

Abstract of thesis presented to the Senate of Infrastructure University Kuala Lumpur
in fulfilment of the requirement for the degree of master of science in construction
management

UTILIZATION OF PLASTIC FIBERS DERIVED FROM WASTE PLASTIC
BAGS IN CONCRETE TO ACHIEVE SUSTAINABILITY IN CONSTRUCTION
PROJECTS.

By

Turlanbekov Asset

2017

Chair: Dr. A.B.M. Amrul Kaish

Faculty: Faculty of Engineering and Technology Infrastructure

Malaysia alone generates approximately 30,000 tonnes rubbish every day, containing around 13% of solid plastic waste. Plastic wastes are not decomposable and have had a negative impact on our eco-system for many years. Besides conventional recycling and landfilling, an alternative disposal of this waste is required for sustainable development. Adding plastic waste as fiber in concrete would play an important role to reduce plastic waste. Research work on producing green concrete is not an exception. This study investigates the properties of concrete containing plastic fibers derived from waste plastic bags. In this study waste plastic bags were manually cut in for two different length (5-12 mm) and (20-35 mm). Nine concrete mixtures were prepared with quantity of 0.1%, 0.2%, 0.3%, 0.4% with both types of plastic fibers. The workability, fresh density, compressive strength, splitting tensile strength, flexural strength and water absorption properties were tested and analyzed at 7, 28 also 56 days for compressive only. Significant improvement in concrete properties was observed with the addition of plastic fibers. Research results showed that depending on quantity of plastic fibers, concrete may reach different strength. A questionnaire survey was also conducted to know the acceptability of the developed concrete by the construction industries. The experimental results and the positive response by the construction industries proved that the utilization of plastic fibers derived from waste plastic bags in concrete is possible and it can enhance the strength of concrete.

Acknowledgement

Working on this thesis was a long and difficult journey in my study in IUKL over the past two years. I struggled in Malaysia in the beginning days as they were difficult and I had the feeling that I couldn't complete the task ahead.

First of all, I'm grateful to God who gave me strength and patience to study abroad and gain more knowledge in Malaysia. I obtained deeper knowledge and experience in science in this research work.

I would like to thank Dr. Amrul Kaish and Dr. Manal Mohsen Abood for their patience, support and guidance in my studies. To all the support staff at IUKL for all your hard work on a daily basis. Even though you are behind the scenes your work will not be forgotten.

To my lifelong friends, thank you for distracting me and pulling me away from this research when I needed to procrastinate and enjoy life.

I appreciate my dearest parents Askhat Turlanbekov and Maukeeva Sveta who supported me emotionally and financially and motivated me to accomplish my mission here. A million of thanks to my elder sister Zhazira who taught me English and dedicated plenty of time to help me improve these skills. A special thanks to my brother Daulet and sister in law Nurgul who supported me throughout. I want to thank my dearest niece Dane who gave me positive energy and always put a smile on my face. Finally, I would like to express my gratitude for Kate Fenton, who gave me advice and encouragement.

Approval

This thesis was submitted to the Senate of Infrastructure University Kuala Lumpur (IUKL) and has been accepted as partial fulfilment of the requirement for the degree of masters. The members of the Thesis Examination Committee were as follows:

Azlinda Saadon

Name of Faculty: Department of Civil Engineering, FETI

Infrastructure University Kuala Lumpur (IUKL)

Chairperson

Dr Norhaiza Binti Nordin

Name of Faculty: Department of Civil Engineering, FETI

Infrastructure University Kuala Lumpur (IUKL)

Internal Examiner

Mohd Nizam Bin Shakimon

Name of Faculty: Department of Civil Engineering, FETI

Infrastructure University Kuala Lumpur (IUKL)

Internal Examiner

Associate professor Dr. Manal Mohsen Abood

Director

Center for Postgraduate Studies

Infrastructure University Kuala Lumpur (IUKL)

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Infrastructure University Kuala Lumpur or at any other institution.

