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Marine Clay Soil Treated with Demolished Tile Waste: A Systematic Literature Review

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Abstract: This systematic literature review investigates the stabilization of marine clay soil using demolished tile waste. The study adopts the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) method to comprehensively analyze existing research in this area.The utilization of waste materials for soil stabilization has gained significant attention due to environmental concerns and sustainability objectives. In this review, we explore the effectiveness of using demolished tile waste as a stabilizer for marine clay soil. The analysis reveals that different types of waste materials exhibit varying degrees of improvement in the soil's properties. The results demonstrate a consistent increase in shear strength after stabilization, indicating the suitability of demolished tile waste as a stabilizing agent for soft clay soils. Interestingly, the highest strength is not obtained at the largest additive quantities. Instead, most research papers report a peak in strength at specific additive proportions and curing time, followed by a decline. This phenomenon occurs when the hydration process is complete, and large lumps form between the clay particles. Furthermore, the size of the additive also plays a crucial role in enhancing the strength of problematic soils. Optimal additive size leads to better distribution and interaction with the clay particles, contributing to improved stabilization results. This review provides valuable insights into the potential of utilizing demolished tile waste for enhancing the engineering properties of marine clay soil. The findings highlight the importance of carefully selecting the type and quantity of additives to achieve the desired stabilization outcomes.

Keywords: Stabilized, treated, clay, Unconfined Compressive Strength (UCS), DTM, cement

1. Introduction

The building works that were installed in soft clay soil are supposed to face new problems compared to the others soil type. Soft clay soil was supposed to experience more collapse due to its high compressibility and problematic characteristics. Construction problems that are generally inadequate on bearing capacity, excessive post-build settlement and uncertainty in the forming of excavations and embankments. Among many stabilizers, cement is most widely used to stabilize soft clay soil but there are certain limitations on the use of cement for example cost effectiveness and etc. Therefore, there is a need to investigate some other suitable admixtures which could be used with an aspect of economic. Many chemicals stabilization techniques such as Demolished Tile Material (DTM) are being

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used nowdays to strengthen the chemical and physical behavior of untreated soil and cut down the damage them cause. These shortcomings are resolved by undertaking a systematic review to measure the effect of Demolished Tile Material (DTM) to increase the strength of marine clay soil. This research can be used as a guide to help in choosing a suitable stabilizer based on the properties of the soil and the compressive strength of soft clay.

1.1 Marine Clay

Working with marine clay soil is highly challenging due to its moisture content. Clay soil will swell as the humidity increased and shrinks as its humidity decreased. In addition, there is a considerable difference in engineering properties between the marine clay and the others soft soil. Marine clays are particularly susceptible to change and fragile when they live underneath pavements or foundations. Their performance is always unpredictable according to previous research (Mohammed Al-Bared & Marto, 2017). (Saleh et al., 2018) said that marine clay natural moisture is higher than its liquid limit index. Besides, its physical properties also play an important role in determining the strength and stability of sea deposits. Particle size distribution, liquid limit, plastic limit, plasticity index, moisture content, specific gravity, organic content, shrinkage limit and mineral composition are the main index properties which is usually affect the compressive strength of marine clay soil.

1.2 Soil Stabilization

Generally, chemical additives are widely used due to low-cost and effectived method to improve the physical properties of clay soil (Saadeldin and Siddiqua, 2013). It can be separated into different part which is traditional and non-traditional stabilizer. The most popular addictives that widely used amongst the traditional stabilization is fly ash and cement. According to previous study, traditional stabilizer gives extra advantages for soft soil stabilization where it can neutralize the acidity and increase the strength behavior on various types of soil especially marine clay soil. Unfortunately, non-traditional stabilizer is one of the chemical formulated stabilize that slightly different from traditional stabilizer where it comes with benefit that can shorten in time for curing process.

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2. Methodology

A systematic literature review was conducted in this research and no materials are used throughout this process. This method used to determine articles and journal related to increase the compressive strength of clay soil stabilized with Demolished Tile Material (DTM) and cement.

2.1 Methods

The method used in this section to obtain articles relating to the compressive strength actions on marine clay treated by combination of Demolished Tile Material (DTM) and cement is discussed. A method called PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis), which include resources Scopus used to conduct systematic review, eligibility and exclusion criteria, steps of the review process (identification, screening, eligibility) and data abstraction and analysis. PRISMA are oftenly used in the field of environmental management field. The PRISMA Statement allows various search of terms related to stabilize clay soil treated by combination DTM and cement in environmental management reviews. The methodology can be used for monitoring the strength of marine clay soil stabilize with DTM and cement at different percentage and curing period.

