregates particles.

The permeability test results agree with the findings of Hazen (1892), who suggests that the relationship between grain size and permeability becomes less linear for larger grain sizes. The results coincides with previous studies on the relationship between grain size and permeability. For instance, Cabalar and Akbulut (2014), find that permeability increases with increasing grain size for sand samples, with a similar trend observed in this experiment. Additionally, Lopik, Zazai, Hartog, and Schotting (2019) report a nonlinear relationship between grain size and permeability for gravel materials, which is similar to the observation from this study for larger grain sizes of greater than 0.25 mm.

7.2 Conclusions

Conclusions drawn from this study can be summarized as follows.

1) The compressive strengths and elastic modulus results for cement mixtures show that the coarse particles from set I (4.75-0.25 mm) have greater strength as compared to those from set II (4.75-0.15 mm).

2) Coarse particles (4.75-0.25 mm) from set I can be used to substitute clean sand for cement mixtures.

3) Fine particles from set I (0.25-0.075 mm) help reduce the proportion of bentonite material in mechanical and hydraulic work applications.

4) Fine particles affect concrete strength, they should be used in an optimized ratio to maintain maximum strength.

5) The increase of fine stone dust (0.25-0.075 mm) weight ratio increases the dry unit weight and decreases the optimum water content.

6) The mixtures containing 60% stone dust exhibit the highest shear strength and friction angle, while displaying the lowest cohesion, settlement, and swelling behavior. This is due to the filling of small void spaces by the fine particles.

7) Higher stone dust contents contribute to a reduction of swell capacity.

8) A mixture of 40% bentonite and 60% stone dust is suitable because it shows the highest maximum dry unit weight, shear strengths.

9) An effective level of compaction requires a bentonite weight ratio for the mixtures of at least 30%. This is primarily to prevent bridging and voids occurring between aggregate particles.

7.3 Recommendations for future studies

The recommendations for future studies are as follows:

1) The effects of repeated loading cycles (fatigue) should be investigated to determine their relationship with the physical and mechanical properties of cement and bentonite mixtures for long-term performance evaluation.

2) Permeability testing should be employed to create mixtures with varying bentonite content and aggregate size.

3) Further testing is desirable for a diverse range of aggregate types and particle sizes.

4) The effect of roundness and sphericity of stone dust particles should be studied.