TABLE OF CONTENTS		Page
ABSTRACT		i
ACKNOWLEDGEMENTS		ii
APPROVAL		iii
DECLARATION		iv
LIST OF TABLES		ix
LIST OF FIGURES		x
LIST OF ABBREVIATIONS		xii
 CHAPTER		
1	INTRODUCTION	1
	1.1 General	1
	1.2 Theoretical framework	3
	1.3 Problem statement	5
	1.4 Research questions	5
	1.5 Objectives of the study	6
	1.6 Research hypothesis	6
	1.7 Scope of the Research	6
	1.8 Significance of Research	8
	1.9 Outline of the Thesis	8
2	LITERATURE REVIEW	
	2.1 Introduction	10
	2.2 Material properties of plastic fibers used in concrete	12
	2.3 Most common used fibers in concrete	14
	2.3.1 Plastic Fibers	15
	2.3.2 Steel Fibers	16
	2.3.3 Glass Fibers	16
	2.4.4 Natural Fibers	16
	2.4 Advantage of using fibers in concrete	17

2.5	Durability properties of Fiber Reinforced Concrete	17
2.6	Effect of plastic fibers in concrete	18
2.6.1	Slump test of plastic fibers reinforced concrete	18
2.6.2	Compressive strength of PFRC	19
2.6.3	Splitting tensile strength of PFRC	21
2.6.4	Flexural strength of PFRC	23
2.6.5	Effects of PF on drying shrinkage of concrete	24
2.6.6	Effects of PF on fire resistance of concrete	25
2.7	Effects of steel fibers in concrete	27
2.7.1	Compressive strength of SFRC	27
2.7.2	Splitting tensile strength of SFRC	29
2.7.3	Flexural strength of steel fiber reinforced concrete	29
2.7.4	Effects of SF on drying shrinkage of concrete	29
2.7.5	Effects of SF on fire resistance of concrete	31
2.8	Research gap	32
2.9	Conclusion	33

3 METHODOLOGY

3.1	Introduction	35
3.2	Materials	35
3.2.1	Ordinary Portland Cement	36
3.2.2	Aggregates	36
3.2.3	Water	37
3.2.4	Polyethylene fibers	37
3.3	Experimental program	38
3.3.1	Experimental Flow Chart	39
3.4	Mixing and casting of concrete	41
3.4.1	Mix design	41
3.4.2	Mixing of concrete	41
3.4.3	Casting of concrete	42
3.5	Testing Procedure	43
3.5.1	Fresh Density Test (Unit Weight)	43

3.5.2	Slump test	44
3.5.3	Compressive test	45
3.5.4	Splitting tensile strength test	46
3.5.5	Flexural test	47
3.5.6	Water Absorption test	49
3.6	Questionnaire Survey	50
3.6.1	Research goals and methodology	50
3.6.2	Preparation of questionnaire survey	50
3.6.3	Information about participants	51
3.7	Conclusion	52
4	RESULTS AND DISCUSSION	54
4.1	Introduction	54
4.2	Fresh properties test results	54
4.2.1	Slump test	54
4.2.2	Fresh density test	55
4.3	Hardened properties test	56
4.3.1	Compressive strength test	56
4.3.2	Splitting tensile strength test	61
4.3.3	Flexural strength test	63
4.3.4	Water absorption test	68
4.4	Questionnaire survey	69
4.4.1	The use of plastic fibers in concrete	69
4.4.2	Expected outcome of PFRC	72
4.4.3	Future perspective of PFRC	73
4.5	Conclusion	75
5	CONCLUSION AND RECOMMENDATIONS	77
5.1	Introduction	77
5.2	Conclusion	77
5.3	Achievement of objectives	79
5.4	Recommendations for Future Research	81