The Scopus database was used to obtain a systematic review of applications and methodologies for stabilization of marine clay soil in the field of geotechnical engineering. The most recent published papers were found based on the several searching keywords such as clay, stabilization, treated and demolished tile materials (DTM) and unconfine compressive strength (UCS). The Table 1 showed the keyword and searching information strategy that related to the topic. A total 110 articles and journals have been extracted in this regard and according to our strategy search. Figure 1 shows the systematic review process from indetification until untill included process.

Table 1 - Keywords and searching information strategy

Databases	Keywords
Scopus	1. TITLE-ABS-KEY ((“stabilize*” OR “treated”) AND (“clay”) AND (“tile waste” OR “DTM”))
	2. TITLE-ABS-KEY ((“stabilize*” OR “treated”) AND (“tile waste” OR “DTM”))

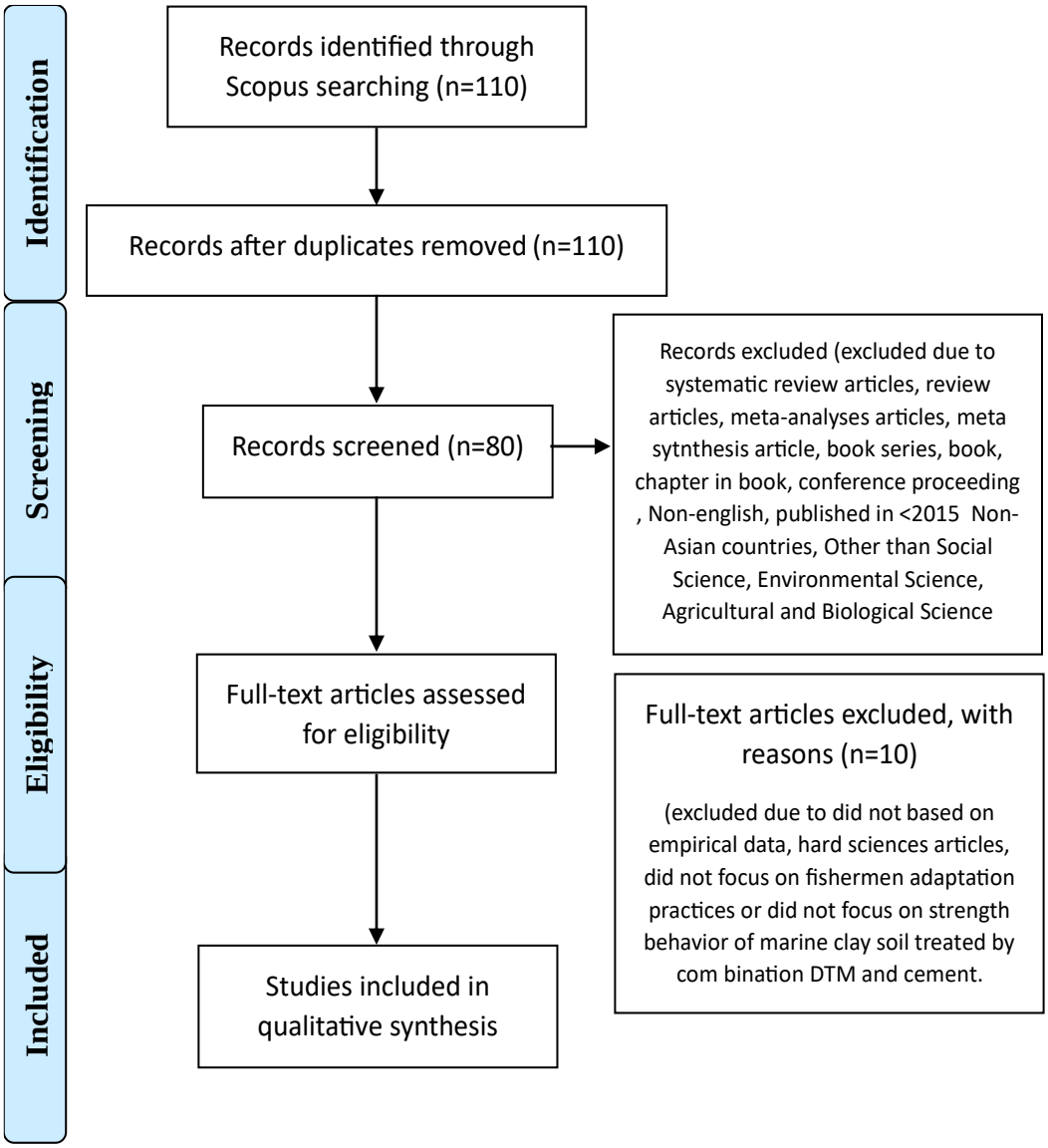

Fig. 1 - Systematic review process

3. Results and Discussion

The remaining assessed from 10 journals were assessed and analysed. Efforts were concentrated on stabilising clay with tile material. Data were extracted by reading through the abstracts first, then the full articles (in-depth) to identify appropriate themes and sub-themes. Qualitative analysis was performed using content analysis to identify themes related to powder stabiliser in clay stabilization. Table 2 shows the result systematic review.

