T. R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF CIVIL ENGINEERING

EFFECT OF POLYPROPYLENE FIBER ON THE STRENGTH PROPERTIES OF STRUCTURAL LIGHTWEIGHT CONCRETE WITH DIFFERENT UNIT WEIGHTS

M.Sc. THESIS

PREPARED BY: FARAYDON HAMA RASH W. MAHMOD
SUPERVISOR: Assoc. Prof. Dr. Mucip TAPAN

VAN-2019

T. R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF CIVIL ENGINEERING

EFFECT OF POLYPROPYLENE FIBER ON THE STRENGTH PROPERTIES OF STRUCTURAL LIGHTWEIGHT CONCRETE WITH DIFFERENT UNIT WEIGHTS

M.Sc. THESIS

PREPARED BY: Faraydon Hama Rash W. MAHMOD

VAN-2019

ACCEPTANCE and APPROVAL PAGE

This thesis entitled "Effect of Polypropylene Fiber on The Strength Properties of Structural Lightweight Concrete With Different Unit Weights" presented by Faraydon Hama Rash W. MAHMOD under supervision of Mücip TAPAN in the department of civil engineering has been accepted as a M. Sc. thesis according to Legislations of Graduate Higher Education on 10/09/2019 with unanimity of votes members of jury.

Chair: Assoc. Prof. Dr. Ercan IŞIK	Signature:
Member: Assoc. Prof. Dr. Mücip TAPAN	Signature:
Member: Dr. Barış ERDİL	Signature:
Member:......................................	Signature:
Member:......................................	Signature:

This thesis has been approved by the committee of The Institute of Natural and Applied Science on ..20../..09../..2019. with decision number ..2019/52-I

Signature

Director of Institute

THESIS STATEMENT

All information presented in this thesis is obtained in a frame of ethical behavior and academic rules. In addition, any information that is obtained from other sources has been cited appropriately in the thesis prepared according to the thesis writing rules.

Faraydon Hama Rash W. Mahmod

ABSTRACT

EFFECT OF POLYPROPYLENE FIBER ON THE STRENGTH PROPERTIES OF STRUCTURAL LIGHTWEIGHT CONCRETE WITH DIFFERENT UNIT WEIGHTS

MAHMOD, Faraydon Hama Rash.W
M.Sc. Thesis, Civil Engineering
Supervisor: Assoc. Prof. Dr. Mucip TAPAN
September 2019, 62 pages

Structural Lightweight Concrete (SLWC) is a commonly used type of concrete in the civil engineering field due to its significant properties such as: better thermal fire resistance and lower unit weight compared with conventional concrete. In this study, pumice stone as a type of lightweight aggregate is used in different sizes from 0.5 to 2 mm to produce three different unit weights of lightweight concrete (G1, G2, and G3) with various percentages of polypropylene fiber volume (0.0 %, 0.25%,0.50%). This study investigated the effect of unit weight and polypropylene fiber on the fresh properties of lightweight concrete such as workability. The effects on the mechanical properties of lightweight concrete were also studied such as compressive strengths, flexural strengths, split tensile strength, thermal conductivity and evaluated temperatures (200, 400, 600 and 800^{o}C). With the reduction of the unit weight of lightweight concrete an increase in workability is observed while the higher the volume of pp fiber the workability increases. With an increase in the volume of polypropylene fiber from 0% to 0.5% and a decrease in the unit weight of lightweight concrete the compressive strength and the split tensile strength decreases. However, the flexural strength, thermal conductivity and evaluated temperatures (200, 400, 600 and 800oC) are all improved. When the percentage of polypropylene fiber is increased from 0.0% to 0.50% the optimum vale of flexural strength is obtained and found to be 2.5 MPa. Without the addition of pp fiber, the maximum values of compressive strength and split tensile strength are obtained to be 30 MPa and 2.11 MPa respectively.

Keywords: Fire resistance, Mechanical property, Polypropylene fiber, Pumice aggregate, SLWC, Thermal conductivity, Unit weight.

ÖZET

POLİPROPİLEN LİFİN FARKLI BİRİM HACİM AĞIRLIĞINA SAHİP TAŞIYICI HAFİF BETONLARIN DAYANIM ÖZELLİKLERİ ÜZERİNDEKİ ETKİLERİ

MAHMOD, Faraydon Hama Rash. W
Yüksek Lisans Tezi, İnşaat Mühendisliği
Tez Danışmanı: Assoc. Prof. Dr. Mucip Tapan
September 2019, 62 sayfa

Taşiyici hafif ağırlıklı beton (THAB) genellikle normal betona göre daha düşük ısıl iletkenliğe, daha iyi yangın dayanımına ve daha düşük birim hacim ağırlığa sahip olduğundan dolayı inşaat mühendisliği uygulamalarında kullanılmaktadır. Bu çalışmada, tane büyüklüğü 0.5-2 mm olan pomza agregası ile farklı oranlarda (0.0%, 0.25%, 0.50%) polipropilen lif katkılı farklı birim hacim ağırlığa sahip taşıyıcı hafif beton üretilerek, beton birim hacim ağırlığının taşıyıcı hafif betonların basınç, eğilme ve yarmada çekme dayanımları, ile termal iletkenlik ve yangın dayanımları üzerindeki etkileri belirlenmiştir. Üretilen numunelerin ultrasonik hız (UPV) ölçümleri ile basınç dayanımları arasındaki ilişki ayrıca incelenmiştir. Çalışma sonucunda, taşıyıcı hafif betonların işlenebilirlik özellikleri birim hacim ağırlığı ile ters orantılı olduğu polipropilen lif miktarının artmasıyla da azaldığı görülmüştür. Lif katkılı taşıyıcı hafif betonların optimum eğilme dayanımları %0.5 lif katkısı ile 2.5 MPa olarak elde edilmiştir. Sonuç olarak, birim hacim ağırlığı 1585 kg/m^3 ve silindirik basınç ve yarmada çekme dayanımları sırasıyla 30 ve 2.11 MPa olan taşıyıcı hafif beton üretilmiştir.

Anahtar Kelimeler: Brim hacim ağırlık, Taşıyıcı hafif beton, Isıl iletkenlik, Basınç Dayanımı, Eğilme Dayanımı, Pomza, Polipropilen lif.

ACKNOWLEDGMENT

In the name of God, the Gracious, the Merciful. First of all, I would like to express my deep gratitude to God.

I would like to take this opportunity to express my profound gratitude and deep regard to my survivor supervisor Assoc Dr: Mucip Tapan, for his outstanding guidance, valuable suggestions, and assistance. I would also like to extend my gratitude to the chair of the Civil Engineering department dearAssoc Dr: Murad for his support. I also thank all the other members of the civil engineering department for their assistance during this thesis. Special thanks go to the staff of the concrete laboratory for their constant help with utilizing the required materials and equipment.

I'm very thankful to my family members, my lovely wife (Banaz) and dear son (Parsa) for their forbearance and help throughout this period of my life. Finally, my completion of this project could not have been achieved without the endless enthusiasm and encouragement from my friends. They have helped with the experimental work as well as with the printing.

2019
Faraydon Hama Rash W. Mahmod

TABLE OF CONTENT

Page

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

Figure **Page**

Figure **Page**

SYMBOLS AND ABBREVIATIONS

Along with a description of some symbols and abbreviations used in this study are presented below:

Symbols	Explanation
N	Axial force
mm	Millimeter
kn	Kilo Newton
MP	Mega Pascal
Kg	kilo gram
C^0	Celsius

Abbreviations	Explanation
UPV	Ultrasonic Pulse Velocity

APPENDIX INDEX

1. INTRODUCTION

1.1. Background

Structural Lightweight Aggregate Concrete (SLWAC) has been known for centuries. It is not a new finding in the history of concrete technology and engineering. It is easy to reach a great number of references related to SLWAC. Centuries back, natural aggregates such as volcanic origin, scoria and pumice were used to manufacture lightweight concrete. In the 3rd millennium B.C, the Sumerians made use of lightweight materials in the construction of Babylon buildings (Fig. 1.1) (Chandra, Satish and Leif Berntsson, 2008). The history of producing lightweight aggregate from natural resources goes back to pre-Roman periods, and its production continues in present-day with volcanic porous rocks. As a matter of fact, the materials from regions of volcanic activities are limited. In the 19th century, while reinforced concrete developed, and due to non-existence of natural porous aggregate in the developed countries, researches started to manufacture artificial aggregate (Clarke, 1993).

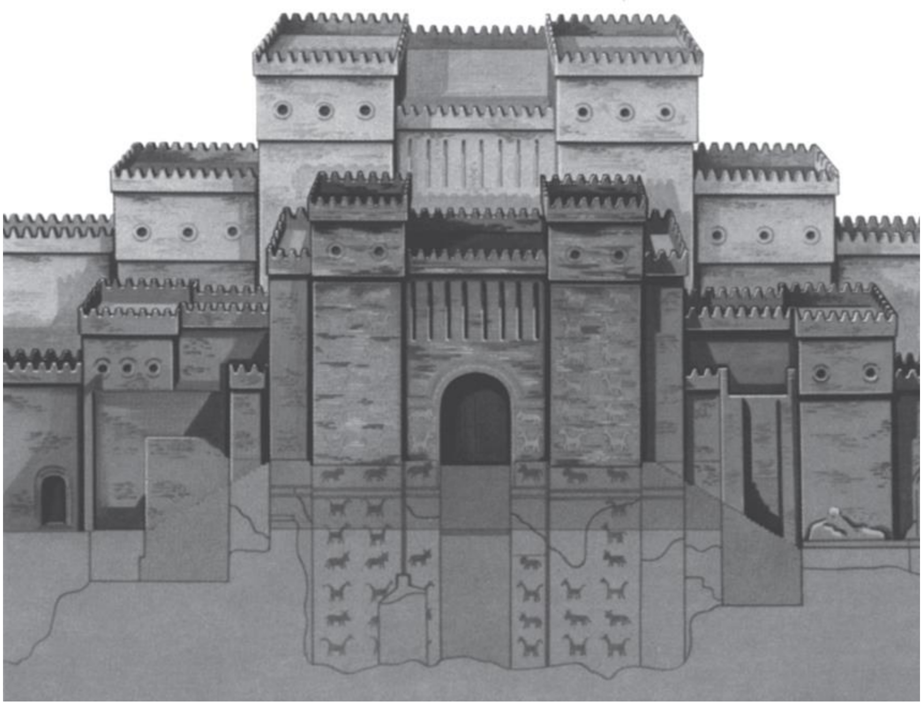


Figure 1.1 Babylon, Iraq, built by Sumerians in the 3rd millennium B.C. (Chandra, Satish and Leif Berntsson, 2008).

Structural lightweight concrete can be defined by a minimum compressive strength of 17 MPa and a unit weight between 1350 and 1900 kg/m^3 (ACI-213R-87, 1998). Structural lightweight aggregate concrete (SLWAC) can be used to reduce the weight of structures. (B. Devi Pravallika1, 2015). Structural lightweight aggregate concrete (SLWAC) has been inspected and successfully utilized in the civil engineering field for many years, especially in long-span bridges, marine platforms, and high rise buildings (Li Jing jun et al., 2016) due to its higher strength to weight ratio (Nahhas, 2013). Lightweight concrete has a great number of advantages as compared to normal weight concrete such as higher strength/weight ratio, low density, improved fire resistance, better durability property, low thermal conductivity coefficient (Libre et al., 2010), better tensile strain capacity and superheat and sound insulation characteristic due to present air voids in lightweight aggregate. In spite of the various advantages, lightweight concrete has disadvantages such as higher brittleness and lower mechanical properties, after peak loads due to the previous failure of lightweight concrete structures (Li Jing junet al.,2016). Using lightweight concrete reduces the dead load of structures which results in smaller cross-section in beams, walls, foundations, and columns. Also reduces the danger of earthquake damages to structures by decreasing the total unit weight of the structure. Usually, natural or artificial lightweight aggregate (LWA) is utilized for replacing parts or fully replacement with conventional aggregate in order to produce structural lightweight aggregate concrete (SLWAC). These aggregates, artificial or natural are available in different places of the world (Libre et al.,2010). Pumice is mostly found in natural lightweight coarse aggregate which is utilized in the production of concrete. Lightweight pumice aggregate (LPA) is a natural aggregate of volcanic origin. It has a low specific gravity (Muralitharan, and Ramasamy, 2017). It is formed by omitting gases in the process of lava solidification. The pumice has a cellular structure produced by the formation of air voids or bubbles when the trapped gases in the molten lava flowing through volcanoes are cooled. The cells are parallel and elongated to each other sometimes interlink. Several countries of the world used volcanic pumice aggregate to produce of lightweight concrete, to date; the use of pumice has been dependent on limited and availability to countries where it can be easily imported or locally available. The lightweight concrete produced by pumice aggregate is measured to be two to three times lighter than conventional concrete (Khandaker and Anwar, 2003). Figure 1.2 shows three methods of manufacture lightweight concrete. The lightweight concrete can be classified according to the production methods:

1. Utilizing a low-density lightweight aggregate by replacing the conventional aggregate.
2. Aerated concrete this type of concrete can be obtained by injecting gas or air bubbles into the concrete and mortar; this is also known as foamed concrete.
3. No-fine aggregate, it is a kind of lightweight concrete, in which the fine aggregates of conventional concrete are omitted. This concrete contains only cement, coarse aggregates, and water. (Neville, 2010), (Mohammed et al., 2014).

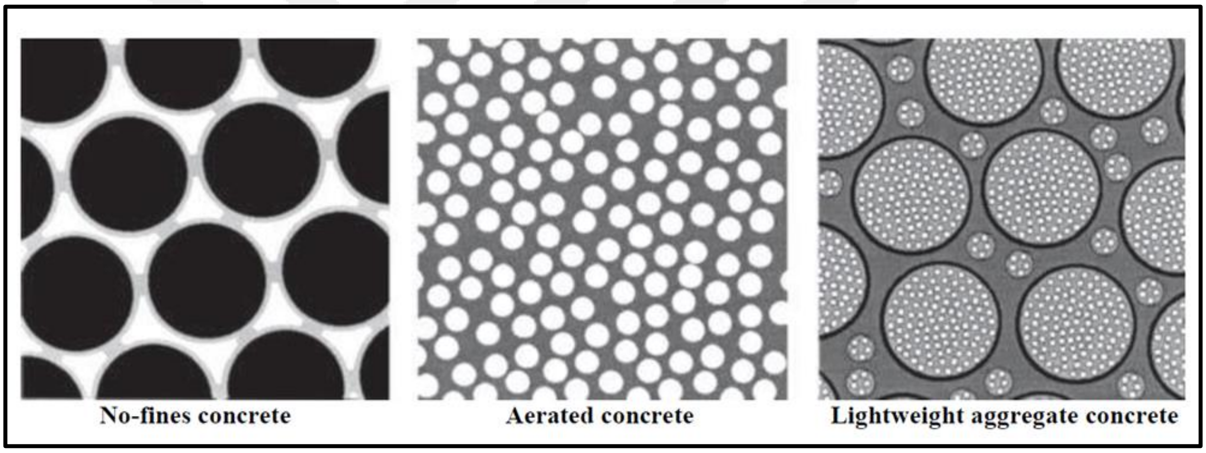


Figure 1.2. Basic shapes of lightweight concrete (Mohammed & Hamad, 2014).

The Purpose of using lightweight concrete can be categorized into three types according to the purpose of using:

1. Structural lightweight concrete with an approximate density range of 1400-1800 kg / m^3 and cylinder compression strength for 28 days or more should be around 17 MPa.
2. Masonry concrete has a density range of (500-800) kg / m^3 and a compressive strength between 7-14 MPa.
3. The heat-insulating concrete has a unit weight of less than 800 kg/m^3 and compressive strength of 0.7-7 kg / m^3, but a thermal coefficient of about 0.3 J / m^2 sec ° C / m. (Mohammed et al., 2014) (Neville, 2010).

One of the techniques to increase the properties of concrete is by dispersing fiber into the concrete. These fibers are synthetic fibers which can be obtained from textile manufacturing and they are obtainable in various shapes and at a cheap price. Polypropylene fibers (PP Fibers) have low specific gravity and low cost. The usage of fibers directly affects the tensile and flexural strengths and it is an important addition to the concrete to decrease plastic shrinkage and thermal cracking (Dharan, Divya S and Aswathy Lal, 2016). Around 3 to 4 decades ago, fibers were used in various researches; however, they were not popular or widely used. As it is very well known concrete has high compressive strength and tensile strength. For this reason, steel reinforcement can be provided to improve the tensile strength but it does not increase durability control cracks. So, polypropylene fiber is the best solution to be used in reinforced concrete to increases the flexural strength and decreases the post cracking behavior (Kumar, Pawan and Dr. A.K. Mishra, 2016). The structures utilizing Fiber Reinforced Concretes has increased. The advantage of using reinforced fibers in the concrete include: increasing the flexural strength, impact strength, toughness, tensile strength also the failure mode of the concrete. The PP fibers added to concrete has no effect or very insignificant effect on the modulus of elasticity and compressive strength. The usage of fiber in a concrete mixture depends on several parameters such as fiber volume, fiber geometry, fiber type, fiber aspect ratio and maximum aggregate size. Addition of fiber to concrete decreases the workability of concrete (Mazaheripour, H et al. 2011). Polypropylene fiber and silica fume affect the mechanical properties of lightweight concrete and resist higher temperatures. The flexural and compressive strengths of reinforced lightweight concrete with pp fiber drop when the temperature increases. While the compressive strength decreases and then increases a little (Shihada and Samir, 2017). The most common way to increase the ductility and strength of concrete is by adding different types of fibers in the concrete mixture. Fiber volume, elastic modulus, aspect ratio and tensile strength of fibers are the most significant properties of fibers that have effects on ductility and concrete strength (Guler, 2018). In this study, polypropylene fiber (12 mm) type is used; it is utilized in proportions of (0.25%, 0.5 % and 0.75%) in volume. The effects of different amounts of polypropylene fiber on the compressive, flexural strength, splitting tensile and workability, as well as compressive and flexural toughness of structural light concretes have been investigated.

1.2. Objective

The main objective of this study is to investigate the effects of fiber content, unit weight and high temperature parameters on the compressive strength of fiber-reinforced structural lightweight concrete. In order to achieve these objectives, firstly, the effect of different volume of polypropylene fiber on the stress-strain curve and the compressive and flexural strength of fiber-reinforced structural lightweight concrete will be determined. Then ultrasonic pulse velocity measurements will be conducted on structural lightweight concrete samples, before and after being exposed to high temperature. This will be done in an attempt to determine the correlation between compressive strength and UPV values of structural lightweight concrete that are exposed to fire. The effect of polypropylene fiber on the residual compressive strength of structural lightweight concrete while exposed to fire will also be obtained. On the other hand, the thermal conductivity properties of each mix will be evaluated. The effect of different amounts of polypropylene fiber and pumice on the compressive strength, splitting tensile strength, flexural strength and workability, as well as compressive and flexural toughness and unit weight of structural lightweight concrete, will be discussed in detail.

1.3. Significance

For structural applications of lightweight concrete, having desired strength with less unit weight will reduce the self-weight of the structural elements, foundation size, and construction costs (Rossignolo, Marcos V. and Jerusa A.2003). Lightweight pumice aggregate is available around the city of Van in Turkey, so it is significant to make use of the lightweight aggregate to produce structural lightweight concrete. In this study, fine-grained pumice aggregate will be used to produce normal strength lightweight concrete. Polypropylene synthetic fibers with low volume ratios (0.25% to 0.5%) will be utilized to increase the strength and toughness capacities of structural lightweight concrete. The change in compressive, splitting tensile and flexural strength of structural lightweight concretes with the use of PP fibers will be studied. The thermal conductivity properties of structural lightweight concrete will also be studied in order to determine the insulation properties and energy saving in case of using structural lightweight concrete in buildings. Finally, the residual compressive strength of structural lightweight concrete samples after exposure to 200, 400, 600 and 800 0C will be determined in order to find the fire performance of structural lightweight concrete.

1.4. Thesis Outlines

Chapter 1: Introduction, Background, Object, Significant and Outline.
Chapter 2: Literature review.
Chapter 3: Materials and Method.
Chapter 4: Results.
Chapter 5: Conclusion.

2. LITERATURE REVIEW

In this chapter a brief review of available studies on lightweight concrete tests will be presented. To examine the properties of lightweight concrete, the properties of strength, temperature and durability must be studied both expermentally and anatylicaly. To do this some of the best already done expermental investgations will be studied and understood. The following literature reviews are analysed.

The interest in using fibers for the reinforcement of composites has improved during the last several years. kolli,Ramujee (2013) studied the strength properties of polypropylene fiber reinforced concrete. In this paper, compressive strength, splitting tensile strength of concrete samples made with various amount of fibers (0%, 1%,1.5%,2%) were determined. The maximum compressive strength (45.25 Map) obtained by 1.5% of polypropylene fiber content.

Guler.S (2018) studied the effects of fiber on the strength and toughness of structural lightweight concrete. In this study, two different sizes (12 and 14 mm) polyamide fiber was used. It was concluded that by using 0.75 hybrids (micro and macro) polyamide fibers, the workability was reduced whereas the compressive strength, toughness, splitting tensile strength and flexural strength of structural lightweight concrete were increased (Gluer, 2018).

Dharan and Aswathy (2016) conducted an experimental study in order to determine the effects of various amounts of (0.5%,1%,1.5%,2%) polypropylene fibers on the strength of structural concrete. It was concluded that, by using an optimum 1.5% of fiber, the compressive, flexural strength and modulus of elasticity of the concrete were improved.

Shihada (2017) investigated the impact of polypropylene fibers on fire resistance in concrete. In order to obtain this, concrete mixtures were prepared by utilizing various percentages of polypropylene: 0%, 0.5%, and 1%, by volume. The samples were heated to 200, 400 and 600 ^{0}C temperatures for exposures up to 6 hours and tested for compressive strength. It was concluded that after fire exposure, the relative compressive strength of the samples with PP fibers were higher than those without the addition of PP fibers. After fire exposure, the highest residual compressive strength was obtained by using an optimum 0.5% of PP fiber.

This research paper provides an empirical study on polypropylene fiber reinforced concrete Mohod (2015). Milind (2015) studied the effects of adding different percentages of polypropylene fibers to high strength concrete properties (mixtures M30 and M40). A pilot program wasin work to explore its effects on compressive, tensile and flexural strength under various curing conditions. The main aim of the investigation program is to study the influence of polypropylene fiber mix by changing the content such as 0%, 0.5%, 1%, 1.5% and 2% and finding the optimum content of polypropylene fibers. A significant improvment in compressive, tensile and flexural strength was observed. However, further investigations have been recommended and should be carried out to gain a deeper understanding of the mechanical properties of fiber-reinforced concrete.