REFERENCES	82
APPENDICES	89
APPENDIX A	89
APPENDIX B	94
APPENDIX C	96

LIST OF TABLES

Table No		Page
2.1	Recycling method and properties of plastic fibers used in concrete	12
2.2	Effect of Age on Concrete Strength	20
2.3	Mix proportions of concrete.	20
2.4	Strength test on nylon and polypropylene FRC versus plain control concrete	22
2.5	Drying shrinkage strain of hybrid fiber – reinforced concrete	25
3.1	Materials needed for concrete mixture.	41
4.1	Slump test results	55
4.2	Density of concrete	56
4.3	Water absorption results	69
C1	Compressive strength of PFRC	96
C2	Splitting tensile strength of LPF 7 days	97
C3	Splitting tensile strength of SPF 7 days	97
C4	Splitting tensile strength of LPF 28 days	98
C5	Splitting tensile strength of SPF 28 days	98
C6	Flexural strength of LPF 7 days	99
C7	Flexural strength of SPF 7 days	99
C8	Flexural strength of LPF 28 days	100
C9	Flexural strength of SPF 28 days	100

LIST OF FIGURES

Figure No		Page
1.1	Theoretical framework	4
2.1	Different type of fibers	15
2.2	Types of steel fibers	28
3.1	Washing process of polyethylene bags	37
3.2	Cutting process of plastic bags	38
3.3	Experimental Flow Chart	40
3.4	Concrete mixer	42
3.5	Measuring the weight of concrete	44
3.6	Slump test	44
3.7	Compression strength test equipment	46
3.8	Process of splitting tensile strength test	47
3.9	Beam ready for testing	48
3.1.0	Furnace	49
3.1.1	Information about respondents	52
3.1.2	Level of education and work experience	52
4.1	From left to right, control mix (CM) and PFRC 0.2%	57
4.2	Compressive strength at 7 days	58
4.3	Compressive strength at 28 days	59
4.4	Compressive strength at 56 days	60
4.5	Load Deflection curve of PFRC with long fibers	60
4.6	Load Deflection curve of PFRC with short fibers	60
4.7	Splitting tensile strength at 7 days	62
4.8	Splitting tensile strength at 28 days	63
4.9	Flexural strength at 7 days	64
4.1.0	Flexural strength at 28 days	65
4.1.1	Plain concrete tested at 28 days	66
4.1.2	Cracking moment of PFRC 0.2%	66
4.1.3	Cracking moment of PFRC 0.1%	67
4.1.4	Load Deflection curve of LPF	67

4.1.5	Load Deflection curve of SPF	68
4.1.6	Percentage opinions on addition of plastic fibers in concrete	70
4.1.7	Opinions according to environmental friendliness of PFRC	70
4.1.8	Acceptability percentages of utilization of plastics in concrete	71
4.1.9	Alternative utilization way of concrete	71
4.2.0	Statistics of monthly usage of concrete and probable replacement by PFRC	72
4.2.1	Type of concrete used in construction site	72
4.2.2	Probable usage of PFRC in construction	73
4.2.3	Statistics of future perspective of PFRC	74
4.2.4	Influence of this research towards the environment	74
4.2.5	Responses about the cost of PFRC and usage in seismically active areas	75
B1	Compacting of concrete on the vibration table	94
B2	Addition of plastic fibers	95

LIST OF ABBREVIATIONS

ACI	American Concrete Institute
BS	British Standard
CM	Control mix
FRC	Fiber Reinforced Concrete
HDPE	High-density polyethylene
LPF	Long plastic fibers
PET	Polyethylene terephthalate
PF	Plastic fibers
PFRC	Plastic Fiber Reinforced Concrete
SFRC	Steel Fiber Reinforced Concrete
PP	Polypropylene
PVC	Polyvinyl chloride
SPF	Short plastic fibers

CHAPTER 1

INTRODUCTION

1.1 General

The construction industry, since ancient times, is not a separable part of mankind's history. Due to the development of the construction industry, people live and work in comfortable apartments and offices. In modern times, people may live wherever they desire. Since the middle of the 20th century construction industries have started to boom which have continued to develop until now. The world is changing gradually, towards constant development; and thus, affecting our environment. Owing to new technologies, it is now become possible to build new towns with full infrastructures in a short time. The construction race has been launched all over the world!

One of the main materials used in construction is concrete. Due to many advantages, such as durability, strength, resistance against physical and mechanical attacks made this material recognized worldwide. The history of using this material takes place thousands of years back to Ancient Rome. They used concrete similar to our modern one and left priceless cultural heritage behind such as the Coliseum and the Pantheon. Over the centuries, it has evolved to modern concrete until Joseph Aspdin invented Portland cement in 1824, the main ingredient in concrete. The beginning of the 20th century became the Century with the greatest development in the construction industry. (Concrete history timeline – Full linear version, 2017).

