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RECYCLING OF WASTE LATEX PAINT IN CONCRETE MORTAR

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Recycling Of Waste Paint in Concrete Mortar

M.Sc. Thesis

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all materials and results that are not original to this work.

Fatma Çağıl BAĞDATLI

ABSTRACT

RECYCLING OF WASTE PAINT IN CONCRETE MORTAR

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Every year, millions of liters of latex paint go to waste around the world. Considering the similarities in the chemical composition of waste paint and polymeric additives, this study aiming to use waste paint in concrete has emerged. In this study, the adequacy of using waste paint as a chemical additive in concrete mortar is discussed. It is a study towards the development of new cementitious materials with a lower environmental impact, given the importance of sustainability as the main driver for future innovations. Except for the amount of waste paint, all materials were kept constant, and the effects of waste paint on the concrete mortar, the properties of hardened concrete, and fresh concrete, were investigated as a result of a number of experiments. As a result of the experiments, it was decided that the optimum amount of paint to be used in the experiment was 3% while improving the fresh concrete properties of the waste paint. It was concluded that not all types of paints could be used, and it was determined that solvent paints disrupted the structure of the concrete mortar and segregated it. It has been concluded that using waste paint as a material that will affect the negative properties of normal concrete positively while eliminating wastes for a more livable environment will affect the properties of concrete in low tension concretes, namely pavements and bridge coatings, in a good way.

Keywords: Concrete, Waste Paint, Concrete Mortar, Latex Paint

ÖZET

ATIK LATEKS BOYANIN BETON HARCINDA GERİ DÖNÜŞÜMÜ

Bagdatli, Fatma Çağıl
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ÖZET

Her yıl dünya genelinde milyonlarca litre lateks boya çöpe gitmektedir. Atık boya ve polimerik katkı maddelerinin kimyasal bileşimindeki benzerlikleri göz önünde bulundurunca atık boyanın betonda kullanımını amaçlayan bu çalışma ortaya çıkmıştır. Bu çalışmada beton harcında kimyasal katkı olarak atık boyanın kullanılma yeterliliği ele alınmıştır. Gelecekteki yenilikler için ana itici güç olarak sürdürülebilirliğin önemi göz önünde bulundurulduğunda daha düşük çevresel etkiye sahip yeni çimentolu malzemelerin geliştirilmesine yönelik bir çalışmadır. Atık boya miktarı hariç bütün malzemeler sabit tutularak atık boyanın beton harcı üzerindeki etkileri sertleşmiş beton ve taze beton özellikleri bir takım deneyler sonucunda incelenmiştir. Yapılan deneyler sonucunda atık boyanın taze beton özelliklerini geliştirirken deneyde kullanılacak optimum boya miktarının %3 olduğuna karar verilmiştir. Her tip boyanın kullanılamayacağı sonucuna varılıp solvent boyaların beton harcının yapısını bozup segresyona uğrattığı tespit edilmiştir. Daha yaşanılır bir çevre adına ve atıkları bertaraf ederken aynı anda normal betonun olumsuz özelliklerini iyi yönde etkileyecek bir malzeme olarak atık boya kullanmak düşük gerilimli betonlarda yani kaldırımlarda, köprü kaplamalarında betonun özelliklerini iyi yönde etkileyeceği sonucuna varılmıştır.

Anahtar Kelimeler: Beton, Beton Harcı, Lateks Boya, Atık Boya

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SYMBOLS AND ABBREVIATIONS

ASTM : American Society for Testing and Materials

MPA : Mega Pascal

SBR : Styrene- Butadiene Copolymer

TS EN : Turkish Standards Institution

CHAPTER 1

INTRODUCTION

1.1 General

Our natural resources are decreasing day by day due to the increase in the world population. In our world where resources are being depleted rapidly, recycling is just as important to make our world livable. Reducing material consumption and recycling qualified waste are among some of the measures we will take. Mixing non-recyclable products into recycling will make this whole process difficult, and the wrong materials thrown can make it impossible to recycle the entire box contents. Although the majority of waste in our country is recyclable, recycling rates are at very low levels. Considering developed countries, we see that most of the waste can be recycled into the economy by participating in recycling.

Concrete is the most consumed material in the world after water. The materials that make up the concrete are cement, water, and aggregate. Cement, on the other hand, takes on the role of the basic binder in the concrete. While water and aggregate are taken from nature, cement is produced in an industrial environment. Cement production, on the other hand, requires a high amount of energy and as a result of studies, it has been found that cement production is responsible for approximately 8% of human-induced CO_2 emissions. According to 2013 statistics, Turkey is the first in Europe in cement production, and it is in the top five in the world. Production of this scale brings with it economic and environmental problems. Since concrete is the most popular material in the world, and cement is the primary binder used in concrete, the importance of making this substance sustainable is better understood when its worldwide use is taken into account. For this reason, we must turn to different solutions to improve sustainability. To reduce the CO_2 emission resulting from cement and to use resources more efficiently, we should turn to different materials.

Plain concrete, however, has many negative properties, including low tensile strength. Chemical additives are added to the concrete to eliminate these vulnerabilities. Various chemical additives are added to the concrete to increase the matrix bond between cement and aggregate and to increase the workability of the concrete. However, these chemical additive applications are expensive. Latex reinforced concrete is produced to eliminate the disadvantages of normal concrete. In this study, it has been studied on the use of waste paint, which is difficult to recycle and has high disposal costs, as a building material in concrete. Proper disposal of waste paint, which cannot be directly recycled and has very high disposal costs, is of great importance. Waste paint is a valuable resource that is disposed of at economic and environmental costs. If the waste paint is not disposed of properly, it will cause important events that will endanger human health, such as polluting underground waters and adversely affecting natural life. The most common disposal method of waste paint is to solidify and then dispose of it in a landfill. Why put it in landfills and cover the cost of recycling when we can economically use a reusable resource? When a recyclable material is reintroduced into the production process, it eliminates all possible problems in the future.

The aim of this study is to increase the efficiency of the construction process, while the adequacy of using waste paint, which is extremely costless, in concrete is discussed. It is not possible to describe waste paint in the classical sense. Since other waste paints are collected together with chemical wastes, it is not possible to obtain only paint waste. In our studies, we worked with waste paints with expired shelf life. Different results have been obtained for different paint types, and it has been observed as a result of experiments that waste latex paint increases the workability and durability of the mortar while obtaining sufficient compressive strength.

CHAPTER 2

LITERATURE REVIEW

2.1. Definition of concrete

Concrete is the most widely used man-made construction material in the world, which gains resistance over time with the addition of chemical and mineral additives by combining aggregate, water, and cement in certain proportions.

Concrete is the most widely used building material. However, normal concrete without additives has many disadvantages, including low tensile strength. Some polymers are added to improve the properties of the concrete or to adapt the concrete to different usage areas or to protect the quality of the concrete in adverse weather conditions.