Lakshmi, S.,Gasper , M.Dinesh, and V.Balaji (2017) This study aims at comparing normal weight concrete and lightweight concrete, using mix M30 with polyethylene carboxyl ether admixture and the production the lightweight concrete using the partial replacement of coarse aggregate with different percentage ratios of pumice from (20%, 50%, 80%, and 100%) . Pumice stone is used in different proportions and different tests have been performed and compared with normal-weight concrete. The utilization percentage ratio 50% obtained low unit weight (1500kg/m3) and the high result compared to other ratios.

Minapu et al., 2014 (2014) In this project the mechanical properties of a structural grad lightweight concrete has been studied, utilizing the M30 mix, and using lightweight aggregate pumice stone as a partial replacement to normal weight coarse aggregate, fly ash and filica fume as mineral admixture. Fly ash and silica fume offer good strength, however, when pumice stone is replaced by 20% the strength reduced more than this percentage

Fibre Reinforced Light Weight Aggregate (Natural Pumice Stone) Concrete have been studied by Rao Kumari,et al., 2013 (2013). In this study, the used mix design was M20 and the best results were obatined at 20% of the lightweight aggregate pumice stone as a partial replacement to normal weight coarse aggregate and with 1.5% fiber.

Also, the average target with an average strength is obtained with M20 cocnerete mix and using 40% pumice and 05% fibers.

In this paper, the compressive and splitting tensile strength of lightweight concrete were affected by silica fume after high temperatures, this was proven theoretically and experimentally Harun Tanyildizi (2007**.** In the mixture, silica fume is used in different percentages of 0%, 10%, 20% and 30% to replace Portland cement. After the specimens are heated in an electric furnace up to 200, 400 and 800 C, they are then tested for splitting tensile and compressive strength. In the paper, the optimum compressive and splitting tensile strength were obtained when 20% silica fume was utilized for all temperatures. The the compressive and splitting tensile strength of lightweight concrete decreased with temperature starting from 200 C.

In this study, the experimental investigation on the properties of pumice lightweight aggregates concrete has been presented Parhizkar, M., and A.R (2011). Two groups of lightweight concrete are used such as lightweight fine with coarse aggregate concrete and natural fine with lightweight coarse aggregate concrete. The durability, mechanical and physical aspects of them are studied. The compressive and tensile strength of LCNF is 20% to 40 % lower than control concrete, but the unit weight of LCNF concrete 30 % lighter than control concrete. The compressive and tensile strength of LCF is 50 % lower than control concrete, but the unit weight of LCF is about 40 % lighter than control concrete.

Saini, Anil , Anurag , and Ashish (2018) this is an expermental paper which focuses on the strength parameters of the newly designed type of concrete. In this study, lightweight concrete has been produced by partially replacing normal coarse aggregate with different percentages of pumice aggregate from 8%, 16%, and 24% and using the M30 mix. The compressive strength improves when 16% of pumice lightweight aggregate is used to replace normal coarse aggregate and the increasing replacement percentage of normal weight coarse aggregate with pumice aggregate the unit weight is obsereved to decrease.

An experimental study was performed by Rajeswari S. (2015) to investigate the influence of replacing normal weight aggregate by different percentages of pumice lightweight aggregate . The study uses mix M25 and utilizes different percentages of pumice (20mm) from 50%, 60% and 70% to produce lightweight concrete to then compare to normal weight concrete . The maximum value of compressive strength is obtained when using 60% replacement of Pumice with coarse aggregate and comparable with normal concrete.

Alduaij, Khalid , M. Naseer , and Khalid (1999) in this research paper lightweight concrete has been produced by using various unit weight aggregates without using natural fine aggregate (no-fines concrete). The compressive strength in lightweight concrete was obtained 22 MPa in 28 days and 1520 kg/m³ dry unit weight.

An experimental investigation was undertaken by Subasi (2009), the study found the effect of utilizing fly ash in lightweight concrete created with expanded clay aggregate. The impacts on mechanical and physical properties of the concrete are studied. The lightweight concrete with 450 kg/m3 cement content and 10% flay ash replacement had the best strength value of 45.97 MPa.

A study was made by Kumar K. G. and C (2016) the research consists of two parts. In the first part, the mixes produced normal weight concrete M20, M25 and M30. In the second part the conventional concrete replaced by various percentages of pumice stone from 10%, 20% and 30%. In the study when M30 grade of concrete used with replacement percentage of 10%, can be effectively used for structural purpose.

An experimental study was performed by (Venkatesh, B. and B. Vamsi Krishna, 2015) to investigate the influence of the replacement of fly ash on the compressive strength in lightweight concrete. In the study, the M25 mix was used in the concrete, and pumice lightweight aggregate was used at various percentages from 25%, and 33.33% to replace normal weight aggregate and the replacement of cement by fly ash in various percentages of 15%,20%, 25%, and 30%. The usage of 25% pumice and 20% fly ash replacement obtained the best value for mechanical property of concrete .

Rai and Dr. Y.P joshi (2014) conducted an empirical study on fiber reinforced concrete. The different types of fibers and their applications are studied. The concrete properties are improved by the addition of polypropylene fibers, the compressive strength is increased by about 16% and the flexural strength increased by about 30% with the addition of polypropylene fibers. The ductility of concrete is improved by additional fibers, and slump test were carried out to find out the consistency and workability of the fresh concrete. The capacity of all-fiber reinforcement is dependent on the performance of a uniform division of the fibers in the concrete.

Karthik, M.,et al (2015) conducted experimental studies on the unit weight of normal weight aggregate concrete and lightweight aggregate concrete. In this study, concrete is produced by natural coarse aggregate which is then replaced by different percentages of pumice lightweight aggregate from 20% to 40% and with 0.5%, 1% & 1.5% of glass fiber and polypropylene fiber. At 0.5% polypropylene fiber and 20% pumice aggregate, the mechanical properties of lightweight concrete were obtained.

Sancak, Y. Dursun , and Osman (2008) have investigated structural lightweight concrete produced by both Pumice and normal weight concrete. In this research, the portaland cement in the concrete mixture was replaced by various percentages of silica fume from 0%, 5% and 10% in weight and adding superplasticizers (SP) by a ratio of 2% of weight. The density of lightweight concrete was 23% less than that of normal weight concrete. After being exposed to high temperatures the compressive strength and weight loss of the concrete were determined. The conventional weight of concrete saw a higher deterioration when compared to lightweight concrete.

Alsadey and Muhsen (2016) studied the effects of Polypropylene Fiber on the strength of concrete and the maximum quantity of polypropylene fibers required to obtain the maximum compressive strength, with the usage of M25 grade concrete. In this paper fibers and other admixtures are added in certain proportions into the concrete in an attempt to develop performance concrete. The utilization is done in various percentages of polypropylene fiber of 1%, 1.5% and 2%, the compressive strengths obtained were 26 N/mm^2 , 26.40 N/mm^2 and 28 N/mm^2 respectively. The best compressive strength of control mix without polypropylene fiber was determined to be 25 N/mm^2.

3. MATERIALS AND METHODS

In this section, the material choice, mix design and the procedure adopted in this project will be reported in detail. The mechanical and physical properties of the materials are illustrated in the tables and figures.

3.1. Selection of Materials

3.1.1. Cement

In this research, in all the concrete mixes ASTM Normal Portland Cement (NPC) CEM I 52.5R was used. This type of cement gave a compressive strength of 52.5 N/mm^2 (MPa) in 28 days. The specific gravity of the cement was found to be 3.156 g/cm^3. It is manufactured as TS EN 197-1-CEM Adana in Turkey. The cement must be new and of uniform consistency, if there is any proof of foreign matters or lumps in the cement, it must not be used. The cement must be stockpiled for an as short duration as possible and under dry conditions. Chemical and Physical properties of cement are given in Table 3.1and 3.2.

Table 3.1. Chemical compositions of Normal Portland Cement

Composition	Content(%)	standard
SiO_2	20.09	-
Fe_2O_3	3.87	-
Al_2O_3	4.84	-
CaO	64.02	-
MgO	1.15	Max 5.0
SO_3	2.83	Max 4.0
Loss On Ignition	2.36	Max 5.0
Insoluble Residue	0.34	Max 5.0
Free Lime	0.80	-
Alkali Equivalent(Na_2O type)	0.65	-
Total Additive	3.85	-

Table 3.2. Physical properties of Normal Portland Cement

Physical Properties	Content(%)	standard
Setting Time (Initial)	165	Min 45
Setting Time (Final)	275	-
Specific Gravity 3,156	3.156	-
Expansion	1	Max 10
Strength for 2 days	21.1	Min 30
Strength for 28 days	56.4	Min 52.5

3.1.2. Silica Fume

Silica fume is a material that is mostly used as a mineral admixture, it is composed of submicron particles (100 to 150 times smaller than a grain of cement), of amorphous (non-crystalline) silicon dioxide (SiO_2). It is considered a significant admixture in concrete due to its physical and chemical properties, for example it is a very reactive pozzolan. Concrete containing silica fume can be very durable and have high strength. Silicon metal and alloys are manufactured in electric furnaces. Silica fumes powder is used in this study in order to increase the fresh and hardened mechanical properties of structural lightweight concrete. Physical and chemical properties of silica fume are given in Table 3.3

Table 3.3. Chemical composition and physical properties of silica fume

Chemical and physical properties	contents
Specific gravity (g/cm^3)	2.2
Specific surface area (cm /g)	20
Loss on ignition (%)	1.89
SiO_2 content (%)	93.1
SO_3 content (%)	0.27
Fe_2O_3 content (%)	0.9
CaO content (%)	0.35
C content (%)	1.22
Total alkali	0.9
Moisture content (%)	0.3

3.1.3. Pumice Aggregate

Pumice is an extrusive igneous volcanic rock shaped through the rapid cooling of air-pocketed lava, which produces a rock which has a low-density and high-porosity. Fine-grained pumice with particle size of 0-3 mm is used as a lightweight aggregate in this study. Raw pumice material is collected from a quarry in Erciş (Van) which is then dried in an oven for 48 hours and then crushed using laboratory type dodge jaw crusher in order to reduce the size of the particles 0-3 mm. In Figure 3.1, pumice size of 0-3mm is depicted.

Figure 3.1. Pumice size aggregate between (0.5-3) mm.

3.1.3.1. Chemical Properties

Pumice is a pozzolanic material due to its response with lime (calcium hydroxide) released during the hydration of cement. Amorphous silica in the pozzolanic materials reacts with lime to form cementitious materials. Chemical analysis shows that volcanic pumice is fundamentally composed of around 61% silica.

Volcanic pumice has a cementitious combination such as alumina, iron oxide and calcium oxide a total of about 30%. Volcanic pumice contains higher oxide quantities (7.67%) of potassium and sodium which are known as alkalis. Higher alkali presence in the volcanic pumice may have certain effects leading to disintegration of concrete due to the reaction with some aggregate this will influence the strength of the cement. Table 3.4, depicts the chemical properties of pumice.

Table 3.4. Pumice chemical properties (Jackson, 1983)

Chemical compound	Chemical composition, %
Calcium oxide (CaO)	4.44
Silica (SiO_2)	60.82
Alumina(AL_2O_3)	16.71
Iron oxide (Fe_2O_3)	7.04
$SiO_2 + Al_2O_3 + Fe_2O_3$	84.5
Sulphur trioxide (SO_3)	0.14
Magnesia (MgO)	1.94
Sodium oxide (Na_2O)	5.42
Potassium oxide (K_2O)	2.25
Loss on ignition	1.52

3.1.3.2. Size of aggregate particles

The pumice aggregate size has a direct effect on mechanical property of concrete. In this study, after having determined the average gradation of pumice, %35 of (0.5-1) mm size of pumice and %65 of (1-2) mm size of pumice are used by volume.

3.1.3.3. Density of aggregates

The bulk density of pumice lightweight aggregate can be defined by the relation between the mass of aggregate and the volume. It must be calculated without compaction. In this project, it is found by drying the pumice aggregate in the oven at 100 °C. Table 3.5 gives the results of unit weight of pumice aggregate by ASTM.

Table 3.5. The density of pumice aggregate(Kg/m^3)

Density	Pumice Aggregate Size	
	(0.5-1) mm	(1-2) mm
Oven dry density	398	445

3.1.4. Filler and Aggregate Stone

Porphyritic is a type of natural stone which will be collected from a quarry in Van and will be used as a filler and normal-weight aggregate in structural lightweight concrete. The raw material will be crushed using laboratory type dodge jaw crusher, in order to reduce the size of the particles to 0-2 mm after being transferred to the laboratory. The crushed materials will then be sieved and sorted according to their particle size (0.5-1 mm and 1-2 mm as fine aggregate and <500 microns as filler) and used in the structural lightweight concrete mixture.

3.1.5. Polypropylene Fiber

Polypropylene is the first stereo regular polymer to have achieved industrial importance. The fibers from Polypropylene are widely used in the construction industry and have become an important member of the fiber-reinforced concrete. Commercially available Polypropylene fibers with fibrillated shape will be used in this study.

3.1.6. Water

The water utilized in the mixing of the concrete is to be fresh and free from any organic and harmful solutions which might lead to deterioration in the properties of the mortar. Potable water is fit for utilize for both the mixing part as well as for curing of beams. However, saltwater is not to be utilized.

3.1.7. Superplasticizer

For achieving better workability for fiber-reinforced structural lightweight concrete, the use of a superplasticizer is required. Therefore, a commercially available superplasticizer with the brand name of Gallium ACE-30 will be used in this study.

3.1.8. Air-Entraining Agents

Air-entrained concrete includes billions of microscopic air cells per cubic meter. These air pockets decrease the weight of the concrete and improve its workability and durability. Air-entrained concrete is produced by utilizing air-entraining admixtures. A commercially available air-entraining admixture with the brand name of MasterAir-200 will be used in order to reduce the weight and improve the workability of structural lightweight concrete that will be produced in this study.

3.2. Proportion Guideline Adopted

3.2.1. Variables

The main objective of this research is to know the structural properties of SLWAC with the addition of pumice aggregate. The compressive strength between 14-36 Mpa which could be utilized in the reinforced concrete structure, in spite of polypropylene fiber used in the mixture to improve the flexural strength of concrete. Several different mixes have been produced and studied.

3.2.2. Proportions Used

In this research, the proportions of materials used in the concrete mixes are all stabilized except for pumice aggregate and polypropylene fibers. The compound of pumice has a direct influence on both the unit weight and the compressive strength. Two different sizes of pumice aggregate are used in different amounts, 35% size 0.5-1 mm and 65% size 1-3 mm in all the mixes. Also, 25% and 50% of polypropylene fibers have been used. With the use of polypropylene fiber in the concrete mixture the workability of concrete decreased, so 5.5 % of Superplasticizer has been utilized to achieve the desired workability. 0.2% Air entraining is utilized in SLWAC to increase its durability and enhance its workability. However, the entrained air bubble influenced both the compressive strength and unit weight. All the proportions used in this research can be seen in Table 3.6.

Table 3.6. Concrete mix proportions

Mix Name	Cement Kg/m^3	Silica fume Kg/m^3	Filler Kg/m^3	Water L/m^3	W/B Kg/m^3	Air Ent. Kg/m^3	SP Kg/m^3	Fine Aggregate			
								pumice		Stone Kg/m^3	PP Fiber Kg/m^3
								35% (0.5-1) mm(L)	65% (1-3) mm(L)		
Mix 1	692	173	207	385	44.5	1.39	38	622.5	1245	894.8	-
Mix 2	692	173	207	385	44.5	1.392	38	622.5	1245	894.8	30
Mix 3	692	173	207	385	44.5	1.392	38	622.5	1245	894.8	60
Mix 4	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	-
Mix 5	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	30
Mix 6	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	60
Mix 7	692	173	207	385	44.5	1.392	38	311	578	894.8	-
Mix 8	692	173	207	385	44.5	1.392	38	311	578	894.8	30
Mix 9	692	173	207	385	44.5	1.392	38	311	578	894.8	60

* SF: Silica fume 0.25 % cement * SP: Superplasticizer 5.5% cement.

* PP Fiber: polypropylene fiber (0.25 % and 0.5%) by volume * L: Liter

* Air Ent: air entrance 0.20% cement * Filler: 0.30% cement

3.2.3. Production Workability

Slump test measures the workability of pumice lightweight concrete at the same time with assessing visually (Figure 3.2). This study attempts to keep a good workable concrete mixture while enhancing the required properties. The same water to cement ratio is used in all the mixtures. When polypropylene fiber is added to the concrete mixtures these mixes experienced a decrease in workability (Mix2, Mix3, Mix5, Mix6, Mix8, Mix9). To obtain good workability, Superplasticizers were utilized.

Figure 3.2. Slump Test.

3.3. Concrete Mixing and Casting

The concrete mixtures are prepared in the laboratory by using a pan-type mixer (B120) with a capacity of 250 Lt showed in figure 3.3. All the used material proportions to prepare the mixtures are explained in Table 3.6. Three types of structural lightweight concrete with a compressive strength of 14-36 Mpa and a unit weight of 1400-1800 kg/m3 are prepared by using 0%, 0.25% and 0.5 % of polypropylene fiber by volume. The effects of the different amounts of polypropylene fiber on the compressive, splitting tensile and flexural strength, workability, as well as compressive and flexural toughness of structural lightweight concrete are investigated. The mixtures are casted into plastic and steel molds and compacted on a vibration table. After 24 h, they will be demolded and stored in a control room maintained at 95% of relative humidity (RH) and 23^{o}C, until the day of the test. Immediately before testing, the water on the surface is removed using a towel. For compressive strength of the specimens 150x300-mm cylinders are used while for the split tensile strength 150x150 mm cubes are used. For flexural strength tests 100x100x400-mm prisms are used and for fire resistance tests 100x100 mm cubes are used. The modulus of elasticity and poison's ratio of structural lightweight concrete are obtained from testing 150x300 mm cylinders at a constant loading rate of 5kN/s. The modulus of elasticity is calculated based on the stress corresponding to 30% of the ultimate load and the longitudinal strain created by this stress. The thermal conductivity tests of the samples are conducted on a machine which works with the principle of the hot and cold plate by using 50x300x300 mm prisms. The fire resistance tests will be conducted using 100x100 mm cubes. The effect of different amount of polypropylene fibers on the residual compressive strength of structural lightweight concrete after exposure to 200, 400, 600 and 800 °C, for one hour; in a heating rate of 6 °C per minute is analyzed.

Figure 3.3. Mixer.

3.4. Tests for Mechanical Properties

3.4.1. Compressive strength test

Concrete compressive strength is tested by taking standard cylinder samples with a diameter of 150 mm and a height of 300 mm from concrete for 28 days. During the 28 days of the curing, the concrete compressive strength is continuously increased and after 28 days this gain is slowed down. Therefore, since the strength of the concrete is 99% at 28 days, it is almost close to its final strength. Therefore, we depend on the results of the compressive strength test after 28 days and we use this strength as the base of our design and evaluation. In this paper, the compressive strength of the specimens is taken using 150x300-mm cylinders and three cylinders are tested for compressive strength at a period of 7, 14 and 28 days after casting. As per ASTM C39 a UTEST hydraulic compression machine with an optimum capacity of 3000 KN is used, as shown in Figure 3.4

Figure 3.4. Compressive strength equipment.

3.4.2. Splitting tensile strength test

The tensile test is one of the most common test methods to test the properties of concrete. It is used to determine the maximum load (tensile strength) and study the behavior of the sample when an axial tensile load is applied. In this test,150mm*150mm cubes are used and tested at 28 days after casting. As per ASTM C39 a UTEST hydraulic compression machine with an optimum capacity of 3000 KN is used, as shown in Figure 3.4

3.4.3. Flexural strength test

The tensile strength of concrete can be measured by flexural strength; un-reinforced beams or slabs specimens are utilized to determine the flexural strength. It can be obtained either by two mid-point loading method as in ASTM C293 or by three-point loading method as in ASTM C78. In this research, the concrete beam specimens are sized 100x100x400 mm using the three-point loading method as in ASTM C78 to determine the flexural strength. UTEST bending apparatus is used, shown in Figure 3.5.

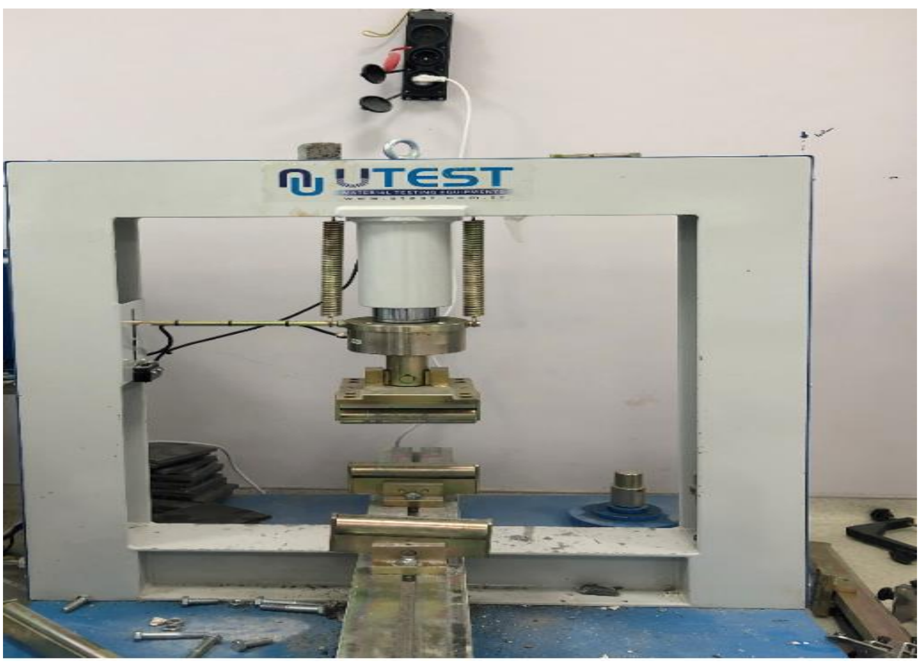


Figure 3.5. Flexural strength equipment.

3.4.4. Thermal conductivity test

Thermal conductivity is one of the most important thermophysical properties used to determine the heat transfer properties of materials. The test is carried out at the age of 28 days, in accordance to BS EN 12664. In this study, the specimens were dried in an oven for 24 hours at a temperature of 105 ± 5 °C to remove any present of moisture. The samples are tested on a machine which works with the principle of hot and cold plate by using 50x300x300 mm prisms.

3.4.5. Fire resistance test

Fire resistance tests place the element or specimen under the specified pressure and heat conditions that is almost the same condition as a fully developed fire. In this study, the fire tests are conducted using 100x100mm cubes. The effect of various amounts of polypropylene fibers on the residual compressive strength of structural lightweight concrete after exposure to 200, 400, 600 and 800 °C, at a heating rate of 6 °C per minute for one hour, will be analyzed. This is given in figure 3.6.

Figure 3.6. Fire resistance.