Table 2 - Result of systematic review

Author(s)	Year	Subject	Results
Zainuddin et al.,	2019	Measuring the Engineering Properties of Marine Clay Treated with Disposed Granite Waste.	The results show that combination with the DTM, the UCS decreased and it slowly increased with an increase in the curing time. The identification of new cementation minerals was not necessary to improve the strength. It found that DTM is suitable material as an additive for the treatment of marine clay.
Al-bared & Marto	2019	Evaluating the Compaction Behaviour of Soft Marine	Different size of recycled blended tiles was able to make an improvement of compaction parameters and

		Clay Stabilized with Two Sizes of Recycled Crushed Tiles.	also can increase the strength of soil when compared with untreated marine clay.
Samson Paul Muller & Janani,	2017	Influence of Tile Waste Powder on The Strength and Swell Characteristics of Expansive Soil.	The results showed that tile waste will increased the value of Unconfined Compressive strength (UCS) with an increasing the percentage of the admixture. The maximum strength was obtained on 20% of the tile waste for 28 days of curing.
Al-Bared et al.,	2018	Utilization of Recycled Tiles and Tyres in Stabilization of Soils and Production of Construction Materials.	The increasing of strength and physical properties were shown in the results. The paper proved that recycled tiles will reduce the settlement and also induce a substantial improvement in strength, liquid limit, plastic limit, compaction parameters clay soil compressibility.
Jamaludin et al.,	2019	Potential and future: utilization of waste material on strength characteristics of marine clay.	The compressive intensity decreased due to increasing DTM percentages in different curing period. It shown that the strength behavior of soil strength also increased.
Sharma	2020	Utilization of Fly Ash and Waste Ceramic in Improving Characteristics of Clayey Soil: A Laboratory Study.	The decreased in pavement thickness showed that the stabilization of the subgrade with waste materials resulted in substantial material requirement savings compared to the use of untreated soil. This combination can used skillfully for subgrade construction for rural roads and low cost highways.
James & Pandian	2018	Strength and Microstructure of micro ceramic dust admixed stabilized soil.	The result showed that, by combining ceramic dust and lime was able to enhance the soil strength.
N. E. B. Zainuddin et al.,	2016	A review: Reutilization of waste material to stabilize marine clay.	The result showed that the strength was increased at the large amount of additives at certain quantity and curing time the strength started constant and dropped after reaching peak. It can be conclude that, reusing the C&D like tile waste can stabilized the soil.
Upadhyay & Kaur	2016	Review on Soil Stabilization Using Ceramic Waste.	Different researchers have drawn the conclusion that the addition of ceramic waste liquid cap, rubber cap and clay soil plasticity index decreased. As the percentage of the ceramic waste dust increased, the UCS of clay soil increased.
(Rajorial & Kaur, 2015) Rajorial & Kaur	2015	Effect of Ceramic Waste on the Geotechnical Properties of Black Cotton Soil	Optimum moisture content of the clay soil decreased as the percentage of ceramic waste increased and MDD was obtained to certain optimum content of ceramic waste and decreased the optimum content of ceramic waste. The CBR and UCS of clay soil increased as the percentage ceramic waste dust rise.

4. Conclusions

This systematic review has highlighted the effect on compressive strength of clay soil with addition of tile materials. The different types of waste materials are suitable for different degree of improvement. Almost all the result shown the increasing in the shear strength and suitable used as stabilizer for stabilizing the soft clay soil. According to the previous research, the results did not show the highest strength was obtained at the largest amount of additives because for most of the research paper evaluated that the strength increases at certain quantity and curing time, then started constant and dropped after reaching at peak. This situation happened when hydration process was complete and large lump created between the particles of clay. Futhermore, size of additive is another factor that contribute on enhancing the strength of problematic soils. Based on systematic literature review, it has been identified that, the compressive strength decreased with increasing additives percentages while increasing curing period the strength of soil sample would also decrease. Thus, it could be concluded that DTM could provide long term strength gain as the highest strength is obtained at 28 days for 5% DTM.

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