2.2. Latex paint

The value of world paint sales in 2013 in terms of US dollars is 130 billion dollars. The amount of it is about 51 million tons. In Turkey, the paint consumption in the domestic market is 2.2 billion dollars. As Europe's 5th largest paint producer, Turkey has approximately 2% of the world market. Paint consumption per capita in Turkey is approximately 11 kilograms per year. (BOSAD 2014)

Paints consist of a mixture of solid and liquid materials. Chemicals used in paint production are pigments, binders (also called synthetic resin and alkyd), additives, solvents, fillers, and diluents. Binders make up 25% of the volume. Pigments, which make up 15% of the volume, are fine particles and give color to the paint. Pigments are finely ground, insoluble dispersed particles that provide coating formulation. Solvents are used to dissolve or break up latex paint. Solvents are made from organic liquids or water and makeup 50% of the paint by volume. Finally, in places with high humidity, antimicrobials are used to prevent paint deterioration. Diluents and additives facilitate the manufacture, application, and performance characteristics of the paint. Plasticizers that are added to increase flexibility make up almost a quarter of the additives. (Greiner 2004)

2.3 Waste latex paint

Our country has an annual paint production capacity of 800 thousand tons and the utilization rate of this capacity is 65%. While water-based paints constitute 55% of this capacity, solvent-based paints constitute 45% of this capacity. Waste latex paint poses a big problem in terms of environmental health today. In our country, the distribution of paint consumption according to usage areas is 55% for construction paints and varnishes, 15% for wood furniture paints, 3% for marine paints, 9% for automotive paints, 9% for metal paints and varnishes, 7% for powder coatings and 2% for other paints. (Water and Environmental Technologies 2012)

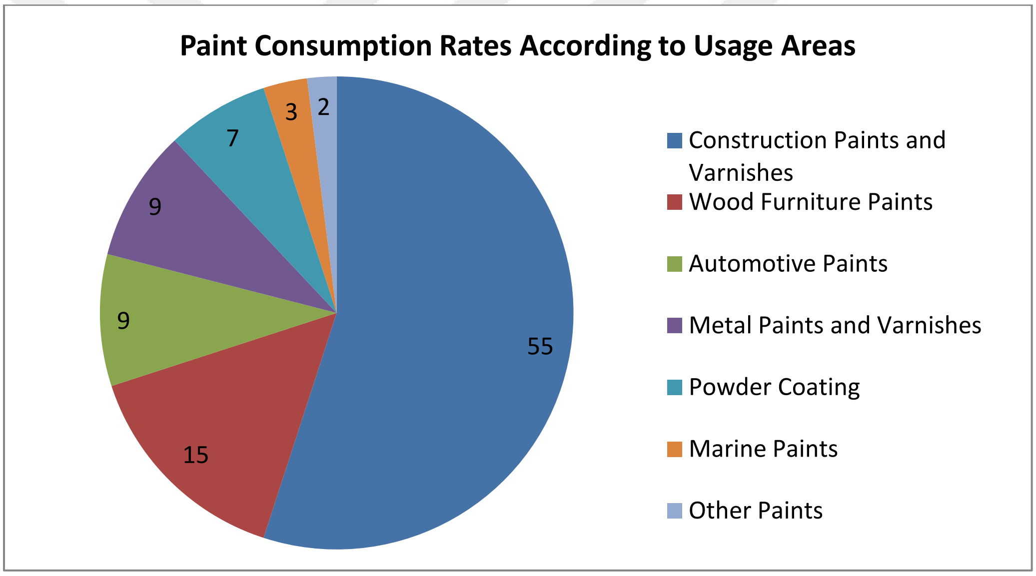

Figure 2.1: Paint Consumption Rates According to Usage Areas

Waste paint is included with the code of 08.01.11* according to the sectoral waste guide of the Ministry of Environment and Urbanization and is classified as hazardous waste. 08 01 11* coded waste, which includes “waste paints and varnishes containing organic solvents or other dangerous substances”, is formed as a result of the paint being used and purchased, its application is abandoned, or the production is low so that it cannot be consumed completely and dries out. (Sectoral Waste Guide 2016)

2.4. Polymer modified concrete

Polymer modified concrete is a special type of concrete developed to improve the limitations found in standard Portland cement concrete. Natural rubber was the first polymer to be used in concrete, but its use has declined due to cost constraints. The studies to improve the properties of concrete date back to the 1920s.

Lefebure (1924) was the first to aim to produce latex-modified mortar and concrete by mixing proportioning methods using natural rubber latexes. Bond (1932) first proposed the use of synthetic rubber latexes for polymer-modified systems. Rodwell (1939) applied modified systems to synthetic resin latexes, including polyvinyl acetate latexes. Shibazaki (1946) demonstrated that polymers such as hydroxyethylcellulose and polyvinyl alcohol are effective for water-soluble polymer-modified mortars.

Geist et al. (1953) made a detailed study on polyvinyl-acetate modified mortar. These studies provided valuable suggestions for the research and development of polymer modifying systems in the following years.

Synthetic polymers were widely accepted in the 1960s. Styrene-Butadiene rubber began to be used extensively in deck and bridge linings after a study by the Dow Chemical Company and the Michigan Highway Department. As a result of the studies, they proved that styrene-butadiene rubber concrete has significantly lower chloride permeability compared to ordinary concrete. (Clear and Chollar, 1978; Ramakrishnan, 1992)

Isacsson and Lu (1995) used additives in asphalt to obtain better road performance in their study.

Ohama (1995) stated that there are polymer films in latex-modified mortar and concrete that prevent the propagation of microcracks and also develop a strong cement-hydrate-aggregate bond. He noted that this effect increases with an increase in polymer content or polymer-cement ratio (defined as the weight ratio of the number of total solids in a polymer latex to the amount of cement in the latex-modified mortar), resulting in increased tensile strength and fracture toughness. Due to the polymer films or membranes formed in the structure, it provides a significant increase in sealing effect, waterproofing, resistance to chloride ion penetration, moisture transmission, carbonation and oxygen diffusion, chemical resistance, and freeze-thaw resistance, proved by experiments that it will increase proportionally.