3.4.6. UPV test

Ultrasonic Pulse Velocity is a testing method used to check for any damage in structural components and it is a non-destructive test for the quality of the concrete materials. It is a widely accepted test for concrete and it is an effective method to assess, and estimate the crack depth. The test uses the standard procedure as (ASTM-597-09, 2016). The travel time of acoustic waves in a medium are being measured is the concept behind the technology and connecting them to the density and elastic properties of the material. The inside condition of the test area is reflected in the Travel time of ultrasonic waves. Low quality concrete correlates higher travel time and high-quality concrete connects to low travel time. In this study, Ultrasonic Pulse Velocity (UPV) is tested by taking standard cylinder samples with a diameter of 150 mm and a height of 300 mm from concrete after 28 days. The test measures the P-Wave and S-Wave by the using Proceq Pundit lab having 54kHz, 125kHz respectively, this can be seen in Figure 3.7.

Figure 3.7. UPV Equipment.

3.4.7. Slump test

Generally, concrete slump value is used to find the workability, which indicates water-cement ratio, but there are different factors containing properties of materials, mixing methods, dosage, admixtures, etc. One of the most important factors affecting the quality of concrete is concrete consistency. Concrete should be poured at the appropriate consistency according to the ambient conditions. In this paper, the ASTM C143 procedure is used to prepare the slump cone (Figure 3.8). A sample is taken from fresh concrete and poured into the slump cone in three equal layers. The rod is used for compaction; each layer is tamped 25 times. After the cone is filled, the surface of the mold is smoothed by the rod. Then the mold is removed vertically. Afterwards, the slump is taken from the vertical distance between the top of the sample and the top of the mold. The results for the slump test is given in Table 3.7.

Table 3.7. Slump value

Mixes	Slump (cm)
Mix1	23
Mix22	13.5
Mix3	1
Mix4	27
Mix5	23.5
Mix6	15
Mix7	28.5
Mix8	25
Mix9	21

Figure 3.8. Slump core test.

4. RESULTS

4.1. Workability

In this study, the slump value and unit weights (density) were measured for all concrete mixes as shown in Table 4.1. Three groups of lightweight concrete with different unit weights have been investigated, in each group of lightweight concrete pp fiber has been added in 0%, 0.25% and 0.5%. The maximum slump values for the control mixes M1, M4 and M7are determined to be 230, 270 and 285 mm respectively. The workability of the controlled mixes was increased with an increase in the unit weight of lightweight concrete since less pumice is used for higher unit weight. Pumice aggregate is a porous material therefore when used in concrete it absorbs the water which decreases the workability.

In each group, the workability of lightweight concrete is seen to decreases with an increase in the volume of pp fiber. In G1 the slump value is decreased from 230 to 10 mm when the pp fiber increases from 0 to 0.5% respectively. The slump value is decreased from 270 to 150 mm in G2 when the pp fiber increases from 0 to 0.5% respectively. In G3 the slump value is decreased from 285 to 210 mm when the pp fiber increases from 0 to 0.5% respectively. The main reason PP fiber highly absorbs water is due to its high specific surface area, therefore, the required water in the concrete mix is significantly lower and make the free flow of fresh concrete difficult (Alsadey et al. 2016).

Table 4.1. Slump value and density

Group	Mixes	Slump (mm)	Density (Kg/m^3)
G1	Mix1	230	1585
	Mix2	135	1580
	Mix3	10	1490

Table 4.1. Slump value and density

Group	Mixes	Slump (mm)	Density (Kg/m^3)
	Mix4	270	1489
G2	Mix5	235	1482
	Mix6	150	1544
	Mix7	285	1726
G3	Mix8	250	1690
	Mix9	210	1614

4.2. Compressive Strength

Uniaxial compression tests were carried out using (300*150) mm cylinder test samples at 28 days in accordance with TS EN 12390-3. This study seeks to find the relationship between stress and strain. The PP fiber volume and the unit weight of concrete have a significant effect on stress and strain of concrete.

Figure 4.1 shows the stress-strain curves of G1, and the maximum compressive strength 29 MPa is obtained for the control mix (M1) which is free of PP fiber. With increasing the volume of PP fiber from 0.25% to 0.5% the compressive strength decreases from 26 to 23 MPa respectively. Increasing the volume of PP fiber decreases the workability of concrete therefore the concrete is not well compacted and also the pp fiber effectively hold the micro-cracks in concrete mass this results in the decrease of the compressive strength (Alsadey et al., 2016). Additionally, when the volume of PP fiber increases the displacement increases.

With increasing the volume of PP fiber from 0 to 0.25% the unit weight of lightweight concrete decreases from 1585 to 1490 kg/m3 respectively, the reduction of unit weight is almost 6% because PP fiber is a lightweight material. The effect of the PP fiber on the compressive strength of G2 is shown in Figure 4.2, the compressive strength decreases by 10% when the volume of PP fiber increases by 0.5%. By adding 0.5% volume of polypropylene fiber in G3, the compressive strength decreases by 40% compared to the control mix (M6) in G3 is shown in Figure 4.3.

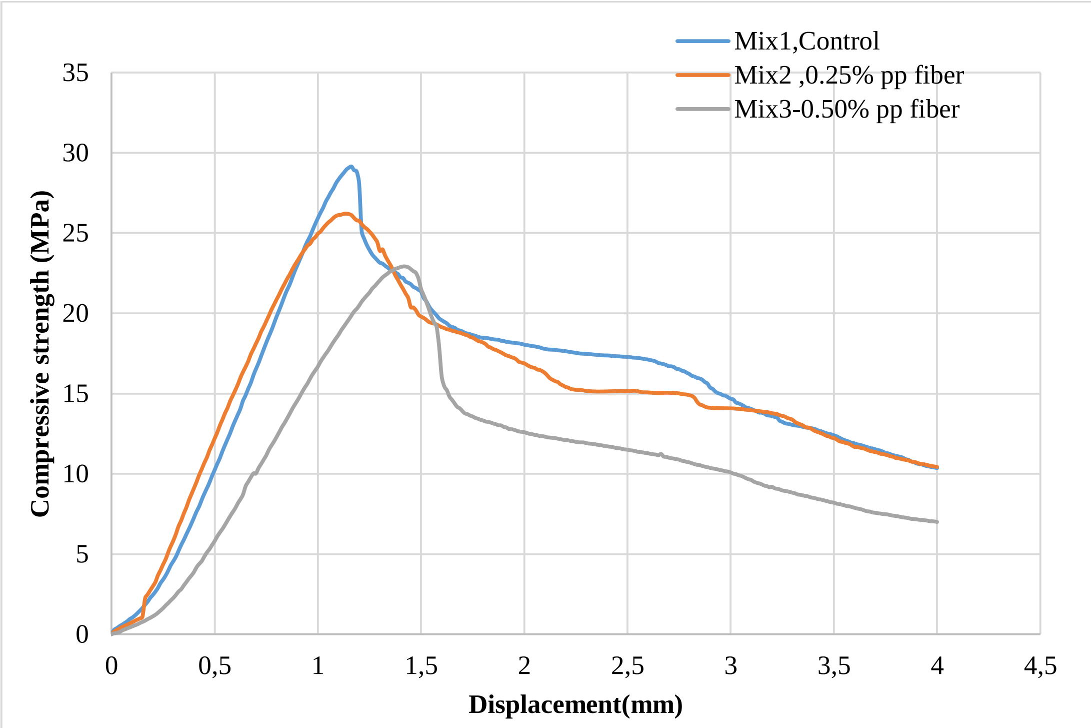


Figure 4.1. The effect of polypropylene fiber on the compressive strength of SLWC specimen's (M1, M2, M3).

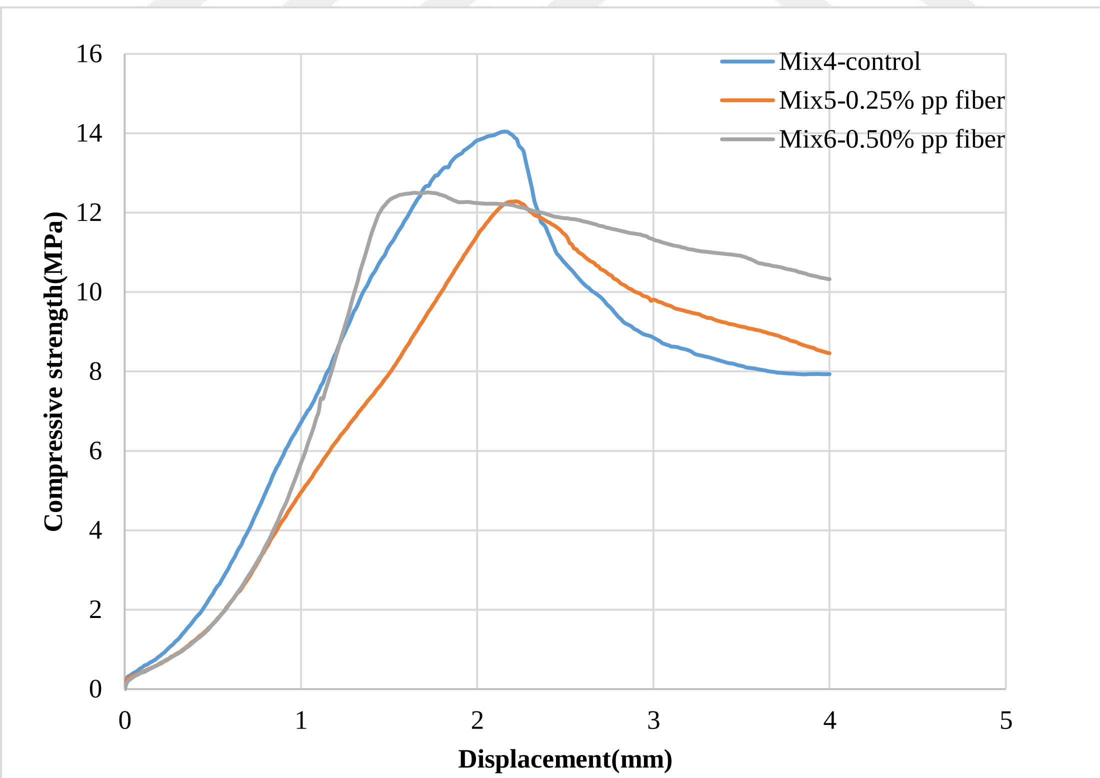


Figure 4.2. The effect of polypropylene fiber on the compressive strength of SLWC specimen's (M4, M5, M6).

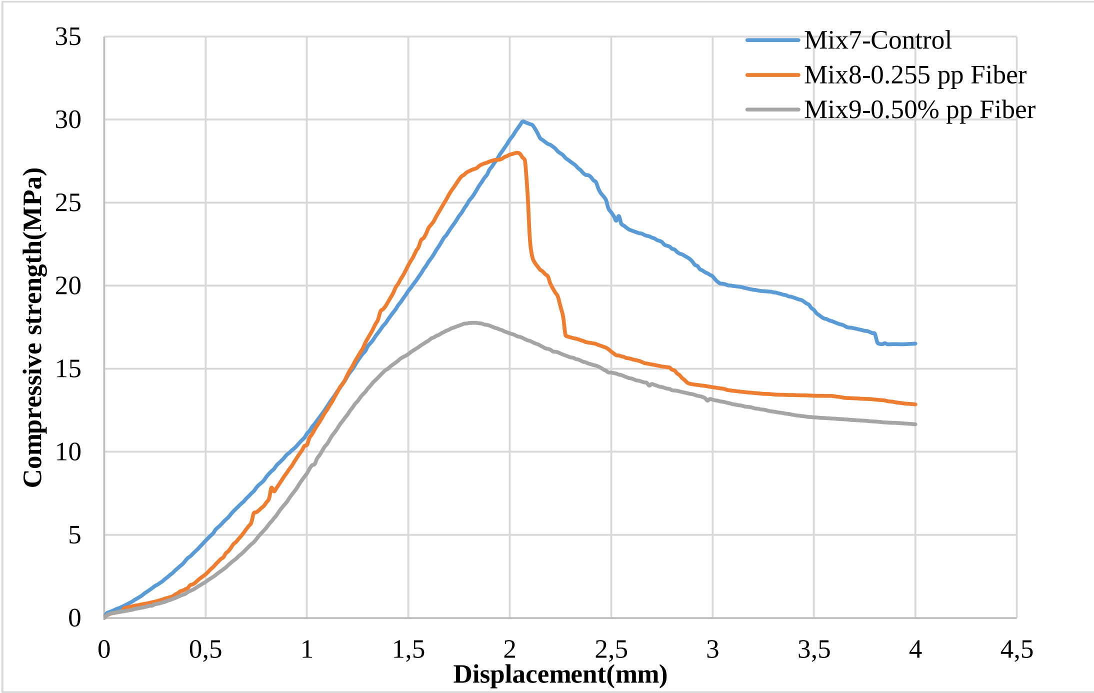


Figure 4.3. The effect of polypropylene fiber on the compressive strength of SLWC specimen's (M7, M8, M9).

Figure 4.4 shows the effect of unit weight on the compressive strength of lightweight concrete for M1, M4 an M7 which are free of PP fiber. The compressive strength of concrete without PP fiber increases from 14 to 30 MPa while the unit weight of lightweight concrete increases from 1489 to 1726 respectively. The higher amount of lightweight aggregate requires lower unit weight. The strength of lightweight aggregate is insignificant, therefore the compressive strength decreases when the unit weight decreases. When unit weight is reduced by 14% the reduction of compressive strength is 53% for lightweight concretes without PP fiber. Figure 4.5 illustrates the effect of unit weight on the compressive strength when the volume of PP fiber is 0.25% constant. The compressive strength is reduced by 56% when the reduction of unit weight is 12% with 0.25% PP fiber. The relationship between compressive strength and unit weight of SLWC specimens (M3, M6, M9) with of 0.5% polypropylene fiber in figure 4.6 shows that increasing the unit weight from 1490 to 1614 kg/m^3 decreases the compressive strength from 23 to 18 MPa respectively. According to the results obtained in this study, lightweight concrete in G3 with different volumes of PP fiber can be used as structural members such as columns, beams, shear walls, and slabs. However, the concrete which is obtained in G2 has a low unit weight that can be used for lightweight elements such as concrete blocks and some pre-cast elements.

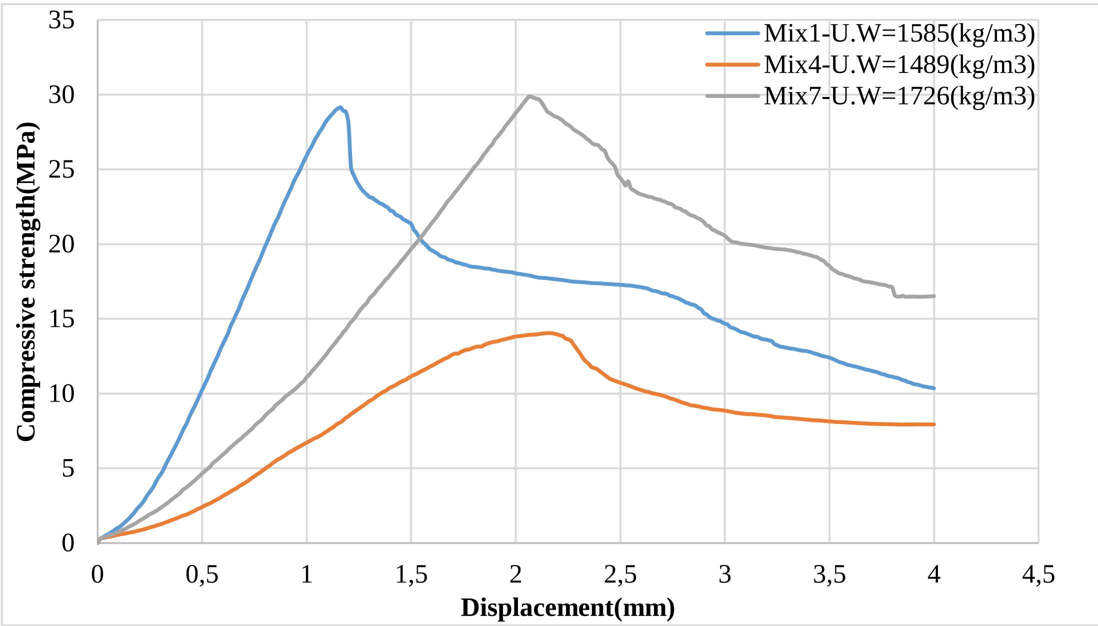


Figure 4.4. The relationship between compressive strength and unit weight of fiber-reinforced SLWC specimens (M1, M4, M7) without polypropylene fiber.

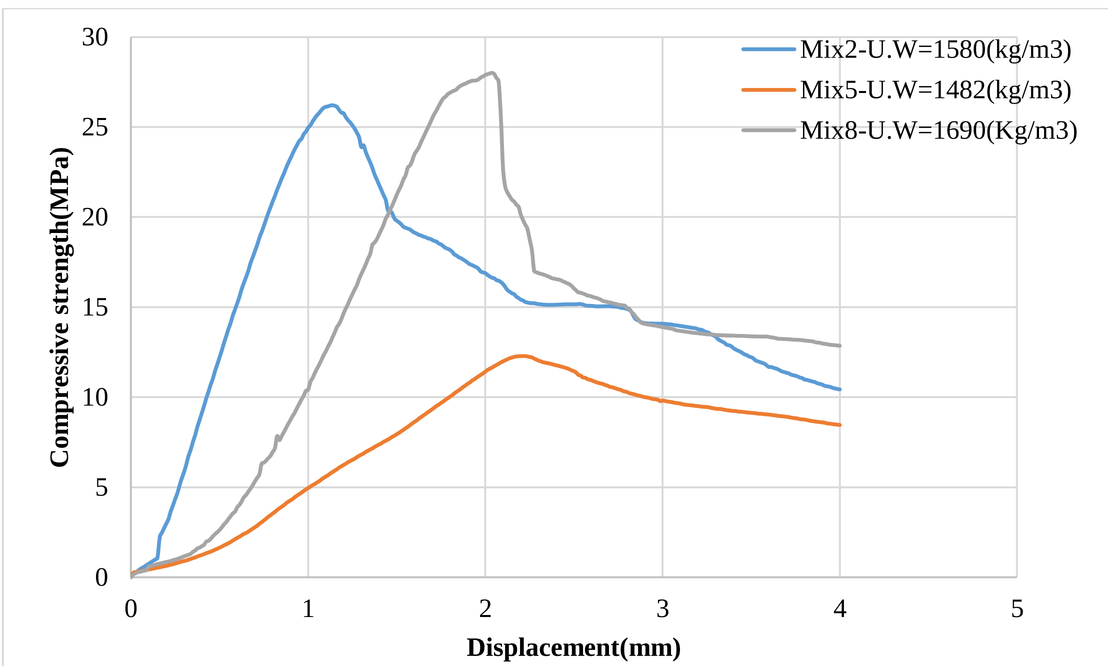


Figure 4.5. The relationship between compressive strength and unit weight of fiber reinforced SLWC specimens (M2, M5, M8) with of 0.25% polypropylene fiber.

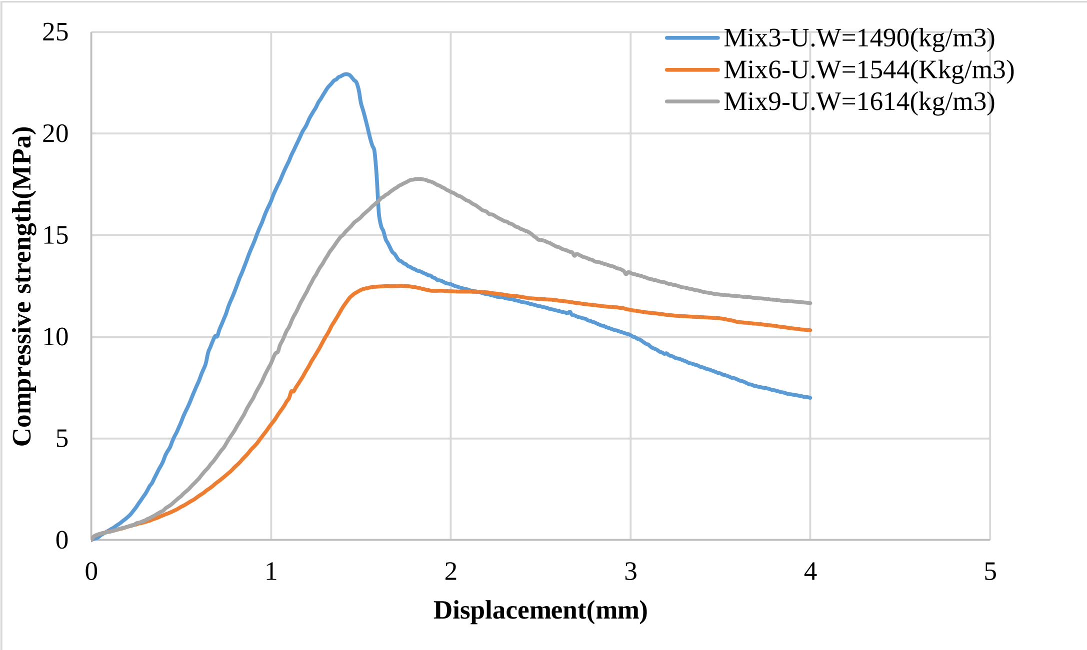


Figure 4.6. The relationship between compressive strength and unit weight of fiber-reinforced SLWC specimens (M3, M6, M9) with of 0.5% polypropylene fiber.

4.3. Flexural Strength

Flexural tensile tests were carried out in the (400*100*100) mm beam test samples at 28 days in accordance with EN 12390-5. This study seeks to find the relationship between compressive stress-strain. The PP fiber volume and the unit weight of concrete have an important effect on the flexural strength of lightweight concrete.

Figure 4.7 shows the effect of PP fiber on the flexural strength of G1 (M1, M2, M3), the maximum flexural strength is found to be 1.82 MPa obtained in M3 which has the highest volume of PP fiber. With the increase of the volume of PP fiber from 0 to 0.5% the flexural strength increases from 1.39 to 1.82 MPa respectively due to improvement in the mechanical bond between the cement paste and fiber (Dharan Divya and Aswathy Lal, 2016). Additionally, when the volume of PP fiber increases the displacement increases because PP fiber works as reinforcement in concrete. Also, with increasing the volume of PP fiber the ductility of concrete is improved. The effect of PP fiber on the flexural strength of G2 is shown in Figure 4.8, with increasing the volume of PP fiber from 0 to 0.25% the flexural strength of lightweight concrete increases by 18%. The effect of PP fiber on the flexural strength of G3 is shown in Figure 4.9. the maximum flexural strength is found to be 2.52 MPa obtained in M8 which has the 0.25% volume of PP fiber.

