

**UTILIZATION OF POLYETHYLENE TEREPHTHALATE (PET)
BOTTLES AS PARTIAL REPLACEMENT OF FINE
AGGREGATES IN CONCRETE PAVING BLOCKS**

THESIS

NICOLE ANNE LABUTAP

SHASHEIL MAUREEN S. NAVARRO

College of Engineering and Information Technology

CAVITE STATE UNIVERSITY

Indang, Cavite

June 2019

**UTILIZATION OF POLYETHYLENE TEREPHTHALATE (PET) BOTTLES AS
PARTIAL REPLACEMENT OF FINE AGGREGATES
IN CONCRETE PAVING BLOCKS**

**Undergraduate Thesis
Submitted to the Faculty of
College of Engineering and Information Technology
Cavite State University
Indang, Cavite**

**In partial fulfillment
Of the requirements for the degree
Bachelor of Science in Civil Engineering**

**NICOLE ANNE LABUTAP
SHASHEIL MAUREEN S. NAVARRO**

June 2019

ABSTRACT

LABUTAP, NICOLE ANNE AND NAVARRO, SHASHEIL MAUREEN S., Utilization of Polyethylene Terephthalate (PET) Bottles as Partial Replacement of Fine Aggregates in Concrete Paving Blocks. Undergraduate Thesis. Bachelor of Science in Civil Engineering, Cavite State University, Indang, Cavite. June 2019. Adviser: Engr. Roslyn P. Peña

The main objective of the study was to determine the feasibility of shredded PET bottles as partial replacement of fine aggregates in concrete paving blocks. Specifically, it aimed to determine the physical properties of PET bottles; determine the density weight of paving blocks with PET bottles; determine the compressive strength of paving blocks at 7, 14 and 28 days after curing; determine and compare the compressive strength of ordinary paving blocks to paving blocks mixed with PET bottles as supplementary fine aggregates; determine the PET bottles content which will produce the paving blocks with the highest compressive strength; find out the most economical and acceptable mixture using PET bottles as partial substitute for fine aggregates, and observe other effects of PET bottles in paving blocks. The study used five mix design of concrete paving blocks with partial replacement of PET bottles to fine aggregates which ranges from 0 percent, 5 percent, 10 percent, 15 percent and 20 percent PET bottles with 7.44 L of water.

Different tests were used in evaluating the effect of different proportions of sand and PET bottles in concrete paving blocks making. These test includes fineness and sieve analysis, density determination (loose and compact), determination of specific gravity, slump test for freshly mixed concrete, and compressive strength test of concrete paving blocks. With respect to physical properties, PET bottles had smooth, angular shape with size ranging from 1.18 to 2.36 and light in weight.

After conducting a series of compression test, the results of average compression test obtained on their 7th day for Treatment 5 containing 20% shredded PET bottles attained the highest compressive strength of 40.57 MPa. Treatments 1, 2, 3, and 4 obtained a compressive strength of 35.43 MPa, 36.59 MPa, 39.51 MPa, and 31.76 MPa, respectively. It implies that the compressive strength of concrete paving blocks increases as the PET bottles also increases.

For the 14th day curing, the highest compressive strength acquired in the Treatment 5 with strength of 51.56 MPa while Treatments 1, 2, 3, and 4 obtained a compressive strength of 45.93 MPa, 50.74 MPa, 51.99 MPa, and 51.51 MPa, respectively. It entails that the strength in Treatment 4 decreases but still Treatment 5 has the highest compressive strength. For the 28th day, Treatment 5 has the highest compressive strength of 61.51 MPa. While 60.98 MPa, 58.51 MPa, 59.03 MPa, and 59.46 MPa were the compressive strengths obtained by Treatments 1, 2, 3, and 4, respectively. This shows that there is uneven decrease and increase but still the highest compressive strength for the 28th day curing is Treatment 5.