Despite the durability of concrete, this material also possesses some disadvantages such as its weakness for tensile strength. Numerous research has been conducted to improve the strength of concrete. In order to enhance this property, in 1970's fiber reinforced concrete was introduced as a way to strengthen the concrete. This invention started the development in strengthening concrete with different types of fibers, such as; still fibers, natural fibers, plastic fibers, glass fibers, etc. Traditional concrete can be improved from brittle to ductile with the addition of fibers. Concrete

REFERENCES

Ahmed, M., Mallick, J., Hasan, M.A. (2016, July) A study of factors affecting the flexural tensile strength of concrete. *Journal of King Saud University-Engineering Sciences*, 28(2), 147-156.

Akca, K.R, Cakir, O., Ipek, M. (2015, November, 15) Properties of polypropylene fiber reinforced concrete using recycled aggregates. *Construction and Building Materials*. 98, 620-630.

Al-Hadithi, A.I., Hilal, N.N. (2016) The possibility of enhancing some properties of self-compacting concrete by adding waste plastic fibers. *Journal of Building Engineering* 8, 20-28.

Allan, M.L., Kukacka, L.E., (1995, April) Strength and durability of polypropylene fibre reinforced grouts. *Cement and Concrete Research*, 25(3), 511-521

Andonian, R., Cotterell, B. "Polypropylene cellulose fiber – cement hybrid composites" (1980).

Ardehana, A.L., Desai, A.K. (2012) Durability of Fiber Reinforced Concrete of Marine Structures. *International Journal of Engineering Research and Applications*. 2(4), 215-219.

Bangi, M.R., Horiguchi, T. (2012, February) Effect of Fibre Type and Geometry on Maximum Pore Pressures in Fibre – Reinforced High Strength Concrete at Elevated Temperatures. *Cement and Concrete Research*, 42(2) 459-466.

Berkowskia, P., Kosior-Kazberuk, M. (2015) "Effect of Fiber on the Concrete Resistance to Surface Scaling Due to Cyclic Freezing and Thawing" *Procedia Engineering*. 111, 121-127.

Cao, Q., Cheng, Y., Cao, M., Gao, Q. (2017, January 30) "Workability, strength and shrinkage of fiber reinforced expansive self-consolidating concrete" *Construction and Building Materials*, 131, 178-185

Cavdar, A. (2013, February) The effects of high temperature on mechanical properties of cementitious composites reinforced with polymeric fibers. *Composites Part B: Engineering*, 45(1), 78-88.

Chanh, N.V., (2004) Steel fiber reinforced concrete. Faculty of Civil Engineering Ho Chi Min City University of Technology. 108-116.

Choi, J., Lee, B.Y., Ranade, R., Li, V.C., Lee, Y. (2016, July) “Ultra-high-ductile behavior of a polyethylene fiber-reinforced alkali activated slag-based composite.” *Cement and Concrete Composites*, 70, 153-158.

Classification of Aggregates as per Size and Shape-Coarse and Fine Aggregates, (2017). Retrieved from <http://theconstructor.org/building/classification-of-aggregates-size-shape/12339/>

Compressive Strength of Concrete & Concrete Cubes. (2017) Retrieved from <http://civildigital.com/compressive-strength-concrete-concrete-cubes/>.

Concrete history timeline-Full linear version. Retrieved from <https://www.concretenetwork.com/concrete-history/>.

Concrete Slump Test-Procedure and Results. (2017) Retrieved from <http://theconstructor.org/concrete/concrete-slump-test/1558/>

Cuchhiara, C., Mendola, L.L., Papia, M. (2003) Effectiveness of stirrups and steel fibres as shear reinforcement. *Cement and Concrete Composites*. 26(7), 777-786.

De Oliveira, L.A., Castro-Gomes, J.P. (2011, April) Physical and mechanical behaviour of recycled PET fibre reinforced mortar. *Construction and Building Materials*. 25(4), 1712-1717.