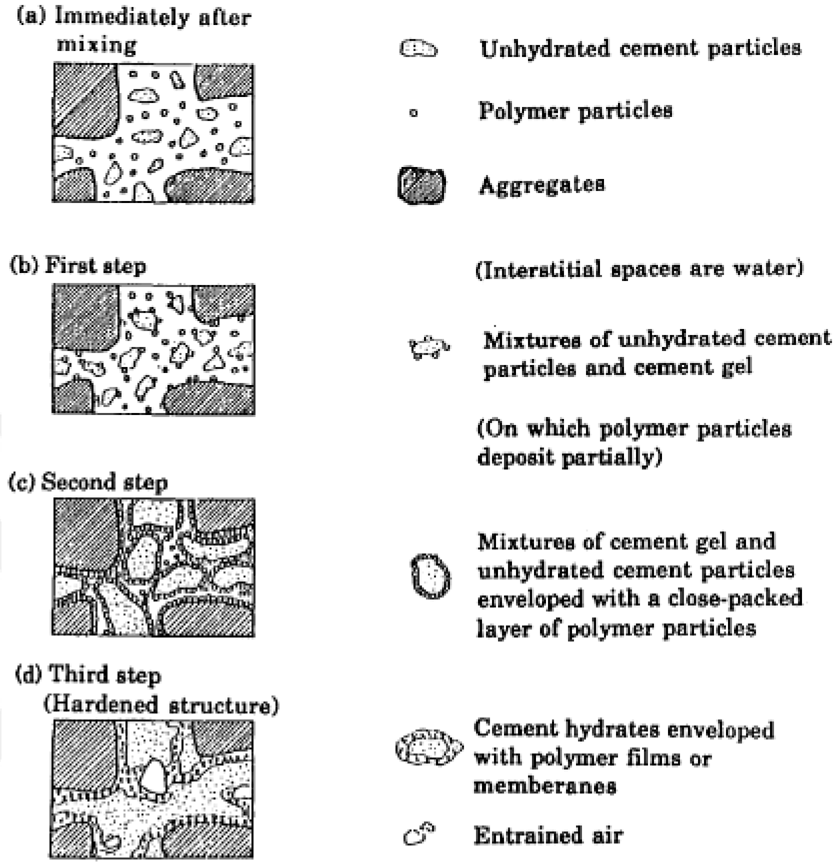

Figure 2.2: Hydration of Cement in the Binder Phase and Formation of Polymer Film (Ohama, 1995)

When the polymer latexes are mixed with fresh cement mortar or concrete in the first stage, the polymer particles are evenly dispersed in the cement paste phase. In polymer-cement paste, cement gel is gradually formed by hydration of cement. While the water phase is saturated with calcium hydroxide, which is crushed during hydration, the polymer particles are partially deposited on the surface of the cement-gel-non-hydrated-cement particle mixtures.

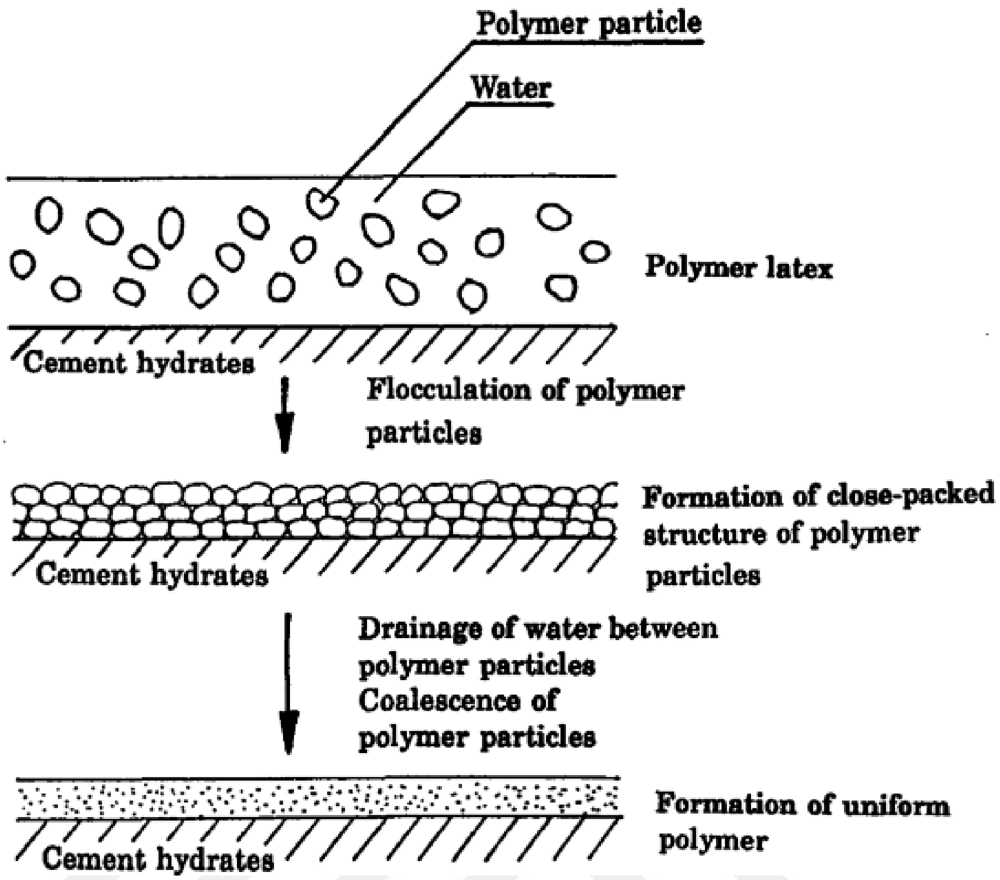

Figure 2.3: Simplified model of polymer film formation process on cement hydrates (Ohama, 1995)

The tightly knitted polymer particles on the cement hydrates coalesce into continuous films or membranes when water is withdrawn from the cement hydration at the end of the third step. These films or membranes bind the cement hydrates together and form a monoitic network in which the polymer phase is intertwined throughout the cement hydrate phase. Such a structure acts as a matrix phase for latex-modified mortar and concrete. Aggregates are bonded to the matrix phase-hardened mortar and concrete.

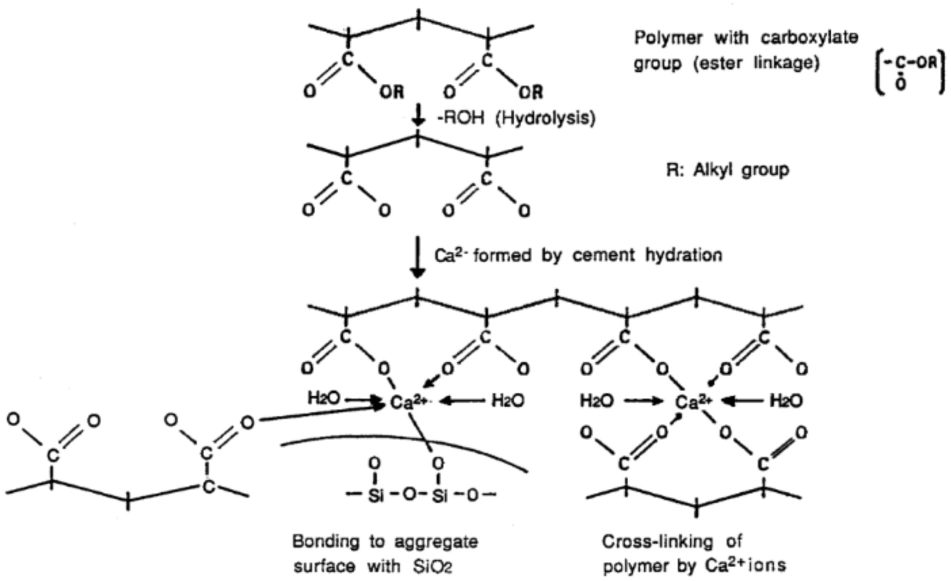

Figure 2.4: Schematic representation of the reaction between ordinary Portland cement and aggregate with the carboxylate group (Ohama, 1995)

Ohama and Ramachandran (1996) demonstrated that polymer added mortar and concrete have superior properties compared to conventional concrete and mortar as a result of their studies.