Results showed that there is uneven change in 15 percent PET bottles content but all treatments obtained compressive strengths which are higher than the control and passed the required compressive strength of paving blocks. The proportion that acquired the highest compressive strength was the mixture with the most amounts of shredded PET bottles (80% - 20%) with compressive strength of 61.71 MPa (8956 psi). Also, concrete paving blocks is considered light weight as PET bottles content increases. Moreover, the authors have determined that the use of PET bottles as aggregates can cause savings ranging from PHP 2.28 to PHP 8.29 depending on the amount of PET

bottles used. The mixture with the highest compressive strength also garnered the lower cost. Treatment 5 with 28 curing days is determined as the most economical mix design with the amount of PHP 16.72 and a compressive strength of 61.71 MPa, which has a cost comparably lower than that of load bearing commercial paving blocks costing PHP 19.00 per unit. Hence, PET bottles as partial replacement to fine aggregates is feasible and highly economical in terms of strength, cost and environmental impact. Further research may be conducted increasing the amount of shredded PET bottles to determine the limit of sand to PET bottles proportion; lower class of concrete mixture may be used to produce paving blocks with lower strength for pedestrian walks and parks; the use of coarse aggregates may also be removed from the mixture to produce non load-bearing blocks; utilization of other polymers as fine aggregates in concrete; and abrasion test may be conducted to determine the abrasive resistance and hardness property of the paving blocks.

TABLE OF CONTENTS

	Page
APPROVAL SHEET.	ii
BIOGRAPHICAL DATA.	iii
ACKNOWLEDGEMENT.	v
ABSTRACT.	xi
LIST OF TABLES.	xvii
LIST OF FIGURES.	xix
LIST OF APPENDIX TABLES.	xx
LIST OF APPENDIX FIGURES.	xxi
LIST OF APPENDICES.	xxii
INTRODUCTION.	1
Statement of the Problem.	2
Objectives of the Study.	3
Significance of the Study.	4
Scope and Limitation.	4
Time and Place of the Study.	5
Definition of Terms.	5
REVIEW OF RELATED LITERATURE.	9
METHODOLOGY.	28
Materials and Apparatus.	28
Methods.	29

Data Gathering.	32
Collection and Preparation of PET Bottles.	32
Sieve Analysis.	32
Physical Properties of PET Bottle.	33
Density test and Specific Gravity Test.	33
Proportioning and Mixing of Concrete Specimen.	33
Slump Test.	34
Casting and Compacting of Concrete Specimen.	35
Curing of Concrete.	36
Compression Test.	37
Experimental Results.	37
Statistical Design.	37
Cost Analysis.	38
RESULTS AND DISCUSSION.	39
Collection and Preparation of Polyethylene Terephthalate (PET) Bottles.	39
Fineness Modulus.	39
Size Gradation.	40
Physical Properties of Shredded Polyethylene Terephthalate (PET) Bottles.	40
Density and Specific Gravity Test.	41
Proportioning and Mixing of Concrete Specimen.	43
Slump Test.	44
Casting and Compacting of Concrete Specimen.	45

Curing of Concrete.	46
Compressive Strength.	46
Statistical Results.	49
Cost Analysis.	54
SUMMARY, CONCLUSION AND RECOMMENDATION.	56
Summary.	56
Conclusion.	58
Recommendation.	61
REFERENCES.	62
APPENDICES.	65

LIST OF TABLES

Table	Page
1 Properties of PET bottles.	13
1 Continued.	14
2 Chemical composition of sand.	15
3 Recommended grades of pavers blocks for different traffic categories as per IS 15658-2006.	21
3 Continued.	22
4 Different proportions of sand and PET Bottles.	34
5 Mix design for nine concrete paving blocks.	38
6 Fineness of sand and shredded PET bottles.	39
7 Size gradation of sand and shredded PET bottles.	40
8 Physical properties of shredded polyethylene terephthalate (PET) bottles.	41
9 Density of materials.	41
10 Specific gravity of materials.	42
11 Density of concrete paving blocks after 7, 14 and 28 curing days.	42
12 Concrete proportion by Max Fajardo.	43
13 Mix design for nine concrete paving blocks.	44
14 Average slump of freshly mixed concrete.	44
15 Average compressive strength of concrete paving blocks in psi.	46
16 Average compressive strength of concrete paving blocks in Mpa.	47
17 ANOVA for compressive strength after 7, 14, and 28 days.	50