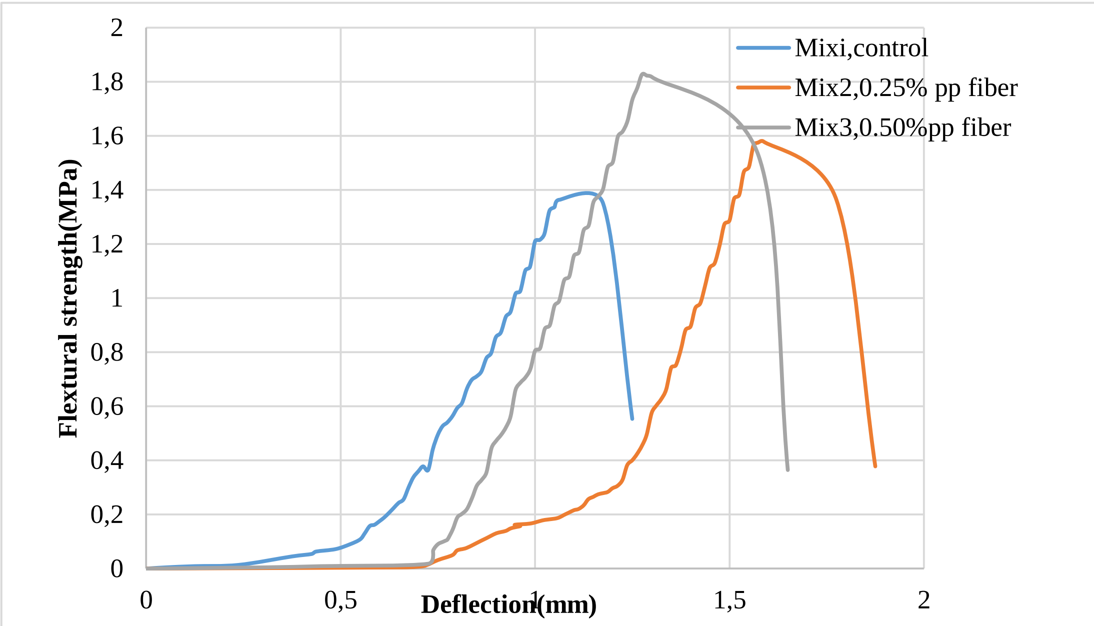


Figure 4.7. The effect of polypropylene fiber on the flexural strength of SLWC specimens (M1, M2, M3).

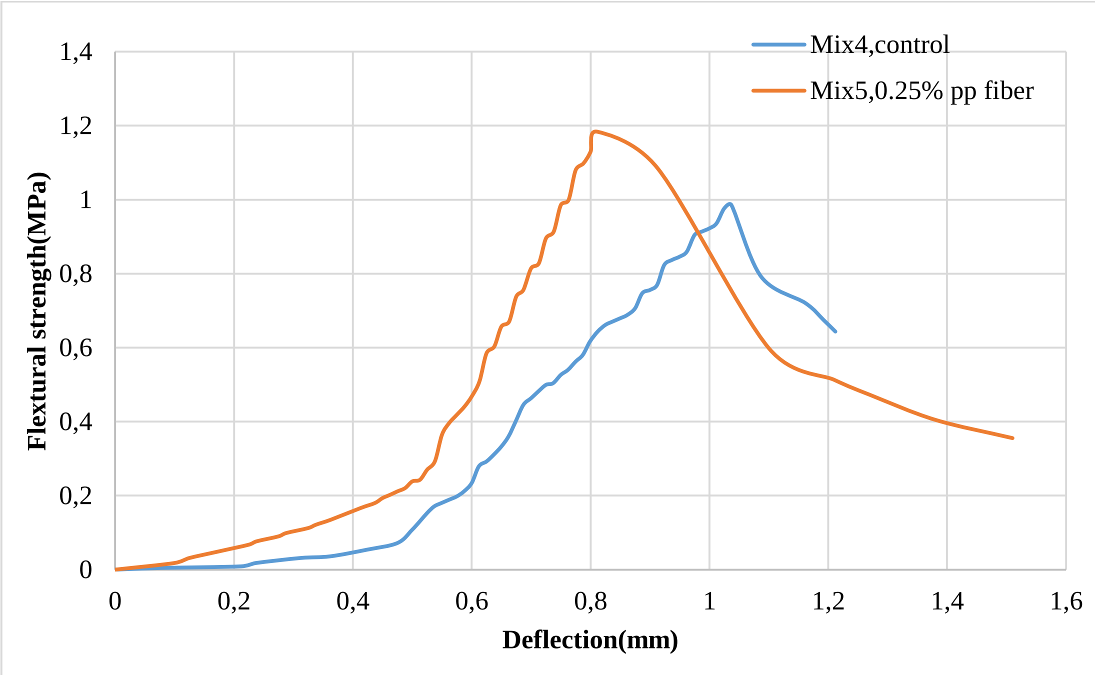


Figure 4.8. The effect of polypropylene fiber on the flexural strength of SLWC specimens (M4, M5).

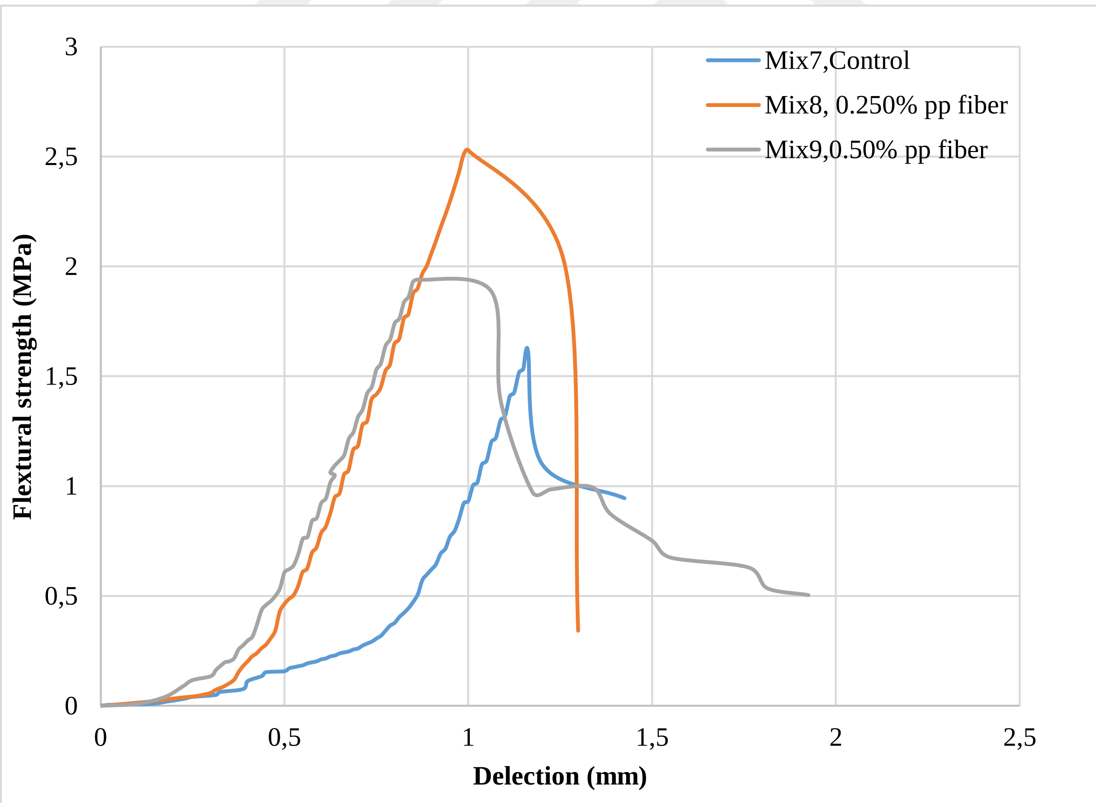


Figure 4.9. The effect of polypropylene fiber on the flexural strength of SLWC specimens (M7, M8, M9).

Figure 4.10 shows the effect of unit weight on the flexural strength of lightweight concrete for M1, M4 and M7 which are free of PP fiber. The flexural strength of concrete without PP fiber increases from 1 to 1.62 MPa while the unit weight of lightweight concrete increases from 1489 to 1726 kg/m^3 respectively. The strength of lightweight aggregate is low, the ratio of the flexural and compressive strength is not constant but is porosity dependent, and therefore the flexural strength increases when the unit weight increases. When unit weight increases by 14% the flexural strength increases by 62% without PP fiber. Figure 4.11 illustrates the effect of unit weight on the flexural strength when the volume of PP fiber is 0.25% constant, the flexural strength increases by 38% when the unit weight increases by 14%. The relationship between flexural strength and unit weight of fiber-reinforced SLWC specimens (M3, M6, M9) with of 0.5% polypropylene fiber in figure 4.12 shows that increasing unit weight from 1490 to 1614 kg/m^3 increases the flexural strength from 1.82 to 1.94 MPa respectively.

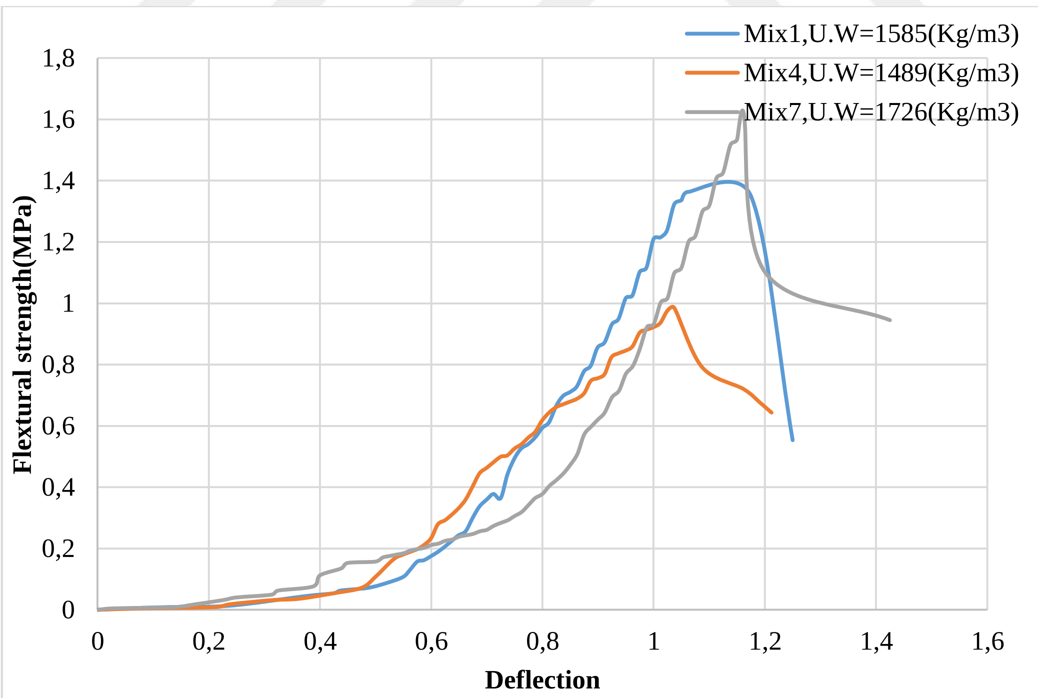


Figure 4.10. The relationship between flexural strength and unit weight of fiber-reinforced SLWC specimens (M1, M4, M7) without polypropylene fiber.

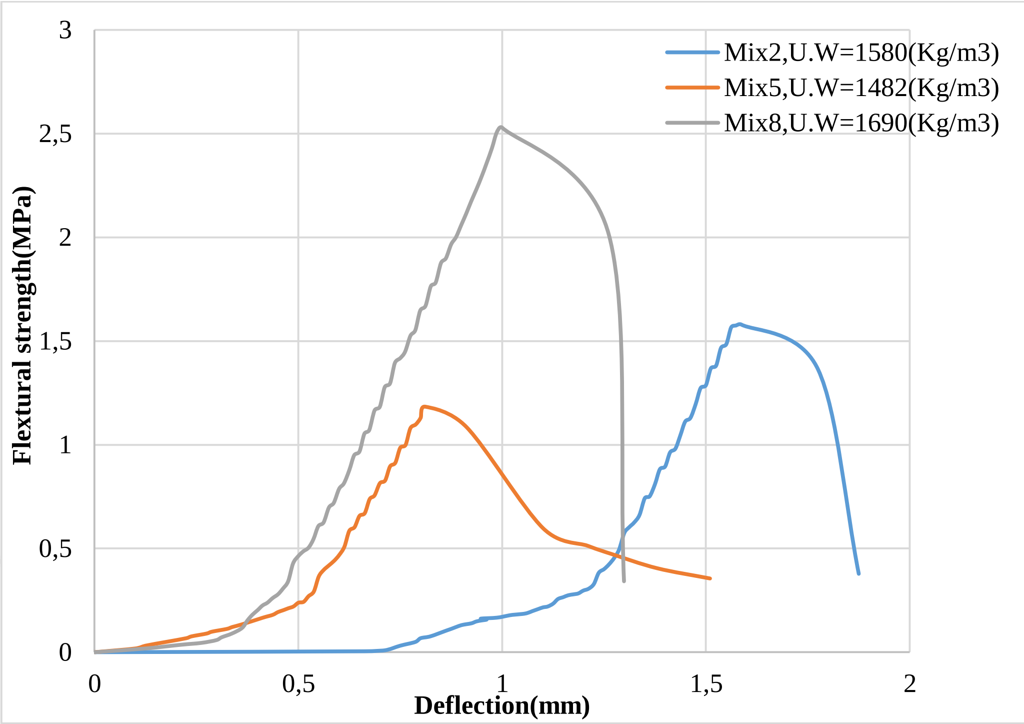


Figure 4.11. The relationship between flexural strength and unit weight of fiber-reinforced SLWC specimens (M2, M5, M8) with0.25% polypropylene fiber.

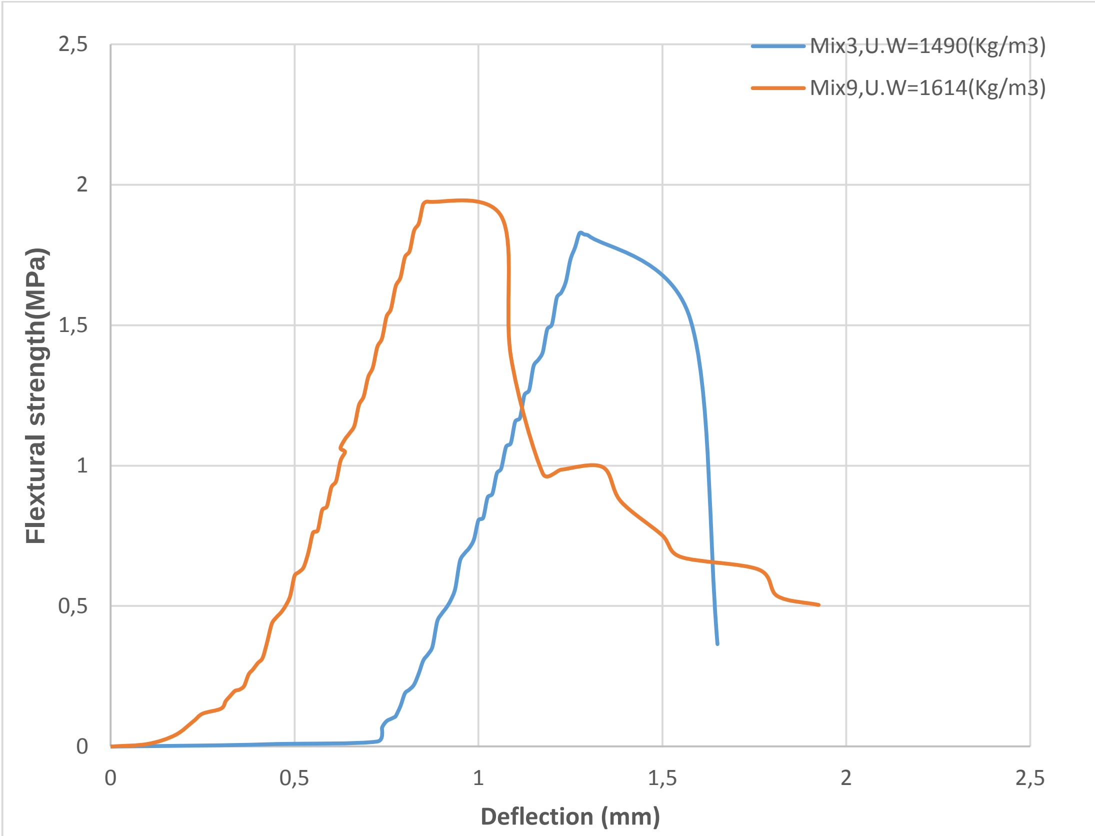


Figure 4.12. The relationship between flexural strength and unit weight of fiber-reinforced SLWC specimens (M3, M9) with 0.50% polypropylene fiber.

4.4. Splitting Tensile Strength

Splitting tensile strength tests were carried out on 150mm*150 mm cube test specimens at 28 days in accordance with EN 12390-6. The split tensile strength decreases with increasing the volume of PP fiber. The split tensile strength systematically decreases in G1 (M1, M2, and M3) by 8% as shown in Figure 4.13 when the volume of PP fiber increases by 0.5%. The reason for this is the weak bonding between pp fiber and cement matrix (Libre et al.,2010). Figure 4.14 shows that the split tensile strength decreases from 1.68 to 1.2 MPa when the volume of PP fiber increases from 0 to 0.5%. The maximum Split tensile strength 2.11 MPa is obtained in M8 when the volume of PP fiber is 0.25% as shown in Figure 4.15.

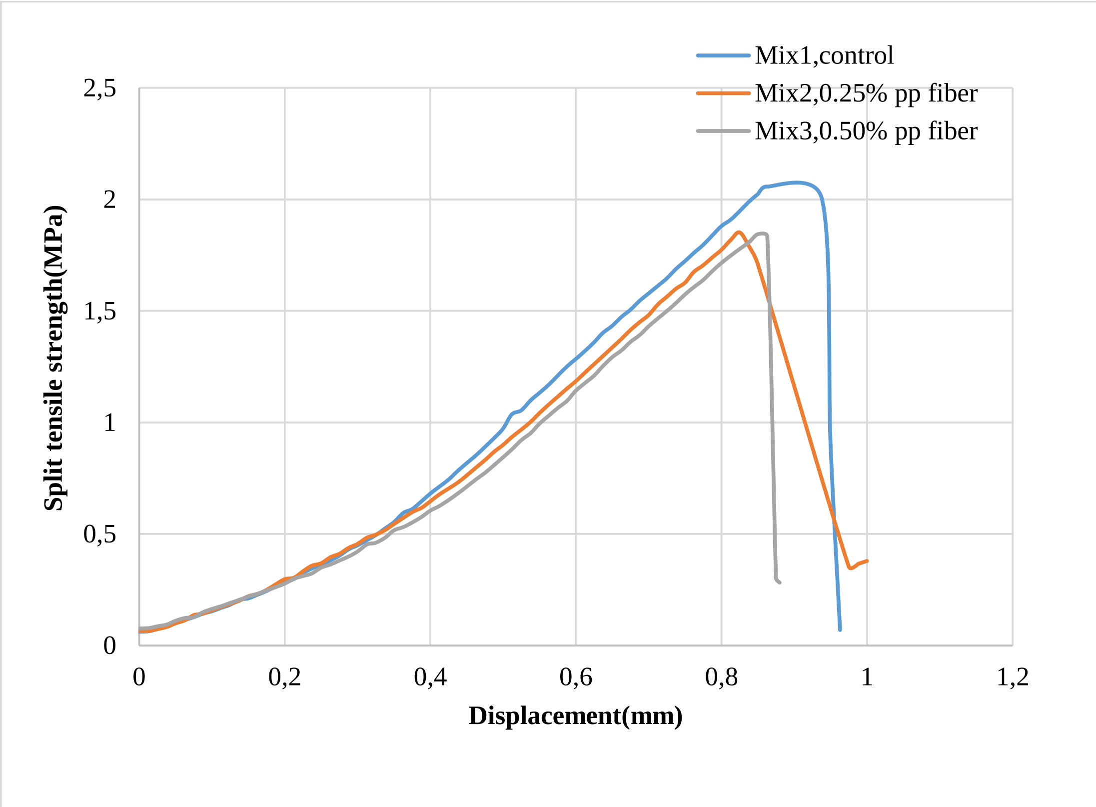


Figure 2.13. The effect of polypropylene fiber on the splitting tensile strength of SLWC specimen's (M1, M2, M3).

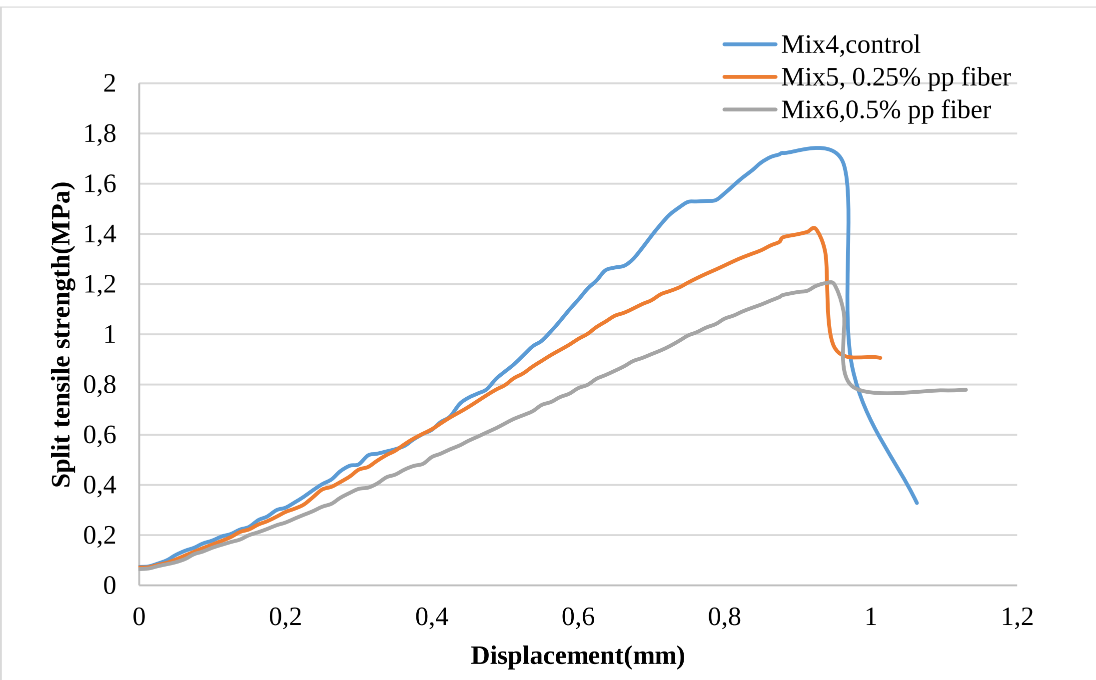


Figure 4.14. The effect of polypropylene fiber on the splitting tensile strength of SLWC specimen's (M4, M5, M6).