Muhammad and İsmail (2012) have worked with natural rubber latex to reduce the effect of chemical attacks on concrete, which affects the strength and durability, which are the most important properties of concrete. He conducted experiments on the performance of concrete modified with natural rubber latex in acidic and sulfated environments. 5% sulfuric acid (H 2 SO 4) and 2.5% sodium sulfate (Na 2 SO 4). The latex/water ratio ranged from 0% to 20%. Ordinary Portland cement was used as cement. It prevented moisture penetration of the modified concrete and increased impermeability, and accordingly, it saved the concrete from excessive degradation due to aggressive attack.

Brenna et al. (2013) showed that the polymer-added cement-based coating has the best effect in delaying the passage of chlorides into the concrete by acting as a barrier compared to the ordinary concrete coating. Experiments have shown that even coatings with lower polymer content guarantee a longer corrosion time than organic coatings.

Shao et al. (2020) investigated the deformation compatibility of two different materials on concrete in this study. 42.5 Portland cement is used. By adding 5%, 10%, 15%, 20%, 25% medium, fine, and coarse rubber pieces to the epoxy concrete, respectively, bending, shedding, compression, and tensile tests were performed. The test results showed that the rubber particles suitable for adding to epoxy concrete should be of medium size (1.5). According to the composite mortar beam test, it has been demonstrated that rubber epoxy concrete can be used as a repair material.

Hammodat (2021) examined the strength of polymer-added cement concrete in his study. In this research, Cem 1 cement conforming to the standards was used. As an additive, the polymer used in the test is a water-based epoxy resin emulsion with 50% solid content. 5 different cement concrete Specimens were prepared, with a polymer percentage of 0%, 5%, 10%, 15%, and 20%, by taking ordinary concrete with a strength grade of C40 as the reference point. While preparing each test piece, the cement-water ratio was kept constant. In his experiments, he investigated the compressive strength, flexural tensile strength, impact strength and flexural fatigue performance, impermeability, frost resistance, abrasion resistance, and slip performance of polymer-added cement concrete. It was observed that flexural fatigue performance and impact strength of cement concrete was improved after the addition of polymer, and the increase in flexural fatigue and impact strength performance increased with the increase of polymer content. Compared with the ordinary cement concrete pavement, the slip resistance and abrasion resistance of the polymer-added cement concrete pavement are improved.

2.5. Latex modified concrete – Styrene-butadiene rubber latex

Styrene-butadiene rubber is used to form latex-modified concrete just like polymer-modified concrete. It has superior properties compared to normal Portland cement. The quality of latex-modified concrete is determined by factors such as polymer-cement ratio, water-cement ratio, polymer type, curing conditions, and air content. (Ohama,1995)

Okba et al. (1997) compared the behavior of latex reinforced concrete with conventional concrete using accelerated corrosion cells in their study. They have proven that concrete with latex additives has superior corrosion resistance properties compared to conventional concrete in structures exposed to extremely aggressive environments.

Shaker et al. (1997) investigated the basic durability aspects of styrene-butadiene-modified concrete compared to conventional concrete. Ordinary Portland cement type 1, natural silica sand, natural gravel, and tap water were used in the experiment. Styrene-butadiene rubber was used as latex. A dose of 15% solid latex material (P/C ratio) to cement by weight was found to be the most appropriate dose for use. As a result of the research, it has been found that the waterproofing, abrasion, corrosion, and sulfate resistance of the modified concrete is superior to the durability of the traditional concrete.

Radomir (1998) conducted some experiments on polymer-modified concrete. As a polymer, latex in the form of dispersion based on butadiene-styrene rubber was used. This increases the tensile strength of concrete. The most important effect of polymer modification is the improvement of properties that increase tensile strength, ductility, adhesion between concrete and reinforcement, and durability of reinforced concrete structures.

Lagerblad and Vogt (2004) demonstrated in their experiments that ultrafine particles can replace cement. He argued that he could change the cement up to 40% and still get the same effect, and he observed that the best effect was when the water/cement ratio was constant even when the cement was changed. As a result of the experiments, it has been proven that ultrafine fillers can replace a significant amount of cement, and this will reduce the environmental impact by reducing energy consumption and CO_2 emissions.

Barluenga and Olivares (2004) conducted an experimental study on a modified latex mortar with different w/c and latex percentages in fresh and hardened conditions. He used CEM 2A type cement and added 0%, 5%, 10%, 15%, 20% and 25% latex to the base mortar by weight of cement. With the incorporation of styrene-butadiene rubber latex into the mortar, due to the lower mechanical capacity of the latex, the constant consistency shows low compressive strength for a cement mortar. This reduction is compensated by the reduction of the water-cement ratio due to the plasticizing effect of latex. These two variables together hold the compressive strength constant for any percentage of latex.

Aggarwal et al. (2007) showed that the addition of polymer to cement mortar improves workability, increases flexural and compressive strength, reduces water absorption, carbonation, and chloride ion penetration. In addition to this situation, epoxy emulsion showed slightly better properties than acrylic emulsion in the same amount of polymer-cement ratio. Therefore, epoxy emulsion-based mortar is a potential material that can be used for repair work in humid and industrial environments.

Yang et al. (2009) conducted some experiments on Portland cement mortar modified with styrene-butadiene rubber latex. Experiments discovered that the inclusion of latex improves the chloride penetration resistance, along with the ionic permeability of the cement mortar, while increasing the ionic transport resistance and lowering the electric capacitance.

Doğan and Bideci (2016) used Styrene-butadiene Copolymer (SBR) in different weight ratios such as control (0%), 1%, 3%, 5%, and 8%, instead of cement in high strength concrete produced with C50/C60 properties. Unit weight, water absorption rate, compressive strength, splitting tensile strength, ultrasonic impact velocity, and frost resistance tests were applied for 3, 7, and 28 days. As a result of the experiments, it has been proven that SBR concrete with a 1% admixture has higher values and strength.

Quiroz et al.(2016) compared the capacity to use waste latex paint to produce concrete for coatings with properties similar to polymer-modified concrete combining styrene-butadiene rubber with five mixtures. Portland cement type 2 was used as the material, and waste latex paint was used in concrete mixtures with a high rate of water-reducing additives. As a result of the experiment, they found that the concrete prepared with waste latex paint had a higher strength gain rate and a higher final strength compared to the concrete Specimens prepared with chemical additives. The mixtures met the 21 MPa compressive strength required to open a traffic road. The results showed that waste latex paint can replace styrene-butadiene rubber-based additive to make an economical latex-modified concrete for coatings.

Bhogayata and Arora (2018) This study was conducted to investigate the effect of the addition of recycled plastic fiber and styrene-butadiene rubber latex in fresh and hardened concrete. As a result of the experiments, it was observed that the modified concrete improved the hardened and fresh properties of the modified concrete due to the improved cracking resistance by using plastic fiber and styrene-butadiene rubber latex together. The combination of these two substances showed a remarkable improvement in the durability properties of concrete. Acid, sulfate ingress, chloride ingress, and water absorption were significantly reduced. In addition, this combination of substances not only increased the ductility of the concrete but also significantly reduced the crack propagation of the concrete mass. This study shows that sustainable concrete with improved properties can be prepared from hazardous plastic waste.