Fiber-reinforced concrete, (2009).Retrieved from https://en.wikipedia.org/wiki/Fiber-reinforced_concrete.

Fike, R., Kodur, V. (2011, October) Enhancing the Fire Resistance of Composite Floor Assemblies through the use of Steel Fiber Reinforced Concrete. *Engineering Structures*, 33(10), 2870-2878.

Frazao, C., Camoes, A., Barros J., Goncalves, D. (2013) Durability of Steel Fiber Reinforced Self-Compacting Concrete. University of Minho, Department of Civil Engineering. 93 – 102.

Grabois, T.M., Cordeiro, G.C., Filho, R.D.T. (2016, February 1) “Fresh and hardened-state properties of self-compacting lightweight concrete reinforced with steel fibers” *Construction and Building Materials*, 104, 284-292.

Gu L., Ozbakkaloglu, T. (2015) Use of recycled plastic in concrete: A critical review. *Waste Management* 51, 19-42.

Hager, I. (2013, March) Behavior of cement concrete at high temperature. *The Journal of Polish Academy of Sciences*, 61(1), 145-154.

Han, C.H., Hwang, Y.S., Yang, S.H., Gowripalan, N. (2005) Performance of spalling resistance of high performance concrete with polypropylene fiber contents and lateral confinement. *Cement and Concrete Research*, 35(9), 1747-1753.

Holschemacher, K., Mueller, T., Ribakov, Y. (2010, May) Effect of steel fibres on mechanical properties of high-strength concrete. *Material & Design (1980-2015)* 31(5), 2604-2615.

Hsie, M., Tu, C., Song, P.S. (2008, October 25) Mechanical properties of polypropylene hybrid fiber-reinforced concrete, *Materials Science and Engineering: A*, 494(1-2), 153-157.

Jameran, A., Ibrahim, I.S., Yazan, S.H.S., Rahim, S.N.A.A. (2015) Mechanical properties of steel-polypropylene fibre reinforced concrete under elevated temperature. *Procedia Engineering*. 125, 818-824.

Janssen, D. J., Snyder, M.N. (1994, June) Resistance of concrete to Freezing and Thawing. *National Academy of Sciences*.

Jun Li, J., gang Niu, J., jun Wan, C., Jin, B., liu Yin, Y. (2015) Investigation on mechanical properties and microstructure of high performance polypropylene fiber reinforced lightweight aggregate concrete. *Construction and Building Materials*. 118, 27-35.

Kaiping, L., Hewei, C., Jing'en, Z. (2004) Investigation of brucite-fiber-reinforced concrete. *Cement and Concrete Research*. 34(11), 1981-1986.

Kakooei, S., Akil, H.M., Jamshidi, M., Rouhi, J. (2012, February) The effects of polypropylene fibers on the properties of reinforced concrete structures. *Construction and Building Materials*, 27(1), 73-77.

Karahan, O., Atis, C.D. (2011, February) The durability properties of polypropylene fiber reinforced fly ash concrete. *Material & Design*, 32(2), 1044-1049.

Kim, S.B., Yi, N.H., Kim, H.Y., Kim, J.J., Song, Y.C. (2010) Material and structural performance evaluation of recycled PET fiber reinforced concrete. *Cement and Concrete Composites*. 32(3) 232-240.

Lie, T.T., Kodur, V.K.R (1996) "Thermal and Mechanical Properties of Steel-Fibre-Reinforced Concrete at Elevated Temperatures" *Canadian Journal of Civil Engineering*, 23(2), 511-517.

Lin, J.H., Huang, C.L., Liu, C.F., Chen, C.K., Lin, Z.L., Lou, C.W. (2015) "Polypropylene/Short Glass Fibers Composites: Effects of Coupling Agents on Mechanical properties, Thermal Behaviors, and Morphology " *Materials (Basel)*, 8 (12), 8279-8291.

Macginley, T.J., Choo, B.S. (2001) Reinforced Concrete: Design Theory and Examples, 2nd ed. London: Spon Press.