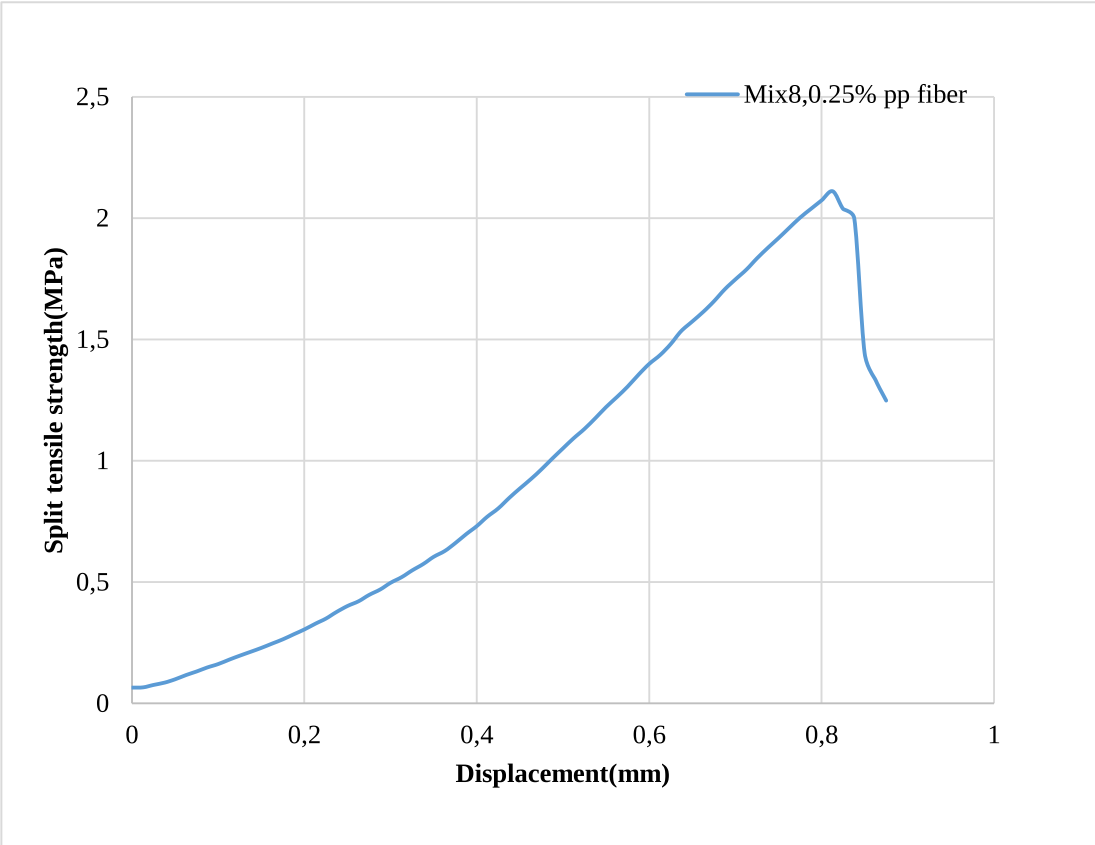


Figure 4.15. The effect of polypropylene fiber on the splitting tensile strength of SLWC specimen's (M8).

Figure 4.16 shows the influence of unit weight on the split tensile strength of lightweight concrete for M1 and M4 which are free of PP fiber. The split tensile strength of concrete without PP fiber increases from 1.68 to 2 MPa when the unit weight of lightweight concrete increases from 1489 to 1585 kg/m^3 respectively. The higher amount of lightweight aggregate requires lower unit weight. The porosity of lightweight aggregate is higher, therefore the split tensile strength decreases when the unit weight decreases. Figure 4.17 illustrates the effect of unit weight on the split tensile strength when the volume of PP fiber is 0.25% constant, the split tensile strength increases by 48 % when the unit weight increases by 14%. The relationship between split tensile strength and unit weight of SLWC specimens (M3 and M6) with 0.5% of polypropylene fiber is shown in figure 4.18. The figure shows that increasing unit weight from 1490 to 1544 kg/m^3 the split tensile strength decrease from 1.84 to 1.2 Mpa respectively.

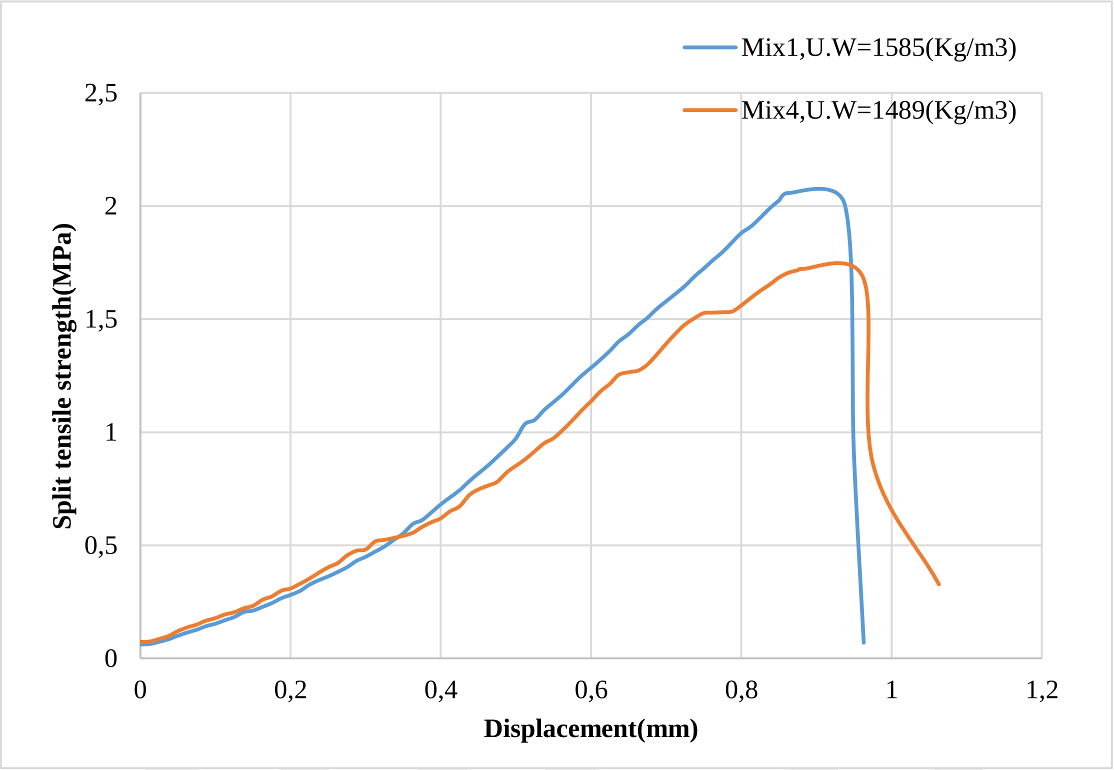


Figure 4.16. The relationship between splitting tensile strength and unit weight of fiber-reinforced SLWC specimens (M1, M4,) without polypropylene fiber.

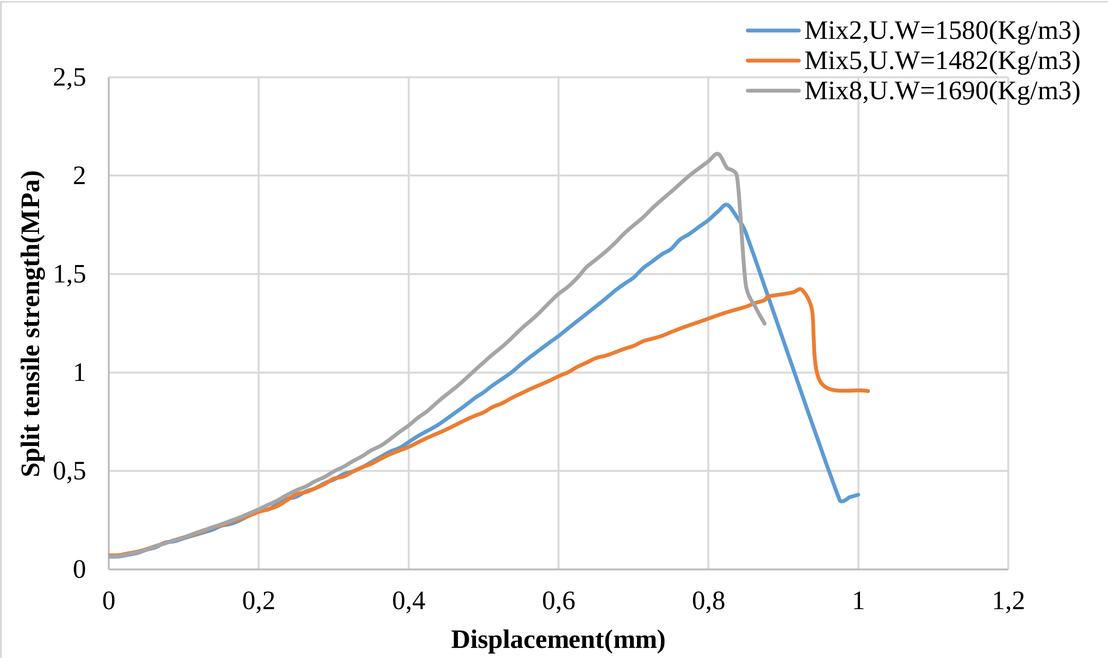


Figure 4.17. The relationship between splitting tensile strength and unit weight of fiber-reinforced SLWC specimens (M2, M5, M8) with0.25% polypropylene fiber.

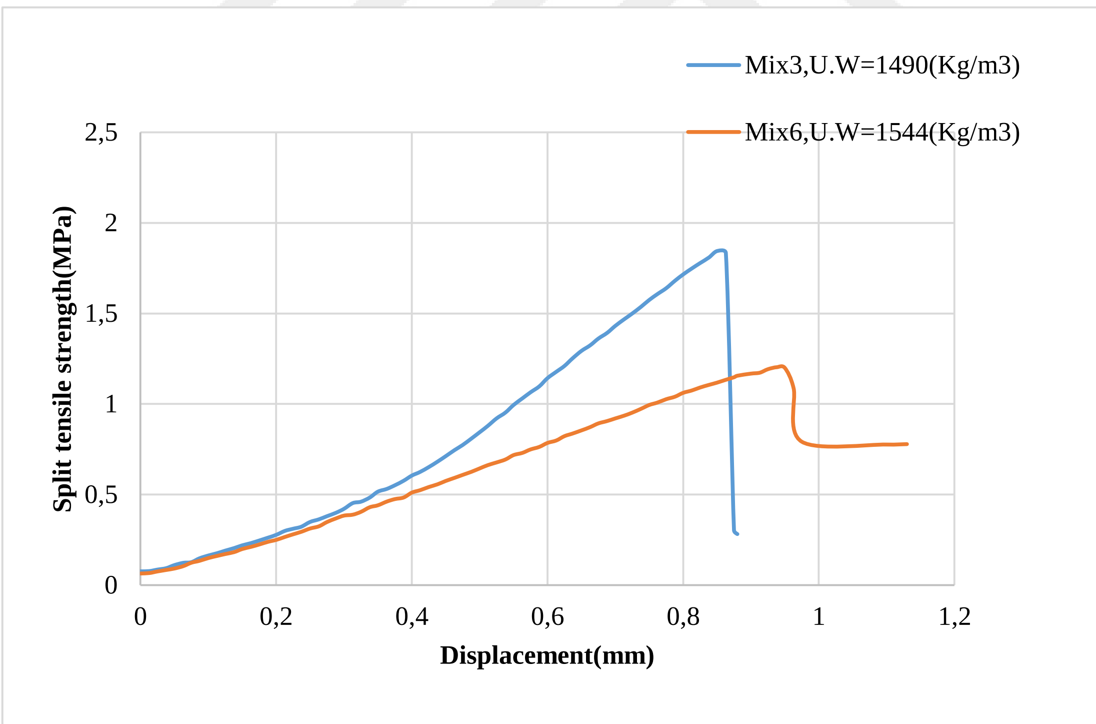


Figure 4.18. The relationship between Splitting tensile strength and unit weight of fiber-reinforced SLWC specimens (M3, M6) with0.50% polypropylene fiber.

Figure 4-19 shows the correlation between split tensile and the compressive strength without polypropylene fiber. When the compressive strength increases the split tensile strength increase with $R^2 = 0.8907$ and $0.4024e^{2.1193x}$, the exponential equation is for different unit weights of lightweight concrete.

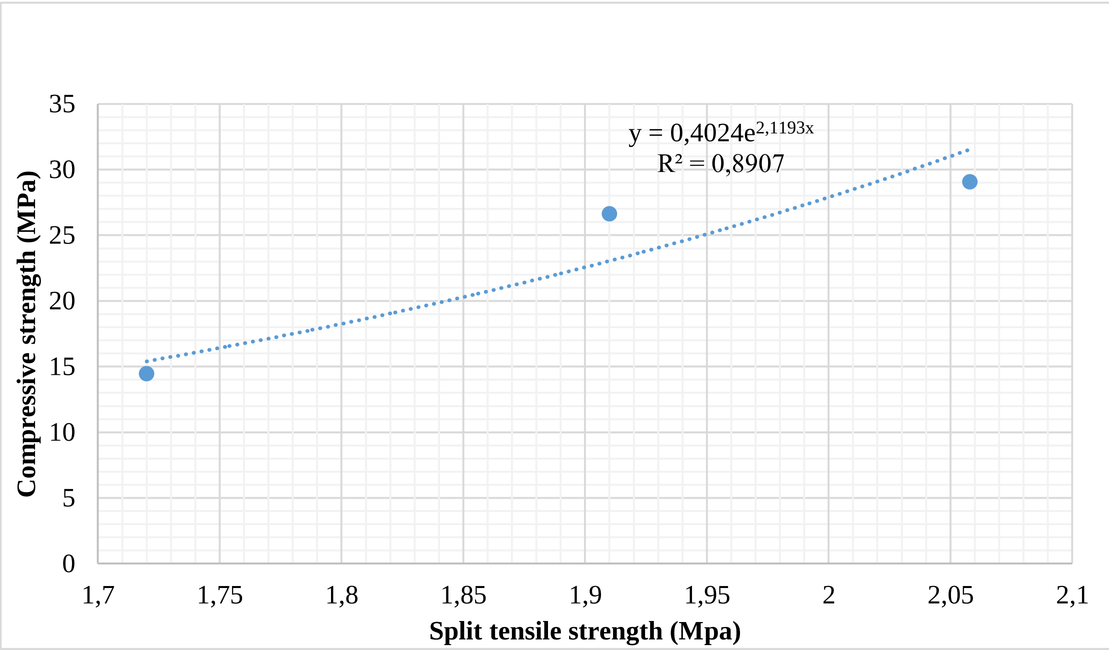


Figure 4.19. Relationship between Splitting tensile strength and the compressive strength without polypropylene fiber.

Figure 4-20 shows the correlation between split tensile strength and the compressive strength with polypropylene fiber. When the compressive strength increases the split tensile strength increases with $R^2 = 0.9154$ and $y = 3.8765e^{0.904x}$, the exponential equation is for different unit weights of lightweight concrete.

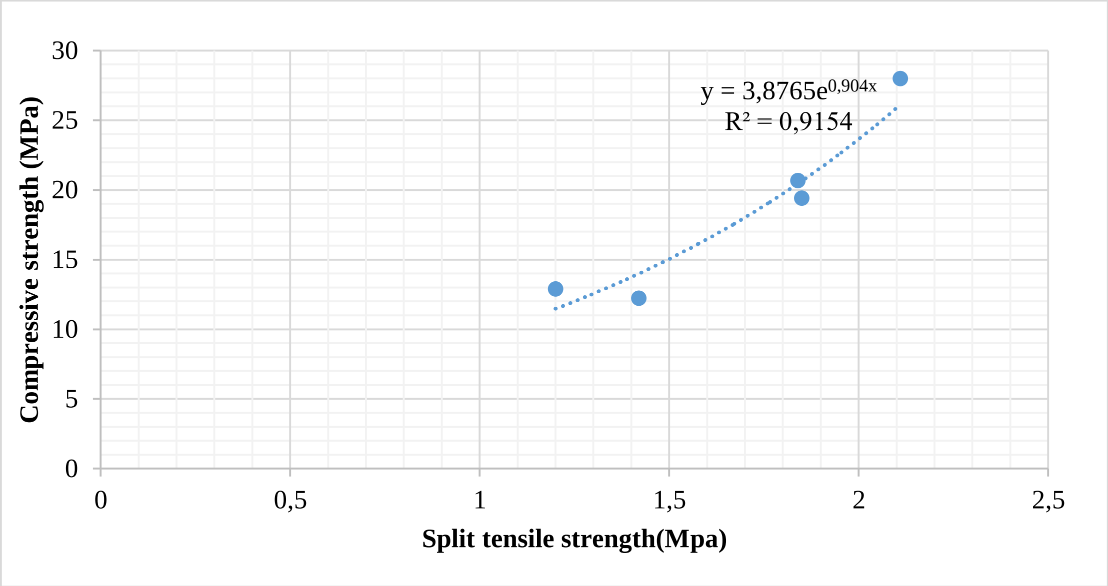
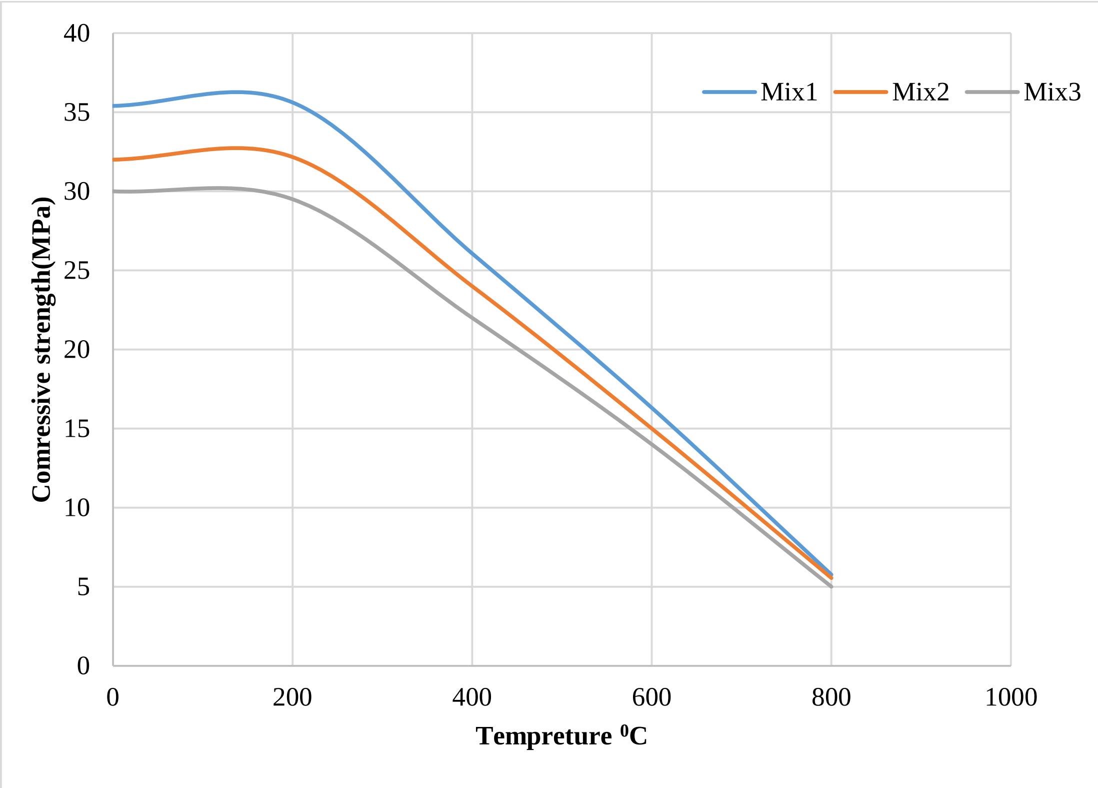


Figure 4.20. Relationship between Splitting tensile strength and the compressive strength with polypropylene fiber.

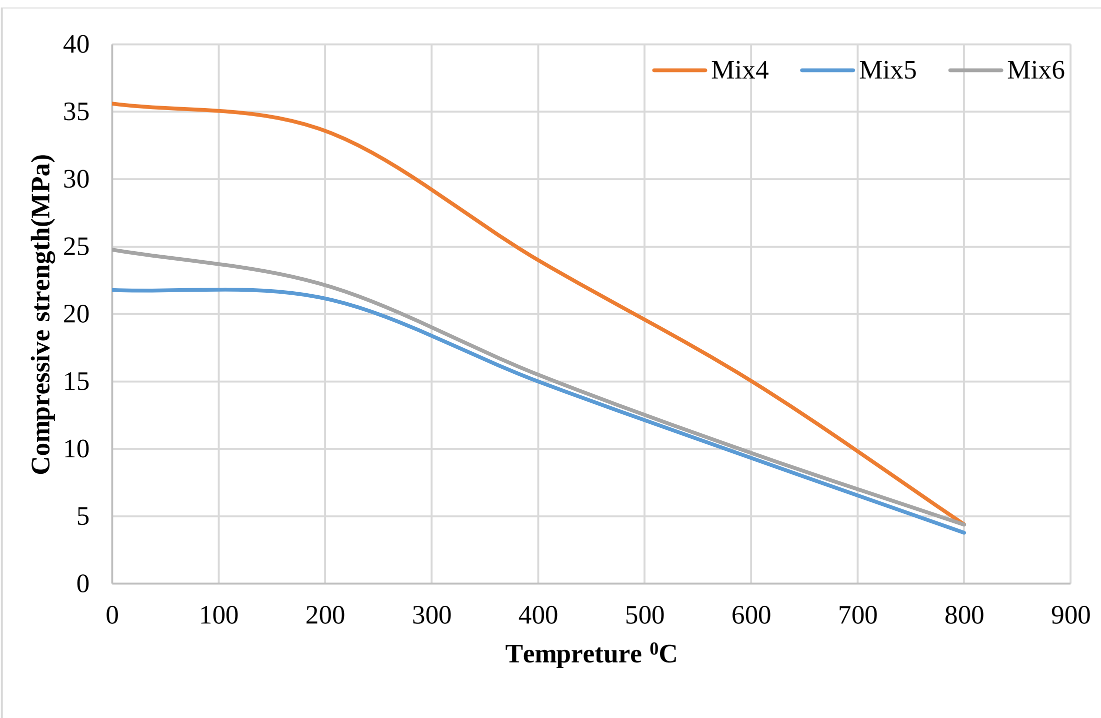
4.5. Fire Resistance

In general, the strength of concrete increases with increasing the temperature, further increases in temperature significantly decreases the strength of concrete. Figure 4.21 shows the influence of elevated temperature on compressive strength with different volume content of PP fiber. Figure 4.21 a, b and Figure 4.22 c indicates that when the temperature increases up to 150^{o}C the compressive strength develops a little. However, further increase in the temperature (more than 150^{o}C) the compressive strength sharply decreases. Increasing the volume of PP fiber reduces the fire resistance of concrete, because the PP fiber already decreases the compressive strength of concrete.