Burhan and Karawi (2020) investigated the physical and mechanical properties of concrete mixtures by using different ratios of styrene-butadiene rubber in permeable concretes that do not contain fine aggregates. Permeable concrete mixtures were produced from normal Portland cement and Styrene-butadiene Rubber (SBR) latex, a synthetic mixture obtained from styrene-butadiene, was used as material. As a result, it was observed that the density and compressive strength of the concrete increased as the polymer content increased, and the rupture modulus and split tensile strength improved when the polymer content increased; in this case, it means that the polymer positively affects the ductility in this type of concrete.

In their study, Grinys and Augonis (2020) used rubber waste instead of fine aggregate in concrete mixtures and analyzed how the mechanical properties of concrete affect its durability as a result of their experiments. Another aim of the study was to discover whether thin pieces of rubber from scrap tires could replace prefabricated air bubbles, a very expensive industrial product. It is modified with carboxylated styrene-butadiene rubber latex for better adhesion to concrete, rubber, and hardened cement paste. Crumb rubber, styrene-butadiene rubber latex, prefabricated air bubbles, and ordinary Portland cement CEM 1 were used as materials. Experimental results showed that concrete modified with small pieces of rubber had a higher freeze-thaw factor and higher closed porosity.

2.6. Recycling waste paint in concrete

Studies on the use of waste paint in concrete are limited. Nehdi and Sumner (2003) investigated the effects of waste paint on concrete.

Segala (2003) stated that the use of waste paint material as a cement additive is not only commercially viable but also an eco-friendly and economically good solution.

Nehdi and Sumner (2003) used waste latex paint instead of concrete mixing water in their study. (ASTM Type 1) cement, slag, coarse and fine aggregates, air-entraining admixture, and water-reducing admixture were used. In general, waste latex contains 15% latex polymers, 59% water, and 25% other solid pigments. They implemented their work on concrete pavements and achieved positive results. It shows that concrete mixes containing waste latex paint can be more economical as they require improved workability, low chloride ion penetration, higher flexural strength, better resistance to deicing salt scaling, less air-entraining, and water-reducing chemical additives. The results also demonstrated that the annual urban concrete pavement build can use the annual production of waste latex paint and produce pavements with improved properties and durability.

Mohammed and Nehdi (2008) investigated the use of waste latex paint in concrete. The ratio of different amounts of waste latex paint was compared with untreated latex. As a result of the studies, it was observed that waste latex paint increased the workability and bending strength, but a tendency to decrease compressive strength was observed. It was concluded that the addition of waste latex paint produces a cementitious matrix with a denser microstructure and increased long-term durability than plain concrete. The addition of waste latex paint increased the durability of concrete in different test regimes. Leak test results on aged concrete Specimens containing waste latex paint showed that the toxic metal emission was negligible. As a result of the study, it is recommended to use 15% waste latex paint instead of adding water to the concrete for non-structural concrete elements such as highway middle barriers, sidewalks, and concrete blocks.

Haigh et al. (2008) investigated the use of waste paint as a polymer additive in concrete wall block filler. The main goal in their work is to produce a block filler mix that can maintain or improve the properties of the hardened material while increasing the efficiency of the construction process. He conducted several tests on fresh and hardened concrete while investigating the optimum waste dye dosage. In his experiments, he investigated the compressive strength, tensile strength, drying shrinkage, and seismic performance of the block fill to evaluate its hardened properties. As a result of experiments and research, it has been determined that waste latex and acrylic-based paint is a suitable additive for concrete wall block filling, and as a result, strength and workability are improved.

Quiroz and Said (2011) used waste latex paint for bridge coatings in their study. Latex modified concrete is used in bridge pavements due to its durability under traffic loads and environmental conditions since bridge cladding is exposed to chloride ion ingress, which can cause corrosion in reinforcement and surface calcification in concrete. Four concrete mixes were used in the study. Two of these mixtures consisted of waste latex paint modified concrete, the other consisted of styrene-butadiene rubber added to concrete, and the fourth consisted of a control mixture of normal concrete. In the experiment, besides the fresh properties of the concrete, the hardened properties were also investigated. As a result of the experiments, a cost-effective polymer-modified concrete can be produced because the waste latex paint modified concrete can replicate the properties of the latex modified concrete. It has been proven that the mixture made with this waste paint provides the necessary physical conditions for bridge pavements.

Mohammad et al. (2011) used waste latex paint in their study. The cement was prepared and cured serial concrete mixes containing polymer content of 1%, 2%, 3%, 5%, and 10% by weight, and was tested for workability, mechanical, and durability properties on days 7, 28, 60. As a result of the laboratory tests, it was determined that the most appropriate amount of polymer to be added to the concrete is 2% according to the cement weight. It has been observed that the workability decreases when the polymer ratio increases in terms of affecting the properties of the concrete. The polymer does not contribute much to the improvement of the compressive strength of the concrete, but when the polymer added to the concrete is 2%, it provides the highest tensile strength and bending strength. In addition, the concrete mix prepared with 2% polymer performed better than the other Specimen percentages compared. As a result, while the optimum amount of polymer for mechanical strength is 2%, durability is best achieved when this percentage is exceeded.

Almesfer et al. (2012) used waste paint as an additive in concrete. This study aimed to use the existing waste paint resource effectively and to take advantage of the similarities in waste paint chemical compositions and polymeric additives used to increase workability in conventional concrete. He investigated the use of waste latex paint in low-strength concrete for block filling in masonry. The study examined various rates of waste latex dye addition to concrete (0-20% water change) to assess optimum dosage. In the study, the effect of waste latex paint on tensile strength, compressive strength, modulus of elasticity, and workability was investigated. As a result of the experiments, it was determined that the waste latex paint would interact negatively with some commercial chemical additives. However, it has been understood as a result of the experiments that waste paint is a suitable additive for block filler mixtures containing traditional chemical additives. He found that waste latex paint is a suitable replacement for conventional additives used in concrete masonry block filler, resulting in permanent strength and advanced workability.

Nehdi and Sumner (2003) developed a new green roofing membrane system with a primed composite coating containing residual paint and evaluated this system experimentally. The performance of roofing containing waste paint was compared to that of a more traditional low-slope roofing system. It was subjected to several experimental programs including static drilling, dynamic impact, peeling, tensile, and fire exposure tests. The static puncture resistance of the primed composite coating significantly improved the dynamic impact performance and fire resistance. It has been demonstrated that utilizing waste paint in the production of roofing systems improves its static properties, as well as large amounts of consumption of this hazardous waste, which will provide significant environmental and economic benefits.