18	Post hoc Tukey HSD multiple comparisons for curing days.	50
19	Post hoc Tukey HSD multiple comparisons for treatment.	51
20	ANOVA for weight after 7, 14 and 28 days.	52
21	Post hoc Tukey HSD multiple comparisons for curing days.	52
22	Post hoc Tukey HSD multiple comparison for treatment.	53
23	Cost of paving blocks per unit.	55
24	Cost of paving blocks per mix design.	55
25	Quantity of PET bottles.	55

LIST OF FIGURES

Figure		Page
1	Size gradation.	17
2	Preparation and properties determination of cement, gravel, sand, and PET bottles.	30
3	Slump and compressive strength determination of concrete paving blocks in all mix design.	31
4	Average slump of freshly mixed concrete.	45
5	Average compressive strength of paving blocks in MPa.	47
6	Average compressive strength of paving blocks in psi.	48

LIST OF APPENDIX TABLES

Appendix Table	Page
1 Fineness of sand.	67
2 Fineness of PET bottles.	67
3 Density of sand.	68
4 Density of PET bottles.	68
5 Density of portland cement.	69
6 Density of gravel.	69
7 Density of concrete paving blocks.	70
8 Slump of freshly mixed concrete.	70
9 Compressive strength of concrete paving blocks after 7, 14, and 28 curing period (in psi).	71
10 Compressive strength of concrete paving blocks after 7, 14, and 28 curing period (in MPa).	71
11 Compressive strength of non- load bearing commercial paving blocks.	72
12 Average weight of concrete paving blocks after 7, 14 and 28 curing days.	72

LIST OF APPENDIX FIGURES

Appendix Figure	Page
1 Preparation of PET bottles.	74
2 Cleaning of PET bottles.	74
3 Grinding of PET bottles grinder.	75
4 Sieve analysis.	75
5 Determination of PET bottles loose and compact weight	76
6 Determination of coarse aggregates loose and compact weight.	76
7 Determination of fine aggregates loose and compact weight.	77
8 Weighing scale, container, slump cone and mixing board.	77
9 The materials used in making PET paving blocks.	78
10 The concrete paving blocks mold.	78
11 Mixing process.	79
12 Slump test.	79
13 Casting in concrete paving blocks mold.	80
14 Removal of hardened concrete paving blocks in the mold.	80
15 Paving blocks was marked with the percentage of PET bottles and the curing days period.	81
16 Curing of concrete paving blocks.	81
17 7, 14 and 28 days curing period concrete paving blocks.	82
18 Determination of compressive strength test in Cavite Testing Center.	82

LIST OF APPENDICES

Appendix	Page
1 Appendix Tables	66
2 Appendix Figures	73
3 Computations	83
4 Procedures and Methods	118
5 Forms	123
6 Compressive Strength Test Results	131

UTILIZATION OF POLYETHYLENE TEREPHTHALATE (PET) BOTTLES AS PARTIAL REPLACEMENT OF FINE AGGREGATES IN CONCRETE PAVING BLOCKS

**Nicole Anne Labutap
Shasheil Maureen S. Navarro**

An undergraduate thesis submitted to the faculty of the Department of Civil Engineering, College of Engineering and Information Technology, Cavite State University, Indang, Cavite, in partial fulfilment of the requirements for the degree of Bachelor of Science in Civil Engineering with Contribution No. CEIT 2018-19-2-052. Prepared under the supervision of Engr. Roslyn P. Peña.

INTRODUCTION

Modern construction industry seeks for more innovative materials challenging the spirit of young engineers to achieve a study that could possibly change the history. Wide variety of materials such as wastes and by-products that would otherwise be discarded as harmful environmental pollutants must be counted as appreciated resources and used in civil engineering applications.

Plastics are a major component of the solid waste stream in many countries. It can be found in many forms, including Polyvinyl Chloride (PVC) bags, Polyethylene Terephthalate (PET) bottles such as blown bottles for soft drink use, containers for the packaging of food and other consumer goods are finding wide range of applications in all fields of life (Savolkar, 2011). According to Nishikant (2016), at present, although some plastics are used in recycling, these non-biodegradable products are used and thrown out