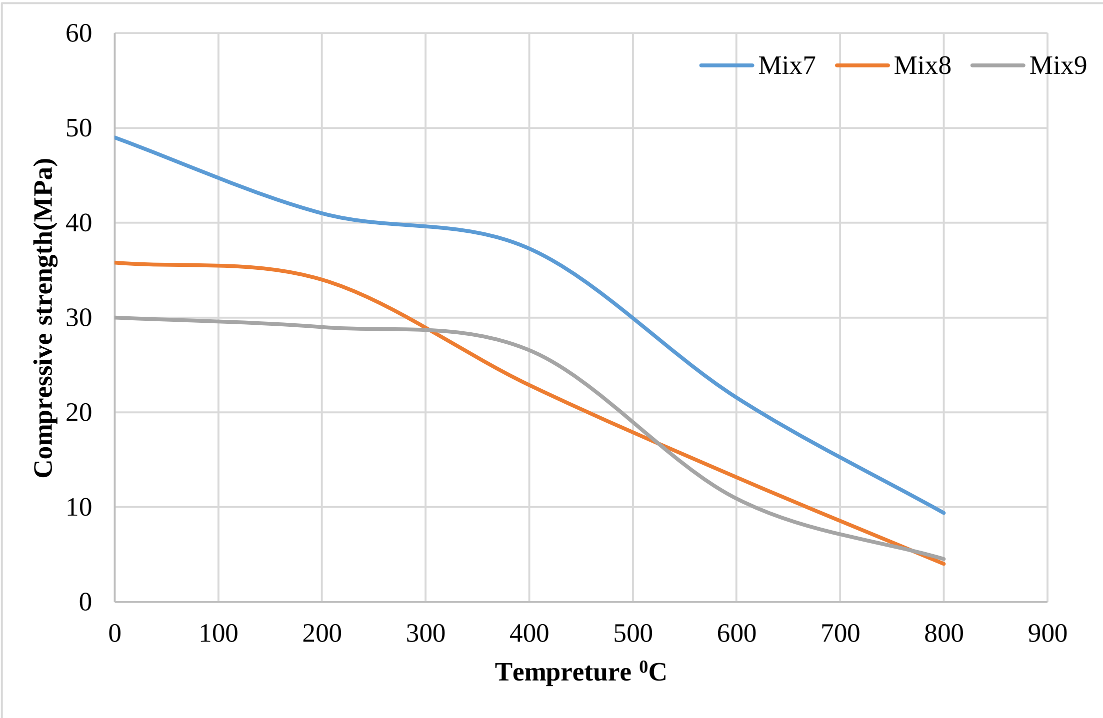


A (M1, M2, M3)

Figure 4.21. The effect of elevated temperature and PP fiber on compressive strength of A (M1, M2, M3).



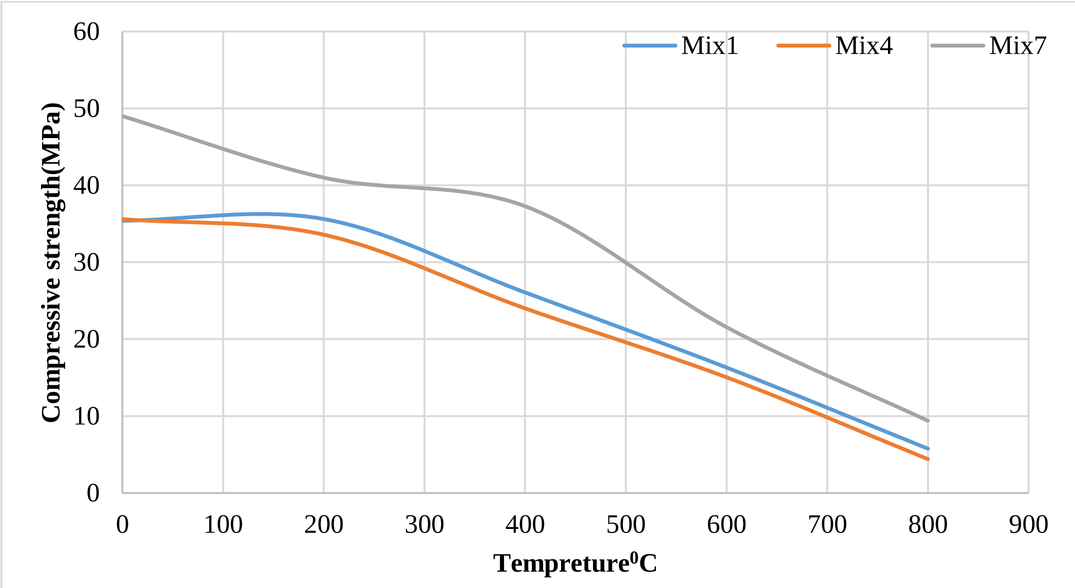
B (M4, M5, M6)



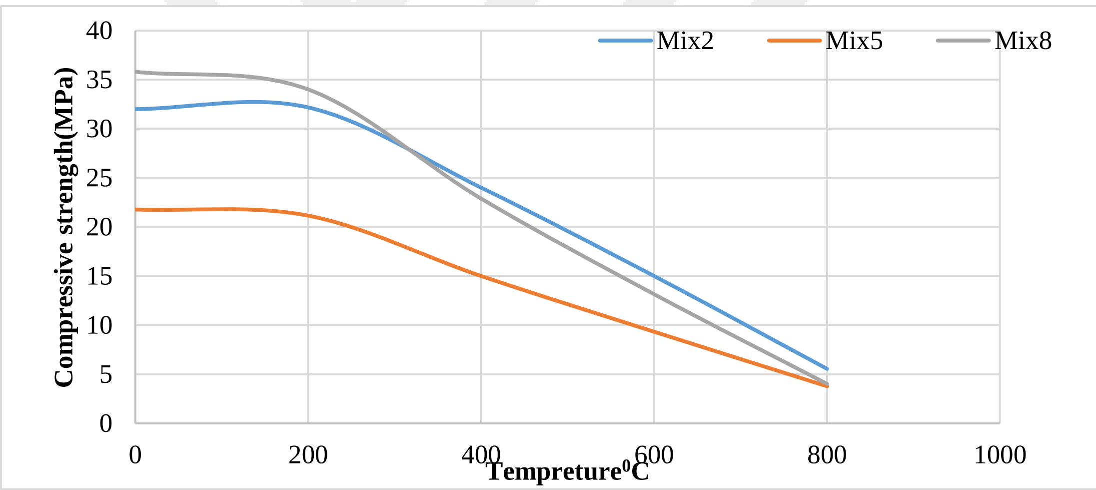
C (M7, M8, M9)

Figure 4.22. The effect of elevated temperature and PP fiber on compressive strength of B (M4, M5, M6), C (M7, M8, M9).

Compared to conventional concrete the fire resistance of Lightweight concrete is higher because more internal holes exist inside (Go Cheer-Germ et al.,2012). Figure 4.23 shows the influence of evaluated temperature and unit weight on compressive strength with different volume contents of PP fiber. Figure 4.23 a, b, and Figure 4.24 c depict that the percentage of compressive strength loss decreases when the unit weight of concrete reduces.

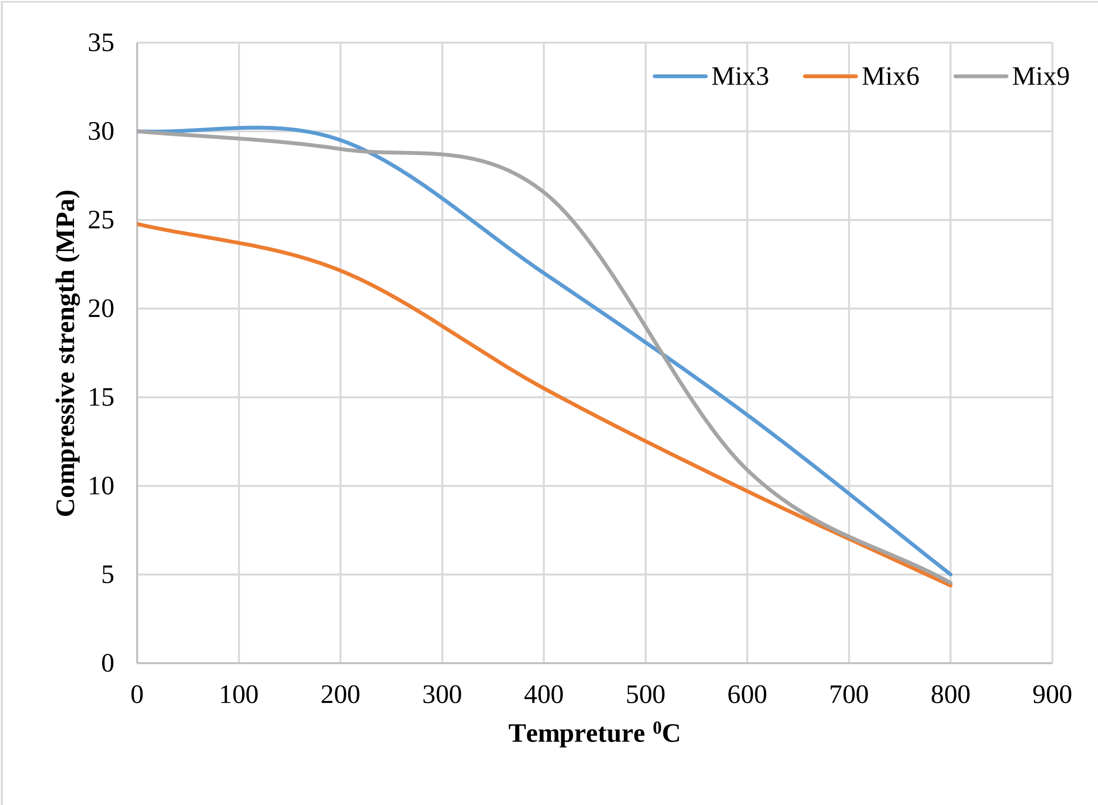


A (M1, M4, M7)



B (M2, M5, M8)

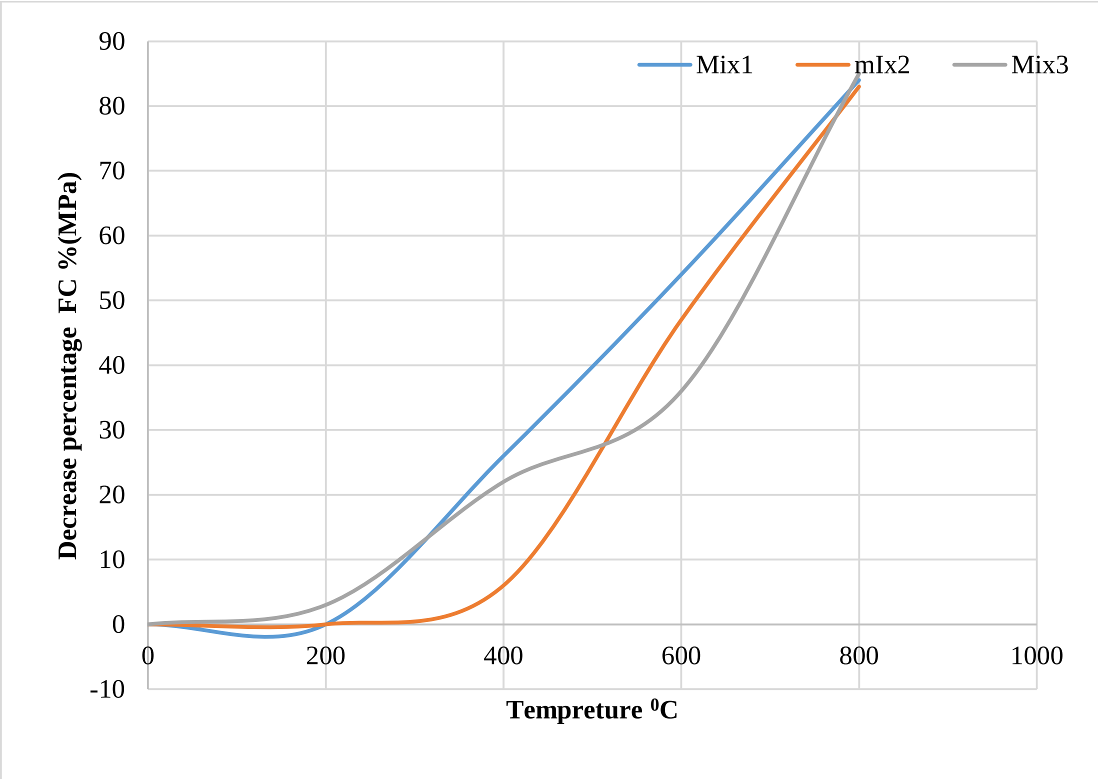
Figure 4.23. The effect of elevated temperature and PP fiber on compressive strength of A (M1, M4, M7) and B (M2, M5, M8).



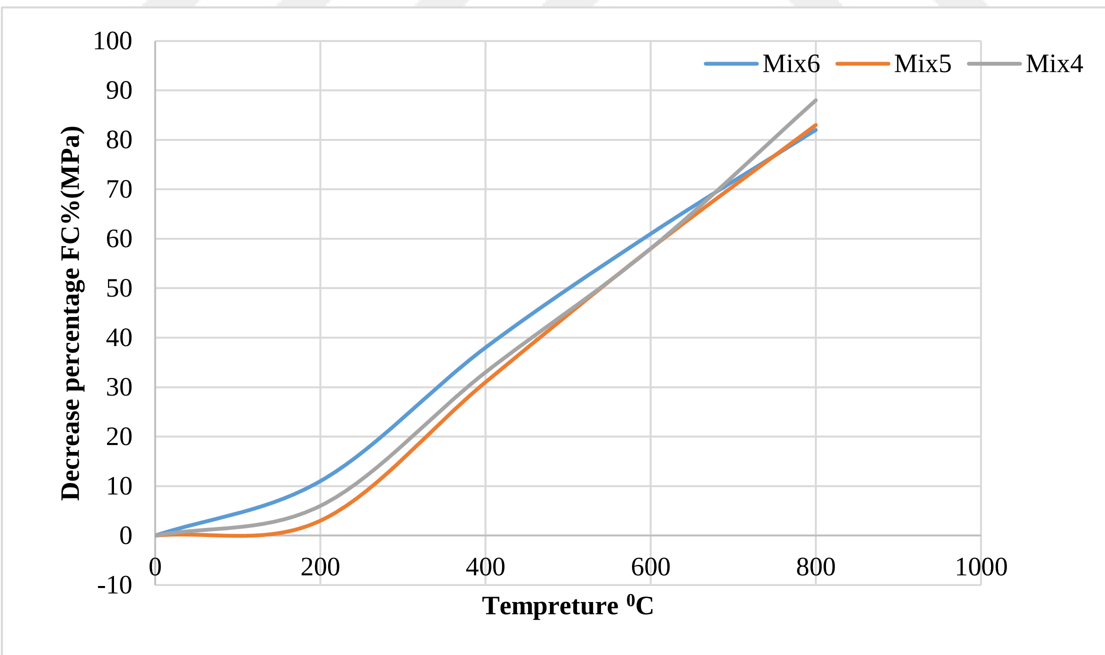
C (M3, M6, M9)

Figure 4.24. The effect of elevated temperature and PP fiber on compressive strength of C (M3, M6, M9).

Figure 4.25 and 4.26 shows that the percentage of compressive strength of lightweight concrete decreases with increasing the volume of PP. When the volume of PP fiber increases more heat is absorbed by fiber particles, therefore, the compressive strength loss is less compared with a concrete mix without PP fiber.

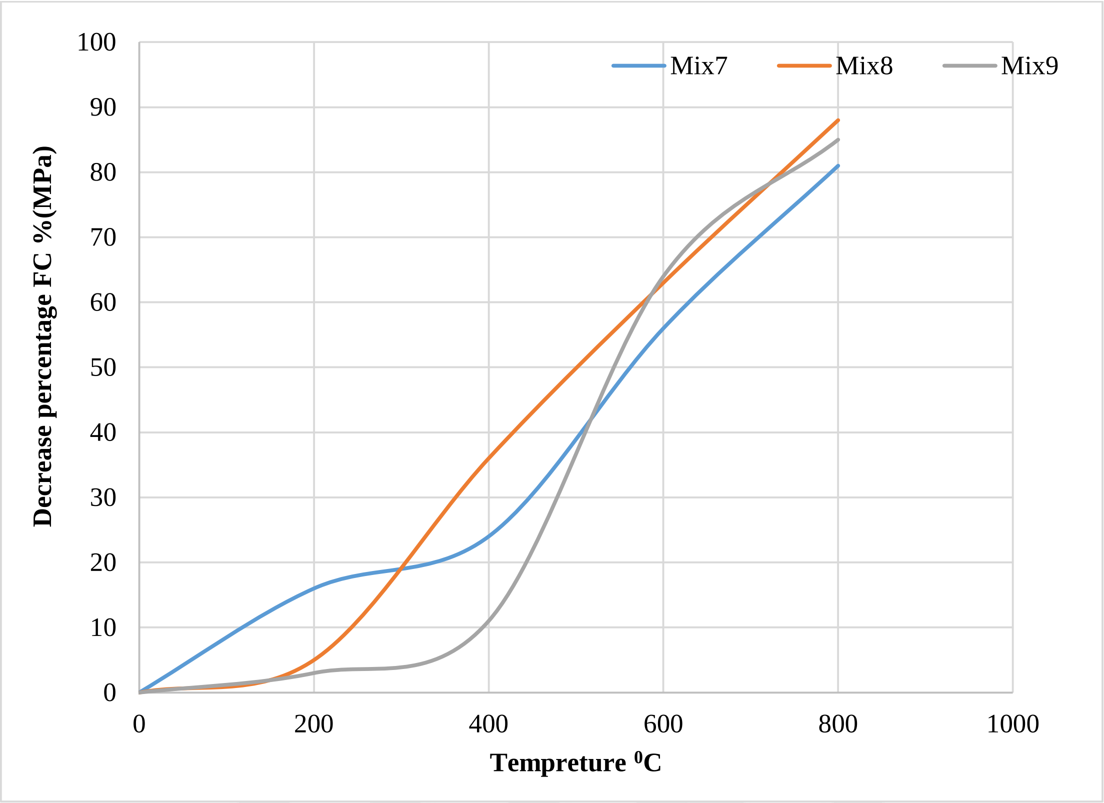


A (M1, M2, M3)



B (M4, M5, M6)

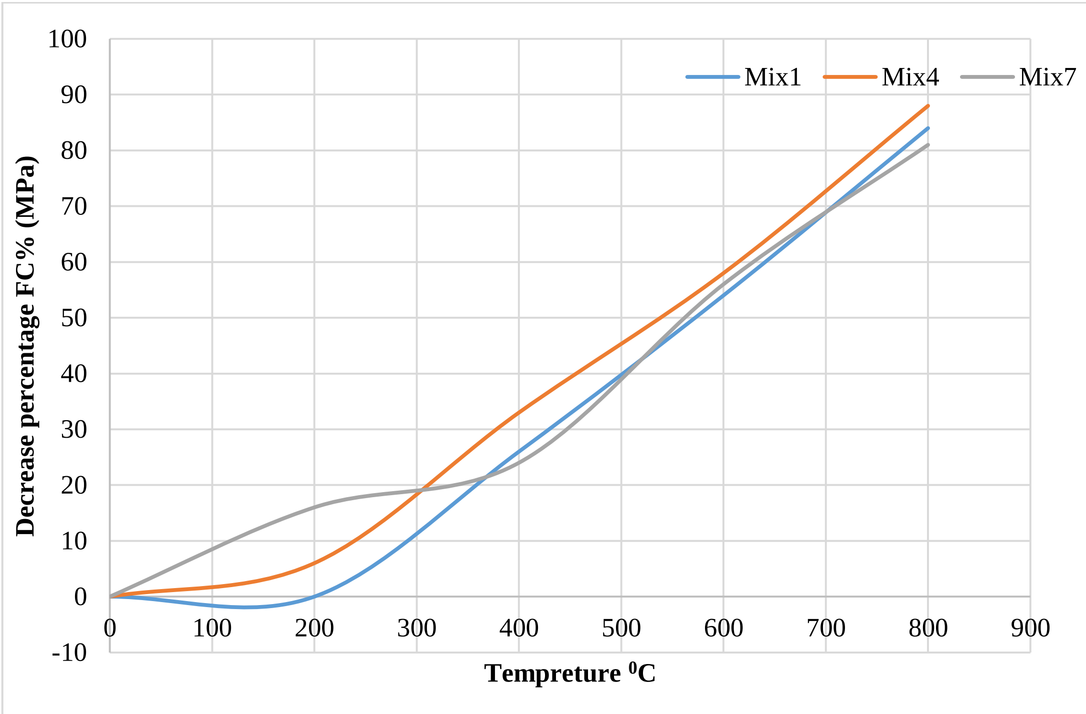
Figure 4.25. The effect of elevated temperature and PP fiber on decrease percentage compressive strength of A (M1, M2, M3), B (M4, M5, M6).



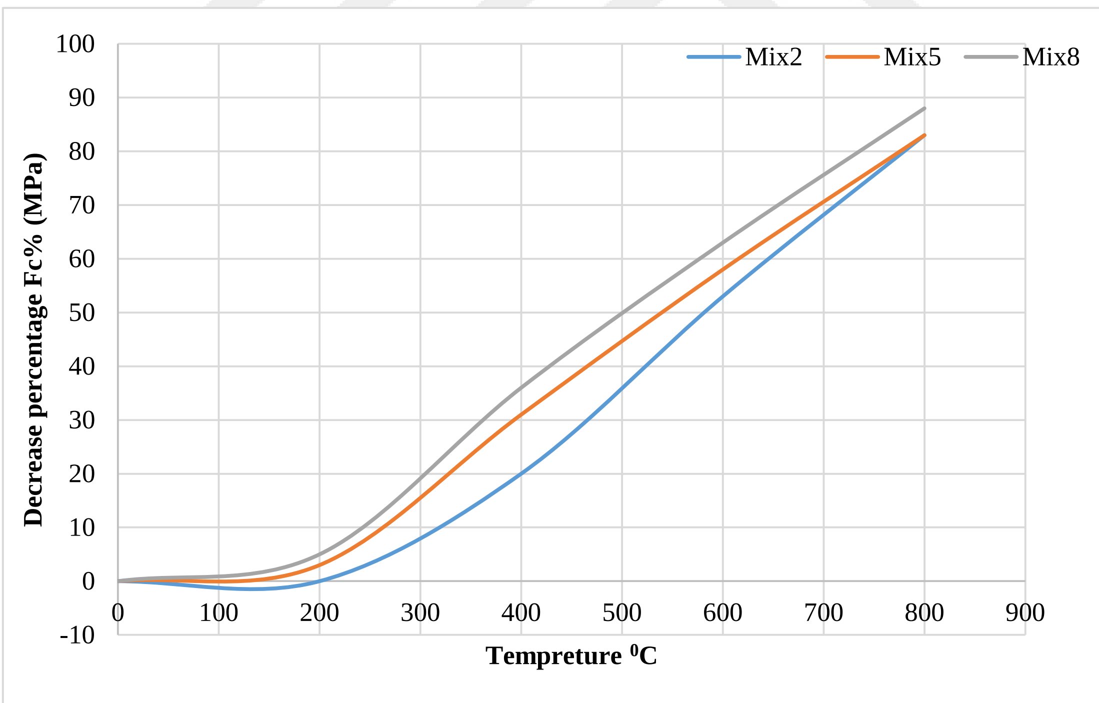
C (M7, M8, M9)

Figure 4.26. The effect of elevated temperature and PP fiber on decrease percentage compressive strength of C. (M7, M8, M9).