Almesfer and Ingham (2014) investigated the potential of using waste latex paint as an additive in non-structural concrete applications such as pavement and its use in low-strength standard 20 Mpa concrete. The same materials (ASTM C150 Type 1) cement used in the standard 20 Mpa concrete mix with a maximum nominal aggregate size of 19 mm were used as material. They were used in conjunction with a commercial air-entraining mixture and a commercial water-reducing mixture of modified polycarboxylates. Waste latex paint Specimens were obtained from the waste paint collection program. Compressive strength tests were performed on all mixtures at 7, 28, and 56 day time periods. As a result of the experiments, it has been proven that waste latex paint can increase the workability and durability of concrete while providing sufficient compressive strength.

Assaad (2015) aims to evaluate the compatibility of waste latex paint components with commonly used water reducers and their effect on changes in flow and rheological properties of cement pastes during mixing. The waste latex paints tested were specifically produced, rather than randomly collected from the waste collection site. They were stored for 6 months to expire. The test results demonstrated that the fluidity was greatly affected by the waste latex paint content, the pigment/diluent ratio, and the percentage used for the substitution of mixing water. It caused a decrease in fluidity in mixtures prepared with waste latex paints added before plasticizers. It turned out that increasing adhesion rates over time between waste latex paints and polycarboxylate-based plasticizers created significant incompatibility.

Said et al. (2016) compared the properties of waste paint used as a chemical additive in concrete with the use of commercially obtained styrene-butadiene rubber. He evaluates the fresh and hardened properties and handling properties of concrete as a result of tests. As a result of the experiments, waste latex paint can be used to replace the styrene-butadiene rubber-based additive used to make an economical latex-modified concrete for coatings. The overall performance of waste latex paint is comparable to mixtures containing styrene-butadiene rubber.

In his study, Assaad (2016) did not collect waste latex paints randomly but showed that the rheological properties of cement pastes are directly affected by the components of waste latex paint, storage conditions, and substitution rates. He has produced waste latex paints to ensure their traceability and they have been stored in open or closed weather conditions so that the expiry date is passed.

Assaad and Issa (2017) investigated the effect of recycled polymers from the paint industry on concrete bond stress shear with embedded steel bars in their experimental study. Experiments have shown whether such behavior will be similar to that applied by untreated polymeric latexes. He tested approximately 50 concrete mixes containing different vinyl acrylic-based polymer concentrations by direct bonding and beam end method. The test results showed that the concrete-rod interface bond stresses occurring in the elastic region were greatly improved with recycled and virgin polymers. This is indirectly related to the pigment and extender powders in waste latex paints. In concrete modified with waste latex paint, the porosity has been reduced, and increased the density of the cement paste reinforcing the transition zone adjacent to the reinforcing bars.

In his study, Assaad (2020) compared the effect of recycled polymers obtained from waste latex paints on the fluidity and mechanical properties of wall cement mortars, and this performance was compared with the properties of untreated polymers and modified wall cement. Waste latex paints were not obtained from the landfill and were specially produced to monitor the components and properties before use. As a result of the experiments, it was observed that the water retention and rheological properties of the mortars containing pure or recycled polymers were significantly higher than the unmodified mixtures. The compressive, flexural, and pull-out adhesion strength of mortars modified with waste latex paint turned out to be quite similar, even higher than equivalent mixtures containing virgin polymers.

CHAPTER 3

MATERIAL-METHOD

In this part 18 specimens have been studied in a laboratory environment and have been named.

3.1 Materials Used in Experiments and Their Properties

3.1.1. Cement

CEM I 42.5 N-type cement was used in the experimental studies. The chemical and physical properties and compressive strength of cement are shown in Table 3.1, Table 3.2, and Table 3.3.

Table 3.1: Chemical Properties of CEM 1 42.5 N Cement

Components	Ratio
Total SiO_2 (%)	18,70
Insoluble Residue (%)	0,49
Al_2O_3 (%)	4,9
Fe_2O_3 (%)	3,31
CaO (%)	63,51
MgO (%)	1,34
$S0_3$ (%)	3,29
Ignition Loss	3,45
Na_2O (%)	0,2
K_2O (%)	0,83
Undetermined	0,43

Table 3.2 : Physical Properties of CEM 1 42.5 N Cement

Specific Weight (gr/cm$^{3)}$	3,11
Set Time Start (dk)	137
Set Time End (dk)	155
Blaine (cm^2/g)	3810
Volume Expansion (Le Chatelier) (mm)	1

Table 3.3: Compressive Strenght of CEM 1 42.5 N Cement

Compressive Strenght (N/mm^2)	
2 Days (MPa)	39,0
7 Days (MPa)	-
28 Days (MPa)	61,9

3.1.2 Aggregates

Natural sand and crushed stone were used as aggregates in the experiment. Experiments were made on natural sand aggregate (0/0.5 mm in size) and the results obtained are given below. Sieve analysis test was carried out according to TS3530 (EN 933-1) standard.

Table 3.4: Sieve Analysis (Granulometry Experiment)

Sieve Aperture (mm)	Sieve (%)
	Natural Sand (North Istanbul)
31,5	100
16	100
8	100
4	100
2	99
1	94
0,5	83
0,25	28
0,125	4,7

Specific gravity water absorption and loose unit weight tests were carried out in accordance with TS EN 1097-6 and TS EN 1097-3 standards. The results obtained are shown in Table 3.5.

Table 3.5: Specific Gravity, Water Absorption and Loose Unit Weight Test

Agrega Type	Surface Saturated with Water Dry Specific Gravity (kg/m^3)	Water Absorption by Weight (%)	Loose Unit Weight (kg/m^3)
Natural Sand	2650	0,9	1410

The mineral ratios found according to the results of the microscope examination are shown in Table 3.6.

Table 3.6: Mineralogical Composition of the Sand Specimen

Mineral and Grain Components	**% Oran**
Kuvars + Kuvars Mineral Parçaları	82-87
Feldspar	1-2
Carbonate Origin Rocks	5-8
Kayaç Parçası	3-4
Piroksen ve Amfibol	1-2
Manyetit	<0,5
Gröna	<1
Epidot + Klorit	<0,5
Turmalin	<0,5

Conslusion: The sand material was named quartz sand.

3.1.2.1 Agregaların Elek Analizi (Granülometre) Deneyi

It was made based on TS 3530 (EN 933-1) standard. Sieve analysis results are shown in Table 3.7.

Tablo 3.7: Particle Size Distribution of Aggregates

Sieve Aperture (mm)	**Sieve (%)**
	Crushed Stone Sand (Bogazici)
31,5	100
22	100
16	100
8	100
4	94
2	55
1	34
0,5	22
0,25	14,5

3.1.2.2. Specific gravity, water absorption and loose unit weight test

It was made based on TS EN 1097-6 and TS EN 1097-3 standards. The test results are given in Table 3.8.

Table 3.8: Specific Gravity, Water Absorption and Loose Unit Weight Test

Agrega Type	Water Saturated Surface Dry Specific (kg/m$^{3)}$	Water Absorption by Weight (%)	Loose Unit Weight (Bulk Density) (kg/m^3)
Crushed Stone Sand	2680	1,7	1620
Crushed Stone Sand 1	2710	0,7	1480
Crushed Stone Sand 2	2720	0,5	1460

3.1.2.3. Fine matter ratio experiment

According to TS EN 3527 principles (using a 0,063 mm sieve), the results of the tests carried out according to the washing method on aggregates are given in Table 3.9.

