www.ijiarec.com

ISSN:2348-2079

Volume-8 Issue-3

International Journal of Intellectual Advancements and Research in Engineering Computations

Experimental study on ground improvement techniques using recycled aggregate porous piles on clayey soil

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ABSTRACT

The project points to the possibility of using recycled aggregate piles for improving the bearing capacity of clayey soil. Recycled aggregates being dumped as waste material, the reuse of the aggregates will be an environmentally friendly activity if the engineering properties of the aggregates stay within the allowable limits recommended by the Indian standards. The project imbibes the study on properties of the recycled aggregates and clayey soil, and effect on bearing capacity of clayey soil on introducing a recycled aggregate pile in it. To investigate the applicability of the recycled aggregate porous concrete pile method as a ground improvement technique, a series of laboratory model plate load tests was performed on soft clayey soil reinforced with recycled aggregate porous concrete pile and stone column respectively.

Keywords: Bearing capacity, Clayey soil Porous piles, Recycled aggregate

INTRODUCTION

In recent years, rapid industrialization across the world has led to significant consumption of natural aggregates such as gravel and sand that are indispensable to constructing infrastructures. To address these issues, many studies have been made on the viability of substituting materials, such as recycled aggregates, for natural aggregates. Since the construction industry consumes a large amount of natural aggregates and also produces a huge mass of construction waste, the recycling of construction waste is of great interest. In particular, because 90 % of construction waste is composed of concrete, asphalt and sand, it is possible to produce recycled aggregate after the waste is appropriately separated and processed. Since the early 1980s, Japan and several European countries have endeavored to use aggregates from crushed concrete for projects such as road bases and new concrete structures. The recycled aggregate is defined as aggregate that is recycled from dismantled structures through physical or chemical processed such as crushing, sorting and so on. Since the recycled aggregate is obtained from various origins, physical properties of the aggregate are not uniform, which leads to difficulties in the application of the recycled aggregate for new concrete structures. In this project, a recycled aggregate porous concrete pile has been developed by replacing natural aggregates with recycled aggregates to overcome issues related to bulging failure or reduced section geometries. Such issues may arise during installation and during the early stages of operation. In addition, the proposed approach utilizes recycled aggregates instead of natural materials. To investigate the applicability of the recycled aggregate porous concrete pile method as a ground improvement technique, a series of laboratory model plate load tests was performed on soft clayey soil reinforced with recycled aggregate

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porous concrete pile and stone column respectively.

When compared to the material properties of granular piers, the pervious concrete material has higher strength and modulus, and similar permeability. Furthermore, since the stiffness and strength of pervious concrete pile are independent of the confinement provided by surrounding soil, it can be used in very soft clay, silt, and organic and peat soils, in which granular piers cannot used. Ultimately, pervious concrete pile combines high strength of concrete piles and high permeability of granular piers which has the potential to result in more economical and effective ground improvement technique [1-5].

AIMS AND OBJECTIVES

In this study, a series of plate load tests was carried out to evaluate the applicability of a porous concrete pile fabricated with recycled aggregates for soft ground improvement. The laboratory plate load tests for evaluating the performance of RAPP were carried out. The current study shows that the settlement reduction in the RAPP-reinforced system is significantly enhanced due to load transfer from the soil formation to the RAPP. Furthermore, the comparison of RAPP and stone column with recycled aggregate was also done [6].

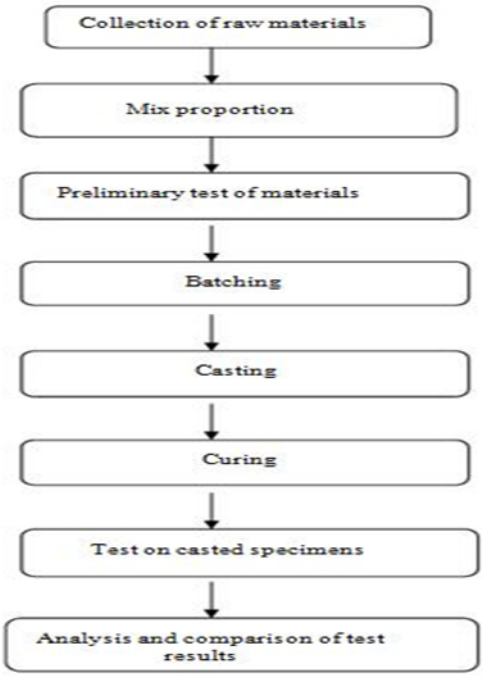
The main objectives of this study are

Investigating the pervious concrete material properties and developing suitable mixing procedures and mixing proportions for pervious concrete pile casting

Developing installation technique for pervious concrete pile and investigating the effects of pile installation effects on soil and pervious concrete pile properties, soil pile interactions, and on pile behavior

To determine the strength characteristics of recycled concrete [7]. To determine whether the use of recycled porous concrete piles improve the bearing capacity of soil. Evaluating the response of pervious concrete piles when subjected to loading conditions.

METHODOLOGY



PREPARATION OF SPECIMEN

Collection of recycled aggregate

Recycled aggregate is produced by crushing concrete to reclaim the aggregate which are collected from the laboratory waste. It has a proportional mortar which attaches to aggregate; it gives a higher porosity and higher strength than normal concrete. It can be used for many purposes.

Crushing and sieving

Recycled aggregate required for the preliminary tests was hand crushed using heavy rammers from the concrete waste obtained from the laboratory and the rest was crushed in crushing unit at Edayar. The recycled aggregates were then divided into different fractions having size 10mm, 12mm, 16mm, and 19mm respectively.