Figure 4.27 B. shows that the percentage of compressive strength loss of lightweight concrete with 1482 kg/m^3 is 82% when the temperature increases up to 800^{o}C. However, the percentage of compressive strength loss of lightweight concrete with 1690 kg/m^3 is 86% in the same conditions.

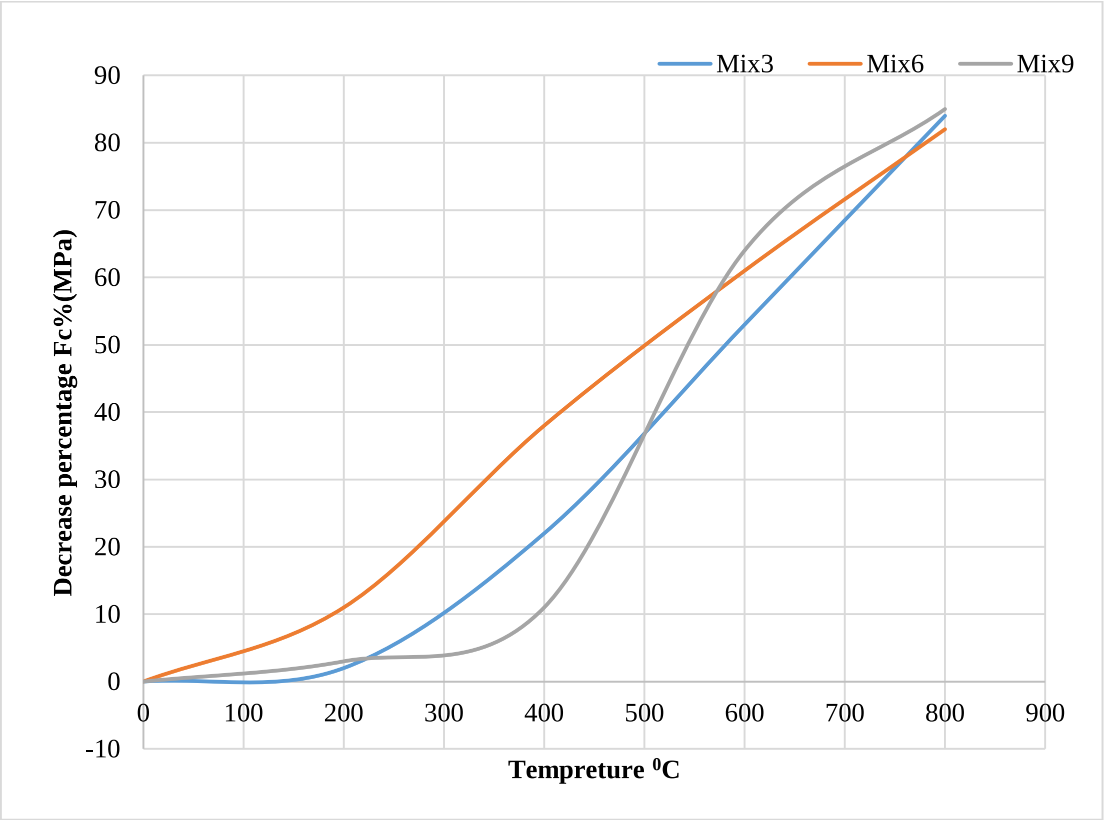


A (M1, M4, M7)



B (M2, M5, M8)

Figure 4.27. The effect of elevated temperature and PP fiber on decrease percentage compressive strength of A (M1, M4, M7) and B (M2, M5, M8).



C (M3, M6, M9

Figure 4.28. The effect of elevated temperature and PP fiber on decrease percentage compressive strength of C. (M3, M6, M9*)*.

Figure 4.29 A, B, 4.30 C, D 4.31 E shows the relationship between compressive strength and ultrasonic pulse velocity (UPV) for lightweight concrete with pp fiber at temperatures of 100^{0}C, 200^{0}C, 400^{0}C, 600^{0}C and 800^{0}C. The correlating between compressive strength and UPV can be shown by the following Eq 4.1:

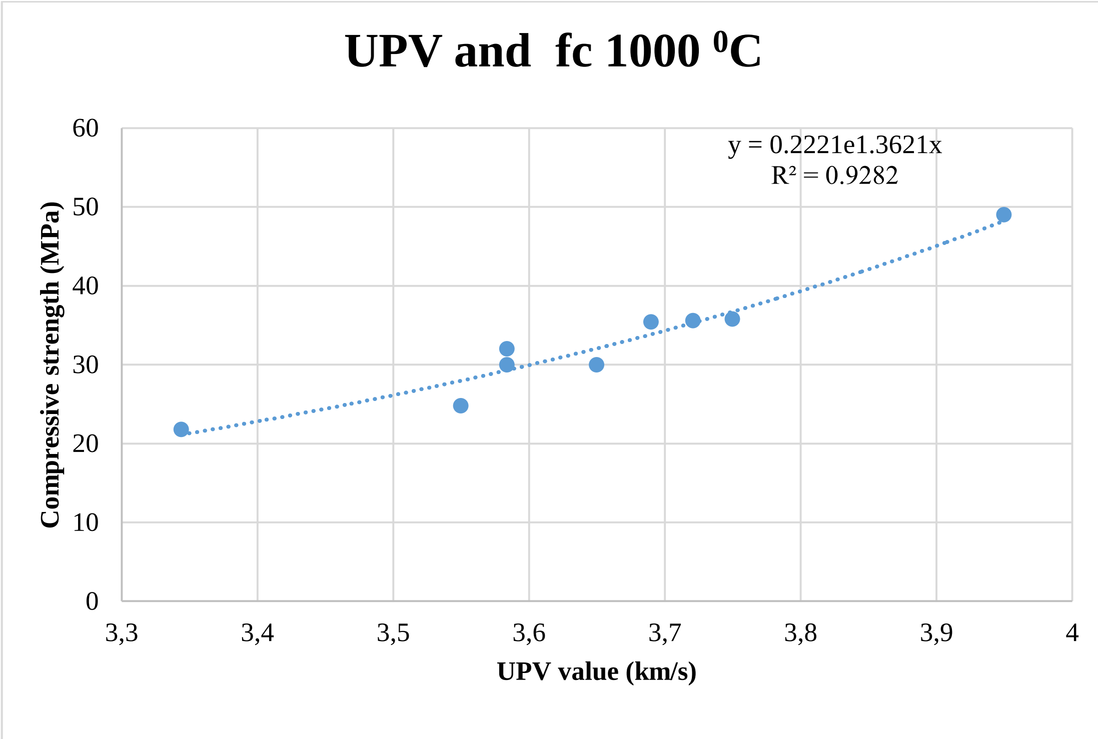
$$Fc = ae^{bv} \quad (4.1)$$

Where

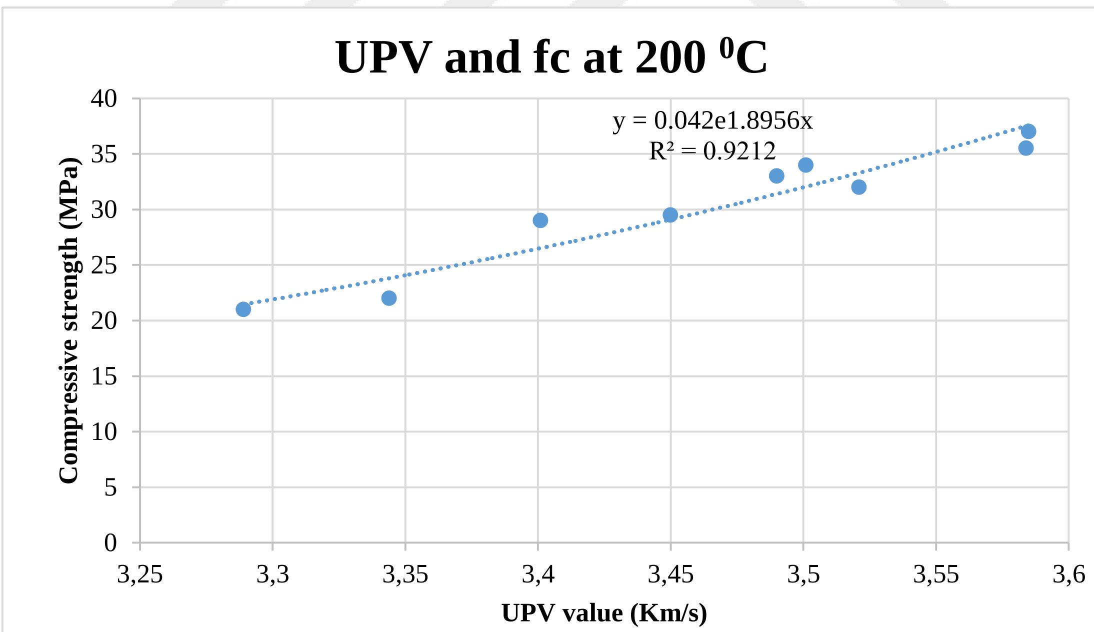
Fc: is the compressive strength of concrete (MPa)

A and b: constant number

v: the value of ultrasonic pulse velocity (km/s)

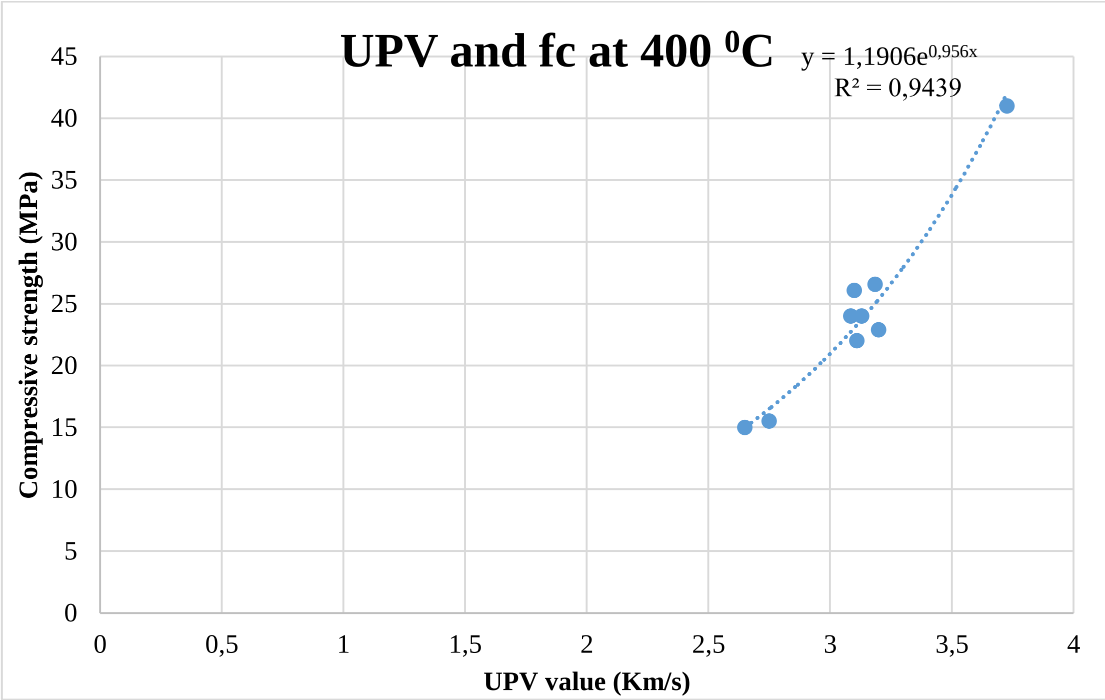


A

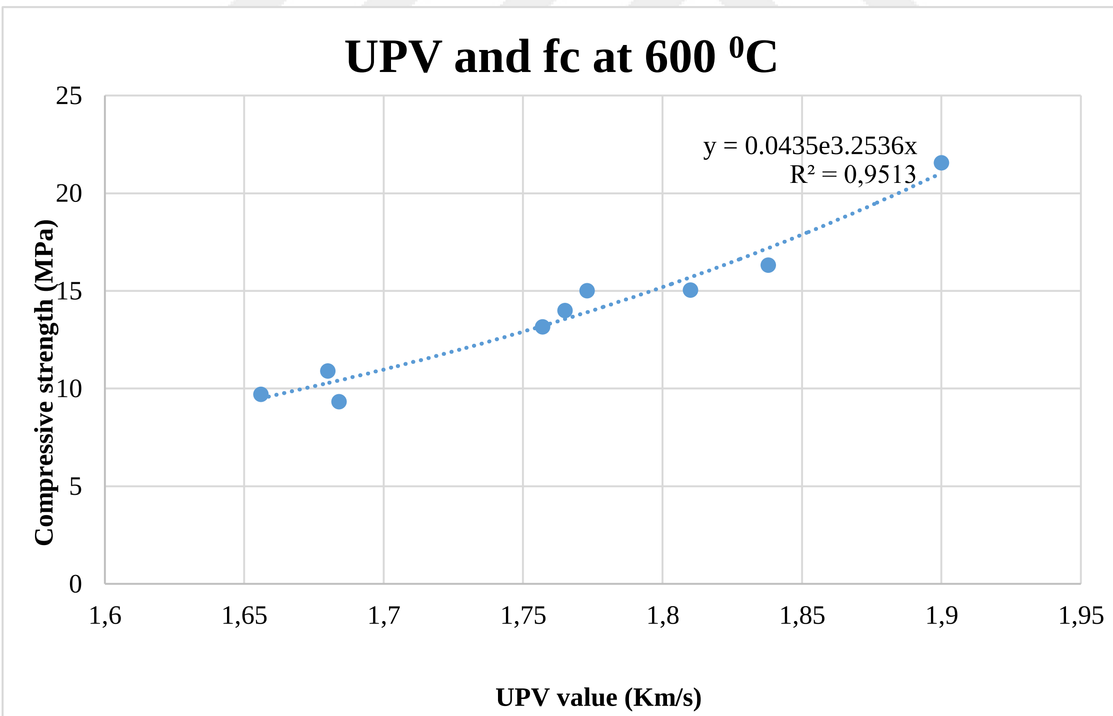


B

Figure 4.29. The relationship between compressive strength and Ultrasonic Pulse Velocity values SLWC of A and B.

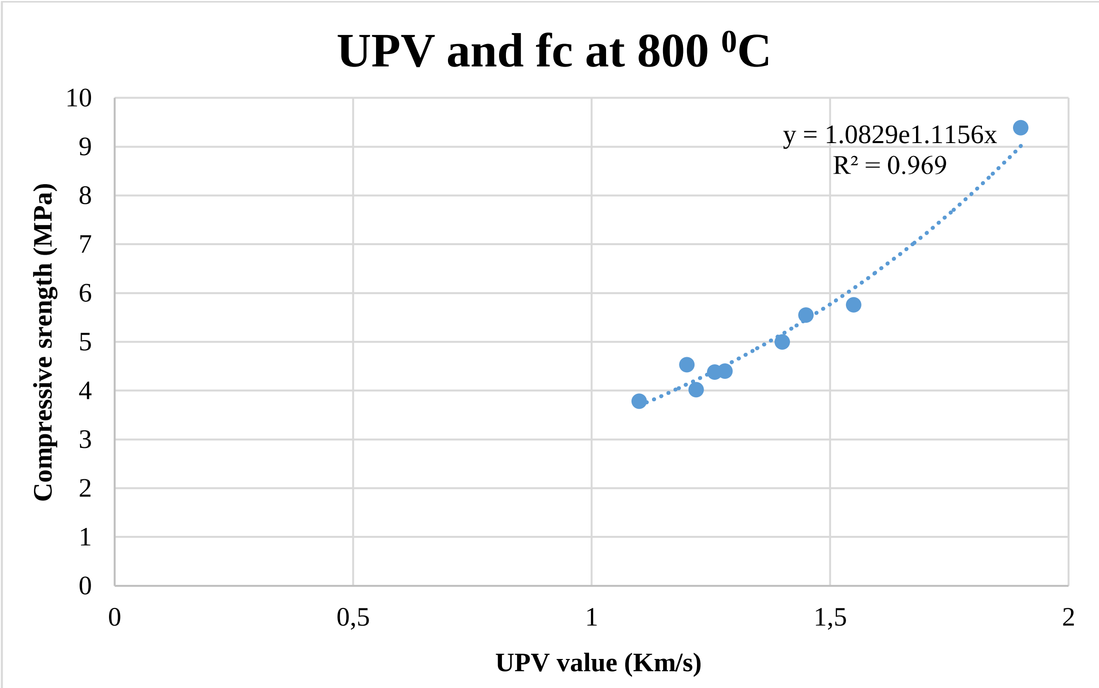


C



D

Figure 4.30. The relationship between compressive strength and Ultrasonic Pulse Velocity values SLWC of C and D.



E

Figure 4.31. The relationship between compressive strength and Ultrasonic Pulse Velocity values SLWC of E.

4.5. Thermal Conductivity

The thermal conductivity of lightweight concrete is essentially influenced by their mineralogical and porosity in the lightweight aggregate to produce lightweight concrete. Generally, the unit weight of lightweight concrete directly affects the thermal conductivity, when the unit weight decreases the thermal conductivity also decreases. This is because of the porosity in the lightweight aggregate caused by decreasing the thermal conductivity. Table 4.1 shows the thermal conductivity and unit weight in each group. The lowest thermal conductivity can be observed in G2 due to the minimum unit weight. Figure 4.26 shows the effect volume of PP fiber on the thermal conductivity. Generally, with increasing the volume of PP fiber the thermal conductivity decreases, because of the pp fiber in the lightweight concrete absorbs the heat during the thermal process.

Table 4.2. Thermal conductivity and Unit Weight Kg/m^3

Group	Mixes	Unit Weight	Thermal Conductivity
	M1	1585	0.3998
G1	M2	1580	0.3269
	M3	1490	0.3495
	M4	1489	0.262
G2	M5	1482	0.2843
	M6	1544	0.2637
	M7	1726	0.4048
G3	M8	1690	0.3589
	M9	1614	0.3422

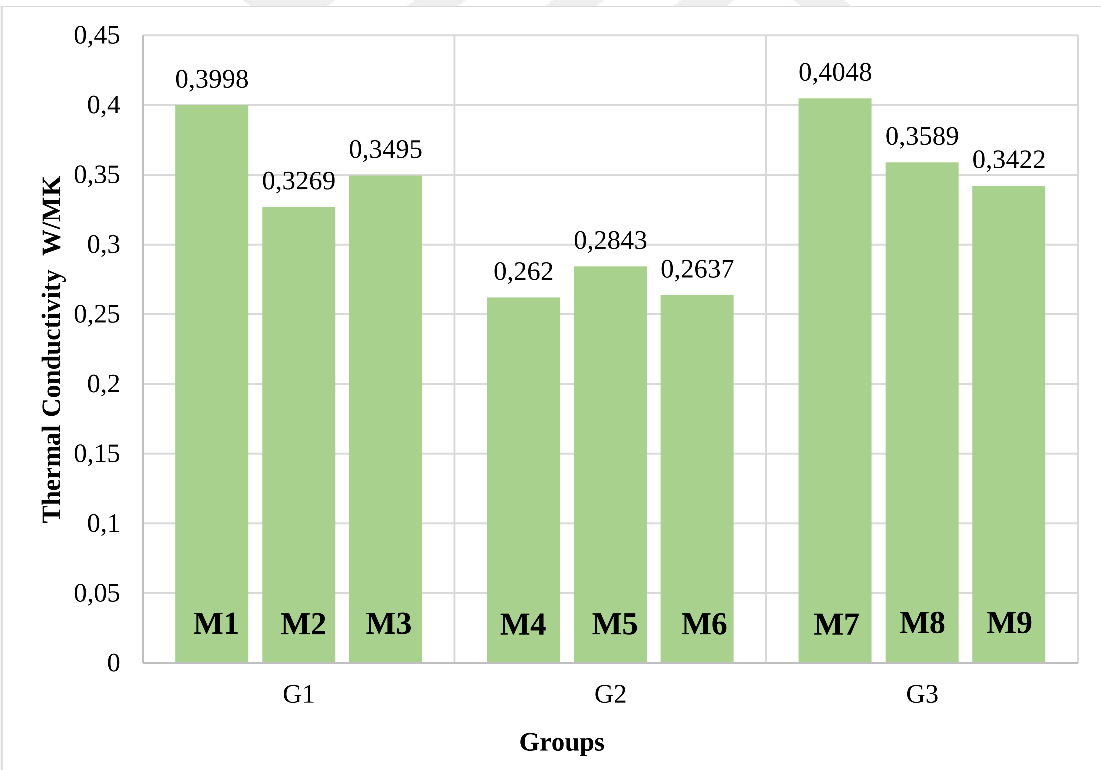


Figure 4.32. The effect volume of PP fiber on the thermal conductivity.

5. CONCLUSION

This study focused on the effect of unit weight and volume of PP fiber on fresh and hardened properties of SLWC and following points were deduced:

1) The volume of PP fiber essentially influences the workability of lightweight concrete, with increasing the fiber content the workability decreases. In G3 the slump value is decreased from 285 to 210 mm when the PP fiber increases from 0 to 0.5% respectively.
2) The optimum compressive strength was found to be 29 MPa in the control mix (M1) which is free of PP fiber. Decreasing the unit weight of lightweight concrete reduces the compressive strength of lightweight concrete and also increases the volume of PP fiber and causes a reduction in the strength of concrete. The compressive strength of concrete without PP fiber increases from 14 to 30 MPa while the unit weight of lightweight concrete increases from 1489 to 1726 Kg/m^3 respectively.
3) The optimum flexural strength was measured to be 1.82 MPa obtained in M3 which has the highest volume of PP fiber. With increasing the volume of PP fiber from 0 to 0.5% the flexural strength increased from 1.39 to 1.82 MPa respectively.
4) The splitting tensile strength decreases from 1.68 to 1.2MPa when the volume of PP fiber increases from 0 to 0.5%. The maximum split tensile strength of 2.11 MPa is achieved in M8 when the volume of PP fiber was 0.25%.
5) In this investigation when the temperature increases in up to 150^oC the compressive strength developed a little. However, a further increase, the temperature from 150 to 800^oC the compressive strength rapidly decreases.
6) In this study when the unit weight decreases the thermal conductivity also decreases. Because of the porosity in the lightweight aggregate caused by decreasing the thermal conductivity. With increasing the volume of PP fiber the thermal conductivity decreases, because of the pp fiber in the lightweight concrete absorbs the heat during the thermal process.