Table 3.9: Fine matter ratio experiment

Agrega Type	Fine Matter Ratio by Weight (%)	Category
Crushed Stone Sand	2,1	f_{10}

3.1.3. Waste Paints

6 different waste dyes have been used in mortar mixes. The properties of the dyes are given in Table 3.10.

Table 3.10: Properties of waste paints

Properties of Waste Paints	AB11	AB12	AB13	AB21	AB22	AB3
Color	White	Pink	White	White	Purple	Yellow
Chemical Structure	Silicone Modified Latex Paint	Silicone Modified Latex Paint	Silicone Modified Latex Paint	Emulsion Based Acrylic Copolymer	Emulsion Based Acrylic Copolymer	Cellulosic Machine Paint
Expiry Date	27/03/2014	09/04/2012	19/10/2010	05/05/2006	06/05/2011	05/05/2006
Condition Obtained	Unfolded	Sealed	Unfolded	Sealed	Unfolded	Unfolded

3.1.4. Chemical Additive

Chemical additives belonging to product class set retarder, superplasticizer, high water reducer product class of the chemical additive used in the experiment have been used. The properties of the chemical additive are shown in Table 3.11.

Table 3.11: Characteristics of the chemical additive

Characteristics	Measured Values	Standart Values	Analysis Method	Fosroc Test Method
HOMOGENEITY	HOMOGENEOUS	HOMOGENEOUS	By sight	T 55
COLOR	BROWN	BROWN	By sight	T 55
RELATIVE DENSITY (g/cm^3)	1,09	1,07 – 1,11	ISO 758	T 45
PH	4,8	4,0 – 6,0	ISO 4316	T 02
SOLID AMOUNT (%)	25,90	24,22 – 26,78	EN 480-8	T 51
WATER SOLUBLE CHLORIDE (%)	0,04	<0,1	EN 480-10	T 47
ALKALINE AMOUNT (%)	APPROPRIATE	<5	EN 480-12	EXTERNAL LAB.
FT – IR SPECTRUM/ ACTIVE COMPONENT	APPROPRIATE	REFERANS IR SPECT.	EN 480-6	T 50

3.1.5. Mortar Mixture Water

Potable tap water was used in the province of Istanbul, where the mortar test Specimens were produced.

3.2. Mortar Mix

In this study, 18 mixtures were prepared by keeping the water-cement ratio constant and adding 1%, 3%, 8% waste paint at the rate of cement for each paint type. To control the changes in the composition of the mortar, a mortar mixture without waste paint was prepared. Finally, to determine the differences between the chemical additive mortar and the cement ratio of 3% in an experimental group, chemical additives were used. The actual amount of material entering the mortar mixture in the experiment is shown in Table 3.12.

Table 3.12: Actual amount of material entered into the produced mortar mixture

Concrete Code	Cement (kg/m^3)	Water (kg/m^3)	Waste Paint (kg/m^3)	Sand (kg/m^3)
AB11-1	2250	1125	22,5	6750
AB11-3	2250	1125	67,5	6750
AB11-8	2250	1125	180	6750
AB12-1	2250	1125	22,5	6750
AB12-3	2250	1125	67,5	6750
AB12-8	2250	1125	180	6750
AB13-1	2250	1125	22,5	6750
AB13-3	2250	1125	67,5	6750
AB13-8	2250	1125	180	6750
AB21-1	2250	1125	22,5	6750
AB21-3	2250	1125	67,5	6750
AB21-8	2250	1125	180	6750
AB22-1	2250	1125	22,5	6750
AB22-3	2250	1125	67,5	6750
AB22-8	2250	1125	180	6750
AB3-1	2250	1125	22,5	6750
AB3-3	2250	1125	67,5	6750
AB3-8	2250	1125	180	6750
RB	2250	1125	0	6750
KKB	2250	1125	0	6750

3.3 Sequence Followed in Production

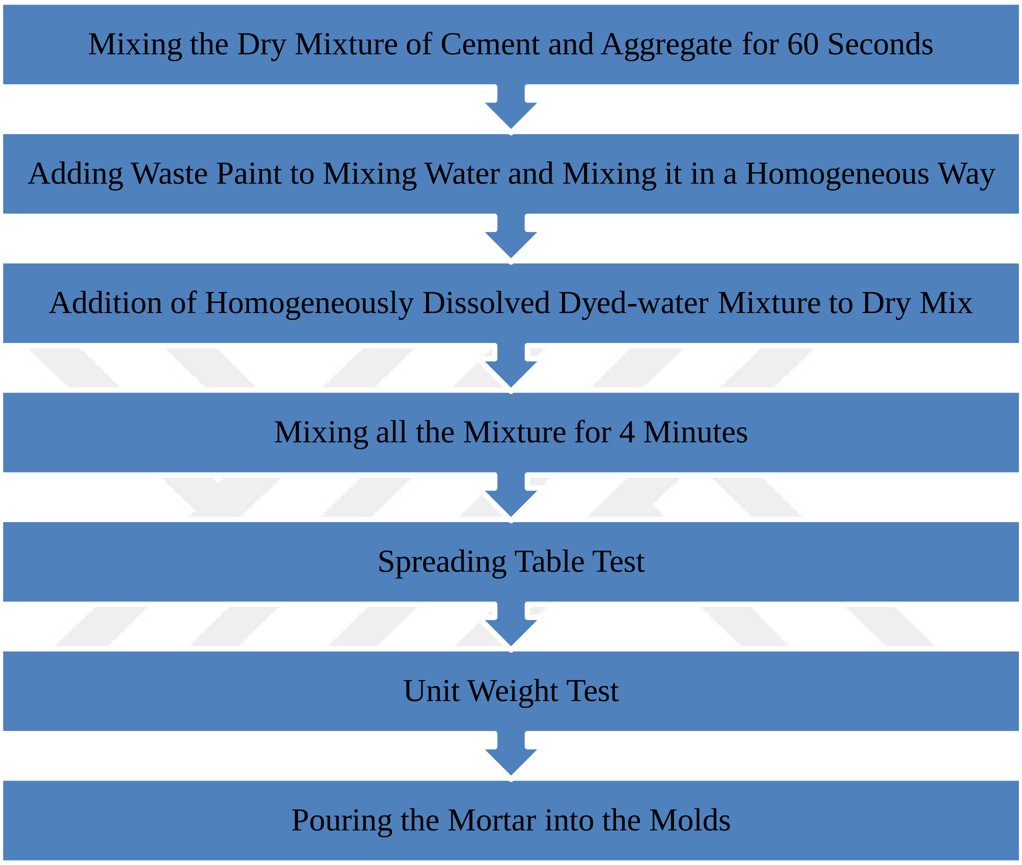

Figure 3.1: Sequence followed in production

The specimens were taken out of the mold one day after production and placed in the concrete curing pool and was kept for 7 and 28 days.