- Mazaheripour, H., Ghanbarpour, S., Mirmoradi, S.H., Hosseinpour, I. (2011) The effect of polypropylene fibers on the properties of fresh and hardened lightweight self-compacting concrete. *Construction and Building Materials*, 25(1), 351-358.
- Mello, E., Ribellato, C., Mohamedelhassan, E. (2014) Improving Concrete Properties with Fibers Addition. *International Journal of Civil, Environmental, Construction and Architectural Engineering*. 12(3) 249-254.
- Musmar, M. (2013) Tensile strength of Steel Fiber Reinforced Concrete. *Contemporary Engineering Sciences*. 6(5), 225-237.
- Naaman, A. E., Garcia, S., Korkmaz, M., Li, V. C (1996) ‘Investigation of the use of carpet waste PP fibers in concrete. *Materials for the New Millennium*, 1, 782-791
- Neville, A.M. (1995) Properties of Concrete, 4th ed.
- Nguyen, V.C. (2001) Steel Fiber Reinforced Concrete, Ho Chi Minh City University of Technology. 108-116.
- Nili, M., Afroughsabet, V. (2010, June) The effects of silica fume and polypropylene fibers on the impact resistance and mechanical properties of concrete. *Construction and Building Materials*. 24(6), 927-933.
- Olivito, R.S., Zuccarello, F.A. (2010, April) An experimental study on the tensile strength of steel fiber reinforced concrete. *Composites Part B:Engineering*.
- Patil, S.P., Sangle, K.K. (2016, June) Tests of steel fibre reinforced concrete beams under predominant torsion” *Journal of Building Engineering* 6,157-162.
- Rostasy, F.S., Hartwich, K. (1985, February) “Compressive strength and deformation of steel fibre reinforced concrete under high rate of strain” *International Journal of Cement Composites and Lightweight Concrete*. 7(1), 1985.
- Siddique, R., Khabit J., Kaur, I., (2007) Use of recycled plastic in concrete: A review. *Waste Management*. 28, 1835-1852.

Solving the plastic problem. (2017) Retrieved from <http://www.thestar.com.my/opinion/letters/2017/01/21/solving-the-plastic-problem/>.

Song, P.S., Hwang, S., Sheu, B.C. (2005, August) “Strength properties of nylon- and polypropylene-fiber-reinforced concretes” *Cement and Concrete Research* 35(8), 1546-1550.

Thompson R.C., Moore C. J., vom Saal, F.S., Swan, S.H. (2009) Plastics, the environment and human health: current consensus and future trends. *Philosophical transactions of the royal society B Biological Sciences*. 364(1526).

Types of Portland Cement. (2017) Retrieved from http://iti.northwestern.edu/cement/monograph/Monograph3_8.html.

Wang, Y., Zureick, A.H., Cho, B.S., Scott, D.E., (1994, January) Properties of fiber reinforced concrete using recycled fibers from carpet industrial waste. *Journal of Materials Science*. 29(16), 4191-4199.

Wegian, F.M., Alanki, A.A., Alsaeid H.M., Alotaibi, F.A., Al-Mitairi, M.S., Kandari, F.A. (2011) Influence of Fly Ash on Behavior of Fibres Reinforced Concrete Structures. *Journal of Applied Sciences*, 11(17), 3185-3191.

Wells, J. (1985) The Role of Construction in Economic Growth and Development. *Habitat International*. 9(1), 55-70.

Xiao, J., Falkner, H. (2006, March) “On residual strength of high-performance concrete with and without polypropylene fibres at elevated temperatures” *Fire Safety Journal*, 41(2), 115-121.

Yehia,S., Douba, A., Abdullahi, O., Farrag, S. (2016, September 15) Mechanical and Durability Evaluation of Fiber-Reinforced Self-Compacting Concrete. *Construction and Building Materials*, 121, 120-133.

Yin, S., Tuladhar, R., J. Riella, Chung, D., Collister, T., Combe, M., Sivakugan N. (2016, July 1) Comparative evaluation of virgin and recycled polypropylene fibre reinforced concrete. *Construction and Building Materials*, 114, 134-141.