Selection of mix ratio

We casted the porous concrete cubes with different water contents of 0.3, 0.35 and 0.4 respectively with 1:4 cement to coarse aggregate ratio and 5% sand. These cubes cured for seven days. After seven days cubes of different mix ratio were subjected to compressive strength. It was found that concrete mix 0.4 W/c ratio is having the maximum compressive strength. Hence it was chosen for pile casting

Selection of size of aggregate for piles

Cubes of 150mm*150mm*150mm was casted by recycled aggregate of sizes 10mm, 12mm, 16mm, 19mm with a mix ratio of 0.35w/c. Each cube cured for seven days in water. After curing, the cubes were subjected to compressive strength test. It was found that cube casted of 10mm size aggregate was having maximum compressive strength thus we selected it for casting piles. Casting of Porous Pile.

ANALYSYS AND RESULTS

Plate load test on plain soil

Load settlement data

Table 1: Plate load test on plain soil

Dial gauge reading				Settlement (mm)	Proving-ring reading (div)	Load		
D1	D2	D3	Mean			kN	N	kg
50	40	50	46.67	0.5	1	4.29	4291	437.41
100	90	100	96.67	1.0	2	8.58	8582	874.82
150	140	150	146.67	1.5	3	0.00	12873	1312.23
200	190	200	196.67	2.0	4	17.16	17164	1749.64
250	240	250	246.67	2.5	5	21.46	21455	2187.05
300	290	300	296.67	3.0	6	25.75	25746	2624.46
350	340	350	346.67	3.5	7	30.04	30037	3061.88
400	390	400	396.67	4.0	8	34.33	34328	3499.29
450	440	450	446.67	4.5	9	38.62	38619	3936.70

PLATE LOAD TEST ON SOIL WITH RAPP

Load settlement data

Table 2: Plate load test on soil with RAPP

Dial gauge reading				Settlement (mm)	Proving ring reading (div)	Load		
D1	D2	D3	Mean			kN	N	kg
50	30	50	43.33	0.43	10	42.91	42910	4374.11
100	60	100	86.67	0.87	12	51.49	51492	5248.93
150	90	150	130.00	1.30	14	60.07	60074	6123.75
200	120	200	173.33	1.73	18	77.24	77238	7873.39
250	150	250	216.67	2.17	21	90.11	90111	9185.63
300	180	300	260.00	2.60	22	94.40	94402	9623.04
350	210	350	303.33	3.03	26	111.57	111566	11372.68
400	240	400	346.67	3.47	26	111.57	111566	11372.68
450	270	450	390.00	3.90	30	128.73	128730	13122.32

PLATE LOAD TEST ON SOIL WITH STONE COLUMN

Load settlement data

Table 3: Plate load test on soil with stone column

Dial gauge reading				Settlement (mm)	Proving ring reading (div)	Load		
D1	D2	D3	Mean			kN	N	kg
50	40	50	46.67	0.47	6	25.75	25746	2624.46
150	120	150	140.00	1.40	7	30.04	30037	3061.88
200	160	200	186.67	1.87	8	34.33	34328	3499.29
250	200	250	233.33	2.33	10	42.91	42910	4374.11
300	240	300	280.00	2.80	11	47.20	47201	4811.52
400	320	400	373.33	3.73	13	55.78	55783	5686.34

COMPARISON OF THE RESULTS

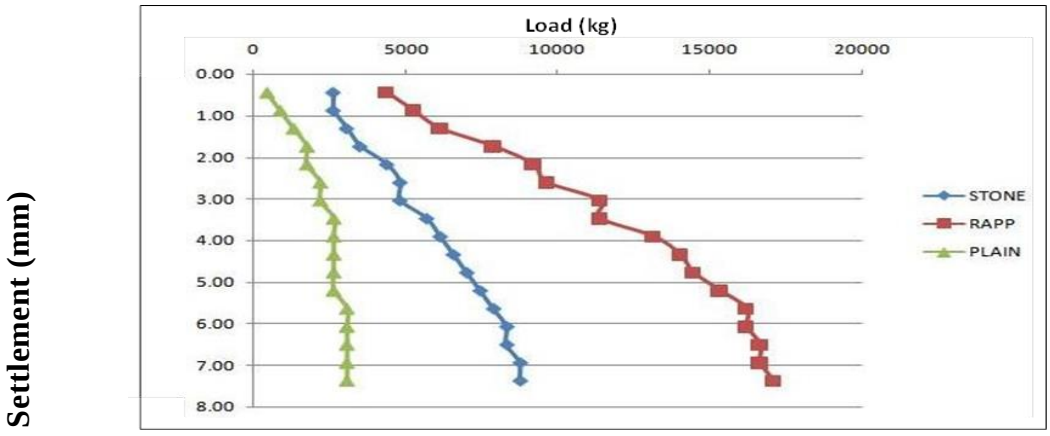


Figure 1: Load comparison results

CONCLUSIONS

In this study, a series of laboratory tests was carried out to evaluate the applicability of a porous concrete pile fabricated with recycled aggregates (RAPP) for the soft ground improvement. All of the experimental results for the RAPP were compared with the case of the SCP. The findings in this study are summarized as follows:

Comparing the vertical displacement, RAPP behaves as a fully composite formation and performs better than stone columns in soil strength. The curing time for the RAPP adopted in this study was only 7 days, which is not enough to mobilize a full capacity of the RAPP. Therefore, the reduced Young's modulus of the RAPP (8,000 kPa instead of 16,400 kPa) from the unconfined compression test result after curing for 28 days shows better comparison to the measured settlement. Finally, the RAPP fabricated with recycled aggregates can replace conventional compaction piles such as the SCP to improve soft soil formation. Introduction of stone columns almost doubled the strength of soil mass, whereas the introduction of the RAPP showed 3 times the strength of soil with stone column.

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