7) In addition, according to the results obtained in this study, lightweight concrete in G3 with different volume of PP fiber can be used in structural members such as columns, beams, shear walls, and slabs. However, the concrete obtained in G2 which has a low unit weight can be used for lightweight elements such as concrete blocks and some pre-cast elements.

REFERENCE

ACI-213R-87. 1998. ***Building code requirements for reinforced concrete (ACI 318-95), American Concrete Institute, Farmington Hills, MI***.

Alduaij, Jamal; Khalid Alshaleh; M. Naseer Haque; Khalid Ellaithy. 1999. Lightweight concrete in hot coastal areas. ***Cement & Concrete Composites*****, 21**: 453-458.

Alsadey, Salahaldein; ,Muhsen Salem. 2016. Influence of polypropylene fiber on strength of concrete. ***American Journal of Engineering Research (AJER),*** (7): 223-226.

ASTM C566-97.1997. ***Standard test method for total evaporable moisture content of aggregate by drying***.

ASTM-597-09. 2016. ***Standard test method for pulse velocity through concrete.West conshohocken (pa): astm international.***

Chandra, Satish; Leif Berntsson . 2008. Historical background of lightweight aggregate concrete. ***Lightweight Aggregate Concrete*****, 82**: 5-19.

Clarke, J. L. 1993. ***Structural lightweight aggregate concrete. CRC Press***.

Dharan, Divya S; Aswathy Lal. 2016. Study the effect of polypropylene fiber in concrete. ***International Research Journal of Engineering and Technology,*** **3**(6): 616-619.

Go, Cheer-Germ; Jun-Ren Tang ; Jen-Hao Chi; Cheng-Tung Chen; Yue-Lin Huang. 2012. Fire-resistance property of reinforced lightweight aggregate concrete wall. ***Construction and Building Materials*****, 30**: 725-733.

Guler, S. 2018. The effect of polyamide fibers on the strength and toughness properties of structural lightweight aggregate concrete. ***Construction and Building Materials*****, 173**: 394-402.

Hassiba, Belaribi; Mellas Mekki; Rahmani Farid. 2018. The relationship between the compressive strength and ultrasonic pulse velocity concrete with fibers exposed to high temperatures. ***International Journal of Energetica*****, 3**(1): 31-36.

K.Murahari; Rama mohan Rao. 2013. Effects of polypropylene fibres on the strength properties of fly ash based concrete. ***International Journal of Engineering Science Invention*****, 5**(2): 13-19.

Karthik, A.; M. Shanmugam; S. Maniselventhiran; B. C. Jeya Dinesh; Francis, A. Abraham. 2015. Fibre reinforced lightweight concrete using pumice stone. ***International Journal of Engineering Research & Technology*****, 3**(11): 1-6.

Khandaker, M. & A. Hussain. 2003. Properties of volcanic pumice based cement and lightweight concrete. ***Cement and Concrete Research*****, 34**: 283-291.

Kolli.Ramujee. 2013. Strength properties of polypropylene fiber reinforced concrete. ***International Journal of Innovative Research in Science, Engineering and Technology*****, 2**(8): 3409-3413.

Kolli.Ramujee. 2013. Strength properties of polypropylene fiber reinforced high strength concrete. ***International Journal of Innovative Research in Science, Engineering and Technology*****, 2**(8): 3409-3413.

Kumar, K. Guru Kesav; C. Krishnaveni. 2016. Study on partial replacement of aggregate by pumice stone in cement concrete.***The International Journal Of Science & Technoledge,*** **4**(3): 113-119.

Kumar, Pawan; Dr. A.K. Mishra. 2016.Comparative study of polypropylene fiber reinforced concrete with conventional concrete pavement design. ***International Journal for Research in Applied Science & Engineering Technology,*** **4**(IV): 662-666.

lakshmi, A.Suba; S. Karthick; Gasper Helden; M.Dinesh Boopathi; V.Balaji Pandian. 2017. Experimental investigation on light weight concrete using pumice aggregate. ***International Journal of Innovative and Emerging Research in Engineering,*** **4**(3): 176-183.

Li, Jing jun; Niu, Jian gang ; Wan, Chao jun ; Biao Jin; Yin, Ya liu. 2016. Investigation on mechanical properties and microstructure of high performance polypropylene fiber reinforced lightweight aggregate concrete. ***Construction and Building Materials journal,*** **118**: 27-35.

Libre, Nicolas Ali; Mohammad Shekarchi; Mehrdad Mahoutian; Parviz Soroushian. 2010. Mechanical properties of hybrid fiber reinforced lightweight aggregate concrete made with natural pumice. ***Construction and Building Materials,*** **25**(5): 2458-2464.

Mazaheripour, H.; S. Ghanbarpour; Mirmoradi a, S. H. 2011. The effect of polypropylene fibers on the properties of fresh and hardened lightweight self-compacting concrete. ***Construction and Building Materials journa*l, **25**(1): 351-358.

Minapu, Lakshmi Kumar; M K M V Ratnam; Dr. U Rangaraju. 2014. Experimental study on light weight aggregate concrete with pumice stone, silica fume and fly ash as a partial replacement of coarse aggregate. ***International Journal of Innovative Research in Science, Engineering and Technology***, **3297**(12): 18130-18138.

Mohammed, Jihad Hamad; Hamad , Ali Jihad. 2014. Materials, properties and application review of lightweight concrete. ***International Journal of Advanced Engineering Applications,*** **37**(2): 10-15.

Mohod, M. V. 2015. Performance of Polypropylene Fibre Reinforced Concrete. ***Journal of Mechanical and Civil Engineering,*** **12**(1): 28-36.

muralitharan, R.S.; V. ramasamy.2017. Development of Lightweight concrete for structural applications. ***Journal of Structural Engineering,*** **44**(4): 336-344.

Nahhas, T. M. 2013. Flexural behavior and ductility of reinforced lightweight concrete beams with polypropylene fiber. ***Journal of Construction Engineering and Management,*** **1**: 4-10.

Neville, A. &. 2010. ***Concrete Technology (Vol.): Harlow.***

Nili, Mahmoud; V. Afroughsabet. 2010. 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.

Parhizkar, T.; M. Najimi ; A.R. Pourkhorshidi. 2011. Application of pumice aggregate in structural lightweight concrete. ***Asian Journal Of Civil Engineering (Building And Housing),*** **13**(01): 43-54

Pravallika, B. Devi; K. Venkateswara Rao. 2016. The study on strength properties of light weight concrete using light weight aggregate. ***International Journal of Science and Research,*** **5**(6): 1735-1739.

Rai, Amit; Dr. Y.P Joshi. 2014. Applications and properties of fibre reinforced concrete amit. ***Int. Journal of Engineering Research and Applications,*** **4**(5): 123-131.

Rajeswari S, Dr. Sunilaa George. 2015. Experimental study of light weight concrete by partial replacement of coarse aggregate using pumice aggregate.***International Journal of Scientific Engineering and Research (IJSER)*, 5**: 50-53.

Rao, N. Sivalinga; Kumari, Y.Radha Ratna; V. Bhaskar Desai; B.L.P. Swami. 2013. Fibre reinforced light weight aggregate (natural pumice stone) concrete. ***International Journal of Scientific & Engineering Research*, 4**(5): 158-161.

Rossignolo, Jo~aao A.; Marcos V. C. Agnesini; , Jerusa A. Morais b. 200. Properties of high-performance LWAC for precast structures with Brazilian lightweight aggregates. ***Cement & Concrete Composites*, 25** (1): 77-82.

S.Rajeswari; , Dr. Sunilaa George. 2016. Experimental study of light weight concrete by partial replacement of coarse aggregate using pumice aggregate. I***nternational Journal of Scientific Engineering and Research*, 4**(5): 50-53.

S.Mohamed R.A.2006. Effect of polypropylene fibers on the mechanical properties of normal concrete. ***Journal of Engineering Sciences*, 4**: 1049-1059.

Saini, Rakesh Kumar; Anil Godara; Anurag Maheswari; Ashish Kumar Meena. 2018. Experimental study on light weight concrete with pumice stone as a partial replacement of coarse aggregate. ***Cement & Concrete Composites*, 7**(5): 48-55.

Sancak, Emre; Y. Dursun Sari ; Osman Simsek. 2008. Effects of elevated temperature on compressive strength and weight loss of the light-weight concrete with silica fume and superplasticizer. ***Cement & Concrete Composites*, 30**: 715-721.

Shihada, Samir. 2017. Effect of polypropylene fibers on concrete fire resistance samir. ***Journal of Civil Engineering and Management*, 17**(2): 259-264.

Subasi, Serkan. 2009. The effects of using fly ash on high strength lightweight concrete produced with expanded clay aggregate. ***Scientific Research*, 4**(4): 275-288.

Tanyildizi, H. & Coskun, A. 2007. Performance of lightweight concrete with silica fume after high temperature. ***Construction and Building Materials*, 22**(10): 2124-2129.

Tanyildizi, Harun. 2009. Statistical analysis for mechanical properties of polypropylene fiber reinforced lightweight concrete containing silica fume exposed to high. ***Materials and Design*, 30**(8): 3252-3258.

TS EN 12390-3. 2003. ***Testing hardened concrete – part 3: compressive strength of test specimens, turkish standard, turkey.***

TS EN 12390-5. 2002. ***Testing hardened concrete-part 5: flexural strength of tests specimens, turkish standard, turkey*** .

TS EN 12390-6. 2002. ***Testing hardened concrete – part 6: tensile splitting strengthfor test specimens, turkish standard, turkey***.

V.Mohana; Dr. D.Suj; E. Niranjani. 2016. Influence of fibre reinforcement on strength and toughness of light weight concrete. ***Construction and Building Materials*, 4**(1): 126-133.

Venkatesh, B.; B. Vamsi Krishna. 2015. A study on the mechanical properties of light weight concrete by replacing course aggregate with (pumice) and cement with (fly ash). ***international Journal of Engineering Research & Technology*, 4**(8): 331-336.

APPENDIX. EXTENDED TURKISH SUMMARY (GENİŞLETİLMİŞ TÜRKÇE ÖZET).

1. GİRİŞ

1.1. Arka fon

Yapısal hafif beton, minimum 17 MPa'lık bir basınç dayanımı ve 1350 ila 1900 kg/m3 arasında bir birim ağırlık ile tanımlanabilir (ACI-213R-87, 1998). (B. Devi Pravallikal, 2015). Taşıyıcı hafif beton inşaat mühendisliği alanında uzun yıllardır, özellikle uzun açıklıklı köprülerde, deniz platformlarında ve yüksek binalarda başarıyla kullanılmıştır (Li Jing jun ve diğ., 2016). Düşük birim hacim ağırlık, iyileştirilmiş yangın dayanımı, daha iyi dayanıklılık özelliği, düşük ısı iletkenlik katsayısı (Libre vd., 2010), daha iyi gerilme kapasitesi ve aşırı ısınma ve ses yalıtımı özelliği gibi normal ağırlıktaki betona kıyasla çok sayıda avantaja sahip taşıyıcı hafif beton kullanılması, binanın ölü yükünü azalttığından, kirişlerde, duvarlarda, temellerde ve kolonlarda daha küçük kesitlerin kullanımını mümkün kılmaktadır. Ayrıca, yapının toplam birim ağırlığını azaltarak, deprem hasarı tehlikesini azaltır. Genellikle, taşıyıcı hafif betonu üretmek için doğal veya yapay hafif agrega kullanılmaktadır. Bu amaçla, volkanik kökenli doğal bir agrega olan pomza çoğunlukla hafif beton üretiminde kullanılmaktadır (Muralitharan, R.S.ve V. ramasamy, 2017).

Betonda, düşük özgül ağırlığa ve düşük maliyete sahip olan polipropilen lif kullanımı ler betonun dayanım özelliklerini iyileştirebilmektedir. Liflerin kullanımı, betonun çekme ve eğilme mukavemetlerini doğrudan etkiler ve plastik büzülmeyi ve termal çatlamayı azaltmak için betona önemli bir katkı sağlar (Dharan Divya ve Aswathy Lal, 2016). Bu çalışmanın temel amacı, lif içeriği, birim ağırlık ve yüksek sıcaklık parametrelerinin lif takviyeli yapısal hafif betonun basınç ve eğilme dayanımları üzerindeki etkilerini araştırmaktır. Bu hedeflere ulaşmak için öncelikle farklı polipropilen lif hacminin farklı birim hacim ağırlıklara sahip taşıyıcı hafif betonların basınç ve eğilme dayanımları üzerindeki etkisi belirlenmiştir. Daha sonra, farklı birim hacim ağırlığa sahip taşıyıcı hafif betonların yüksek sıcaklık etkisindeki dayanım özelliklerini belirlemek üzere tez kapsamında üretilen taşıyıcı hafif betonlar bir saat boyunca 200, 400, 600 ve 800 ^{0}C sıcaklıklara tabi tutulmuştur. Yangına maruz kalan yapısal hafif betonun basınç dayanımı ve UPV değerleri arasındaki korelasyonu belirleyebilmek için ultrasonik hız ölçümleri gerçekleştirilmiştir.

2. MATERYAL VE YÖNTEM

2.1. Materyal

Bu araştırmadaki tüm beton karışımlarında silis dumanı, 0.5 – 2 mm çapında pomza agregası, 0.5-1 mm ve 1-2 mm ince porfirik agrega, hiperakışkanlaştırıcı, hava sürükleyici ve ASTM Normal Portland Çimento (NPC) CEM I 52.5R kullanılmıştır. Katkı oranına göre ayrıca polipropilen lif kullanılmıştır.

2.2. Yöntem

2.2.1. Beton Karıştırma ve Döküm

Beton karışımları, 250 Lt. kapasiteli bir mikser kullanılarak laboratuarda hazırlanmıştır. Karışımları hazırlamak için kullanılan tüm malzeme oranları Tablo 1'de açıklanmaktadır. Hacimce % 0, % 0,25 ve % 0,5 polipropilen lif kullanılarak, birim hacim ağırlığı 1400 - 1800 kg/m^3 olan üç tip yapısal hafif beton hazırlanmıştır. Farklı miktarlardaki polipropilen lifinin ve taşıyıcı hafif betonun birim hacim ağırlığının, yapısal hafif betonun basınç, eğilme, çekme dayanımı ve işlenebilirliği ve yangın dayanımı üzerindeki etkileri incelenmiştir. Hazırlanan karışımlar plastik ve çelik kalıplara döküldükten sonra titreşim tablasında sıkıştırılmış, 24 saat sonra, test gününe kadar %95 bağıl nemde (RH) ve 23C^{o}'de kür havuzunda bekletilmiştir. Testten hemen önce, yüzeydeki su bir havlu kullanılarak kurutulmuştur. Numunelerin basınç dayanımı için 150x300 mm'lik silindirler ve yarmada çekme dayanımı için 150x150 mm küpler eğilme dayanımı için 100x100x400 mm prizmalar ve yangın dayanımı için de 100x100 mm küpler, ısıl iletkenlik için de 300x300x50 mm'lik prizmalar kullanılmıştır. Basınç testleri 5kN/s sabit yükleme altında yapılmıştır. Farklı miktarda polipropilen lif içeren taşıyıcı hafif betonların yangın dayanımları, dakikada 6 C°'lik bir ısıtma hızı ile bir saat boyunca 200, 400, 600 ve 800 °C'ye maruz kaldıktan sonra elde edilmiştir.

Tablo 1. Beton karışımı oranları

Karışım Adı	Çimento Kg/m^3	Silis Dumanı Kg/m^3	Filler Kg/m^3	Su L/m^3	S/B Kg/m^3	Hava Sürükleyici Kg/m^3	Hiperakışkanlaştırıcı Kg/m^3	İnce Agrega			
								Pomza		Porfirik Kayaç Kg/m^3	PP Lif Kg/m^3
								35% (0.5-1) mm(L)	65% (1-3) mm(L)		
Mix 1	692	173	207	385	44.5	1.39	38	622.5	1245	894.8	-
Mix 2	692	173	207	385	44.5	1.392	38	622.5	1245	894.8	30
Mix 3	692	173	207	385	44.5	1.392	38	622.5	1245	894.8	60
Mix 4	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	-
Mix 5	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	30
Mix 6	692	173	207	385	44.5	1.392	38	466.8	933.6	894.8	60
Mix 7	692	173	207	385	44.5	1.392	38	311	578	894.8	-
Mix 8	692	173	207	385	44.5	1.392	38	311	578	894.8	30
Mix 9	692	173	207	385	44.5	1.392	38	311	578	894.8	60

SF: Silika dumanı% 0.25 çimento * SP: Süper akışkanlaştırıcı% 5.5 çimento.
* PP Lif: polipropilen lif (% 0.25 ve% 0.5) hacimce * L: Litre
* Hava Girişi: Hava girişi% 0,20 çimento * Dolgu: % 0,30 çimento

3. BULGULAR VE TARTIŞMA

3.1. İşlenebilirlik

Bu çalışmada, tüm beton karışımları için ilk olarak çökme değeri ve birim ağırlıklar ölçülmüştür. Farklı birim ağırlıkları olan üç hafif beton grubu incelenmiştir, her hafif beton grubuna farklı miktarlarda PP lif % 0, % 0,25 ve% 0,5 eklenmiştir. Kontrol karışımları için maksimum çökme değerleri M1, M4 ve M7'nin sırasıyla 230, 270 ve 285 mm olduğu belirlenmiştir. Kontrollü karışımların işlenebilirliği, hafif betonun birim ağırlığındaki artışla artmıştır.

3.2. Basınç dayanımı

Birinci grup numunelerin gerilme-gerinim eğrileri incelendiğinde M1 numunesinin en yüksek basınç dayanımına, 29 MPa, sahip olduğu görülmektedir. PP lif miktarının hacimce % 0.25'ten % 0.5'e yükseltilmesi ile basınç dayanımı sırasıyla 26 ve 23 MPa'ya düşmüştür.

3.3.Eğilme dayanımı

Maksimum eğilme dayanımı, en yüksek PP lif hacmine sahip olan M3'te 1.82 MPa olarak elde edilmiştir. PP lif hacminin % 0'dan % 0,5'e çıkarılmasıyla birlikte, eğilme mukavemeti, çimento hamuru ile elyaf arasındaki mekanik bağdaki iyileşmeye bağlı olarak sırasıyla 1.39'dan 1.82 MPa'ya yükselmektedir.

3.4.Yarmada çekme dayanımı

Yapılan çalışmada yarmada çekme dayanımının PP lif hacminin artmasıyla azaldığı görülmüştür. Yarmada çekme dayanımı, PP lifinin hacmi % 0,5'e arttırıldığında G1'de (M1, M2 ve M3) % 8 oranında sistematik olarak azalmıştır. PP lif hacmi % 0,5 oranında lif kullanılan betonlarda yarmada çekme dayanımı 1,68 MPa'dan 1,2 MPa'ya düşmüştür.

3.5.Yangın dayanımı

Yüksek sıcaklığın, farklı miktarlarda lif içeren farklı birim hacim ağırlıklarına sahip taşıyıcı hafif betonların basınç dayanımı üzerindeki etkisi incelenmiş 150C^{o}'ye kadar basınç dayanımında önemsenmeyecek bir artış gözlenmiştir. Sıcaklığın arttırılmasıyla birlikte basınç dayanımı keskin bir şekilde azalmıştır.

3.6.Isıl İletkenlik

Hafif betonun birim hacim ağırlığı doğrudan ısı iletkenliğini etkiler, birim ağırlık azaldığında ısı iletkenliği de düşer. Bunun nedeni, hafif betondaki gözenekliliktir. En düşük ısı iletkenliği, minimum birim ağırlığı nedeniyle G2'de gözlenmiştir.

4. SONUÇLAR

Yapilan bu çalışmada taşıyıcı hafif betonalarda kullanılan lif katkısının hafif betonun işlenebilirliğini olumsuz yönde etkilediği belirlenmiştir.
En yüksek basınç dayanımı, PP lif içermeyen kontrol karışımında (M1) 29 MPa olarak bulunmuştur. Hafif betonun birim ağırlığı azaldıkça, hafif betonun basınç dayanımı azalmıştır. Birim hacim ağırlıkları 1489 ile 1726 Kg/m^3 arasında değişen lif katkısız hafif betonların silindirik basınç dayanımları 14 ila 30 MPa arasında elde edilmiştir.
En yüksek lif hacmine sahip olan M3'te en yüksek çekme mukavemeti (1,82 MPa) elde edilmiştir. Lif hacminin %0'dan %0.5'e yükseltilmesiyle, eğilme dayanımı sırasıyla 1.39'dan 1.82 MPa'ya yükselmiştir. Yangın dayanımları incelenen numunelerde sıcaklığın 150C^o'ye kadar arttırılmasıyla basınç dayanımında önemsenmeyecek bir artış gözlenmiş daha yüksek sıcaklıklarda basınç dayanımlarında ciddi azalmalar elde edilmiştir.

CURRICULUM VITAE

Faraydon Hama Rash W. Mahmod was born in - Halabja / Iraq, finished his secondary and high school education in Khurmal School in 2004. The same year had accepted in Civil Engineering Department of Engineering College at Salahaddin University – Erbil. In 2009, he had graduated from Civil Engineering Department. In February 2017, he started postgraduate studying master's degree in the Civil Engineering Department, Institute of Natural and Applied Sciences at Van Yüzüncü Yıl University – VAN.

UNIVERSITY OF VAN YUZUNCU YIL
THE ISTITUTE OF NATURAL AND APPLIED SCIENCES
THESIS ORIGINALITY REPORT

Date: 19/9/2019

Thesis Title: EFFECT OF POLYPROPYLENE FIBER ON THE STRENGTH PROPERTIES OF STRUCTURAL LIGHTWEIGHT CONCRETE WITH DIFFERENT UNIT WEIGHTS

The title of the mentioned thesis, above having total 62 pages with cover page, introduction, main parts and conclusion, has been checked for originality by Turnitin computer program on the date of 19/9/2019 and its detected similar rate was 16% according to the following specified filtering

Originality report rules:

- Excluding the Cover page,
- Excluding the Thanks,
- Excluding the Contents,
- Excluding the Symbols and Abbreviations,
- Excluding the Materials and Methods
- Excluding the Bibliography,
- Excluding the Citations,
- Excluding the publications obtained from the thesis,
- Excluding the text parts less than 7 words (Limit match size to 7 words)

I read the Thesis Originality Report Guidelines of Yuzuncu Yil University for Obtaining and Using Similarity Rate for the thesis, and I declare the accuracy of the information I have given above and my thesis does not contain any plagiarism; otherwise I accept legal responsibility for any dispute arising in situations which are likely to be detected.

Sincerely yours,

19-9-2019

Name and Surname: Faraydon Hama Rash W.Mahmod

Student ID#:17910001138

Science: Civil Engineering Department

Program: ....

Statute: M. Sc. ☑ Ph.D. ☐

APPROVAL OF SUPERVISOR

Assoc. Prof. Dr. Mucip TAPAN)

APPROVAL OF THE INSTITUTE

Prof. Dr. Suat Şensoy