3.4 Specimen Codes

In this study, the concrete Specimens produced in the laboratory and the percentage of waste paint in it are shown in Table 3.13 with numbers.

Table 3.13: Specimen Codes

Specimen Codes	Explanation
AB11-1	1st Kind Waste Latex Paint - Waste Paint Rate %1
AB11-3	1st Kind Waste Latex Paint - Waste Paint Rate %3
AB11-8	1st Kind Waste Latex Paint - Waste Paint Rate %8
AB12-1	2 st Kind Waste Latex Paint - Waste Paint Rate %1
AB12-3	2 st Kind Waste Latex Paint - Waste Paint Rate %3
AB12-8	2 st Kind Waste Latex Paint - Waste Paint Rate %8
AB13-1	3 st Kind Waste Latex Paint - Waste Paint Rate %1
AB13-3	3 st Kind Waste Latex Paint - Waste Paint Rate %3
AB13-8	3 st Kind Waste Latex Paint - Waste Paint Rate %8
AB21-1	1st Kind Acrylic Waste Paint - Waste Paint Rate %1
AB21-3	1st Kind Acrylic Waste Paint - Waste Paint Rate %3
AB21-8	1st Kind Acrylic Waste Paint - Waste Paint Rate %8
AB22-1	2 st Kind Acrylic Waste Paint - Waste Paint Rate %1
AB22-3	2 st Kind Acrylic Waste Paint - Waste Paint Rate %3
AB22-8	2 st Kind Acrylic Waste Paint - Waste Paint Rate %8
AB3-1	Solvent Waste Paint - Waste Paint Rate %1
AB3-3	Solvent Waste Paint - Waste Paint Rate %3
AB3-8	Solvent Waste Paint - Waste Paint Rate %8
KKB	Chemical Additive Concrete
RB	Reference Concrete

3.5 Fresh Concrete Tests

Spreading table tests and unit weight test measurement tests were carried out from fresh concrete tests.

3.5.1. Spreading Table Test

This test is done as defined in TS EN 12350-5. For the spreading table test, a manually operated model was used, and in this model, the falling speed is adjusted by the user by turning the handwheel. The diameter of the table is 300 mm, the diameter of the bottom/top face of the truncated cone-shaped mold is 100.0/70.0 mm. The height of the truncated cone-shaped mold is 60.0 mm, and the drop height is 10.0 mm. The spreading table is shown in Figure 4. The mortar taken from the mixing bowl to the tray is placed in the truncated cone-shaped mold on the spreading plate so that it fills half. After hitting 15 times with a brass-coated mallet, the other part of the mold is filled and another 15 strokes are applied. After the upper surface of the mold is cleaned and smoothed with a trowel, the mold is pulled out. The diameter of the spread Specimen is measured in 2 different axes by turning the arm of the test instrument 15 times, once per second, and the average of the values read is recorded. The initial diameter value of the mortar in the mold is 100 mm, and the spreading diameter is more than 100 mm due to the consistency of the mortar after the spreading application. This process was repeated for each mortar mix produced, and the results are given in Chapter 4.

Figure 3.2: Spreading Table

3.5.2. Unit Weight Test

Before placing the produced mortars in the molds, the unit weight of the fresh concrete was found by taking it into a cylindrical container with a known volume. The unit weight results of the mortars are shown in Table 3.15.

Unit volume weight of concrete, b (kg/m3)

$$b = \frac{A - B}{V}$$

V: Mold Volume (dm^3)

A: Weight of container and fresh concrete

B: Empty container weight

The Formula has been used.

3.6. Hardened Concrete Tests

Hardened concrete tests are divided into two main groups. Cylinder compressive strength test, bending test, modulus of elasticity test, which are made to determine their mechanical properties, are examined in the first group. In the second group, a capillary water absorption test was performed to determine the durability properties of concrete.

3.6.1. Cylinder Pressure Test

Cylindrical specimens with dimensions of 100x200 mm were used in the cylinder pressure test. It was kept in a curing pool at 20 ± 2° C for 7 days and 28 days. The kept Specimens were taken from the curing pool and subjected to a uniaxial compression test after concrete capping. By adding a cap to the lower and upper surfaces of the mortar Specimen, the pressure applied by the concrete press is distributed uniformly on the Specimen surface. Figure 5. In the compressive strength test, force is applied with the help of the pressure press device without impact. Figure 6. This process, which is continued until the Specimen breaks, is stopped at the time of Specimen breakage. The pressure test was carried out in Istanbul Technical University Building Materials Laboratory in accordance with TS EN 12390-3 standard. The results obtained from the pressure test are given in Table 3.16.

Figure 3.3: Cylinder Specimen Capping Process

Figure 3.4:Cylinder Pressure Test

3.6.2. Three-Point Bend Test

Prism Specimens of 160x40x40 mm length were cured at 23°C ±2 for 7 and 28 days. Before the test, the parts of the Specimens that fit on the supports and the part where the load is applied were filed to ensure that the load is properly seated. MTS Criterion Model 43 electromechanical test system was used in the experiment. Figure 8. In this experiment, the maximum stress occurs at the midpoint of the outer surface of the beam. The test specimen is placed in the middle of the supports in a horizontal position and the force is applied from the middle point. Figure 9. During the test, the deflection value in the middle of the beam is measured while the F force is increased. These measurements are made at the midpoint of the specimen with the highest deflection and moment. As a result of the experiments, the change in the bending strength and fracture energy of the material with the change of the paint/cement ratio was investigated. This stress on the outer surface is calculated for any point of the load-deflection curve with the following formula.

$$\sigma = \frac{3PL}{2bd^2}$$

Here;

σ: Stress on beam surface at the midpoint (N/mm2)

P: Force (N) at any point of the load-deflection curve

L: Distance between two supports (mm)

b: Beamwidth (mm)

d: Height of beam (mm)

Figure 3.5: Electromechanical Tester

Figure 3.6: 3-Point Bend Experiment Setup

3.6.3. Capillary Water Absorption Test

While performing capillary waterabsorption testst on concrete, prism Specimens of 7 and 28 days were used. At the end of the curing periods determined as 7 and 28 days, it was kept in a 60̊ oven for 24 hours and completely dried. In the experiment, the surfaces other than the 40x40 mm surface of the Specimens that will come into contact with water are covered with paraffin, and contact with water is prevented. Figure 10. Then, as seen in the figure, the Specimens are placed on the tray so that only the bottom surface comes into contact with water Figure 11. First, the dry weight of the Specimens is measured. From the beginning, the amount of water absorbed by the capillary is determined by weighing with an electronic scale with an accuracy of 0.01 at the 1st, 4th, 9th, 16th, 25th, 36th, 49^{th}, and 64th minutes and on the 1st day. Capillary water absorption is found by using the formula below.

$$q^2 = k \times t$$

q: Amount of water absorbed per unit time(cm^3/cm^2)

k: Capillary water absorption coefficient(cm^2/sec)

t: Elapsed time (sec)

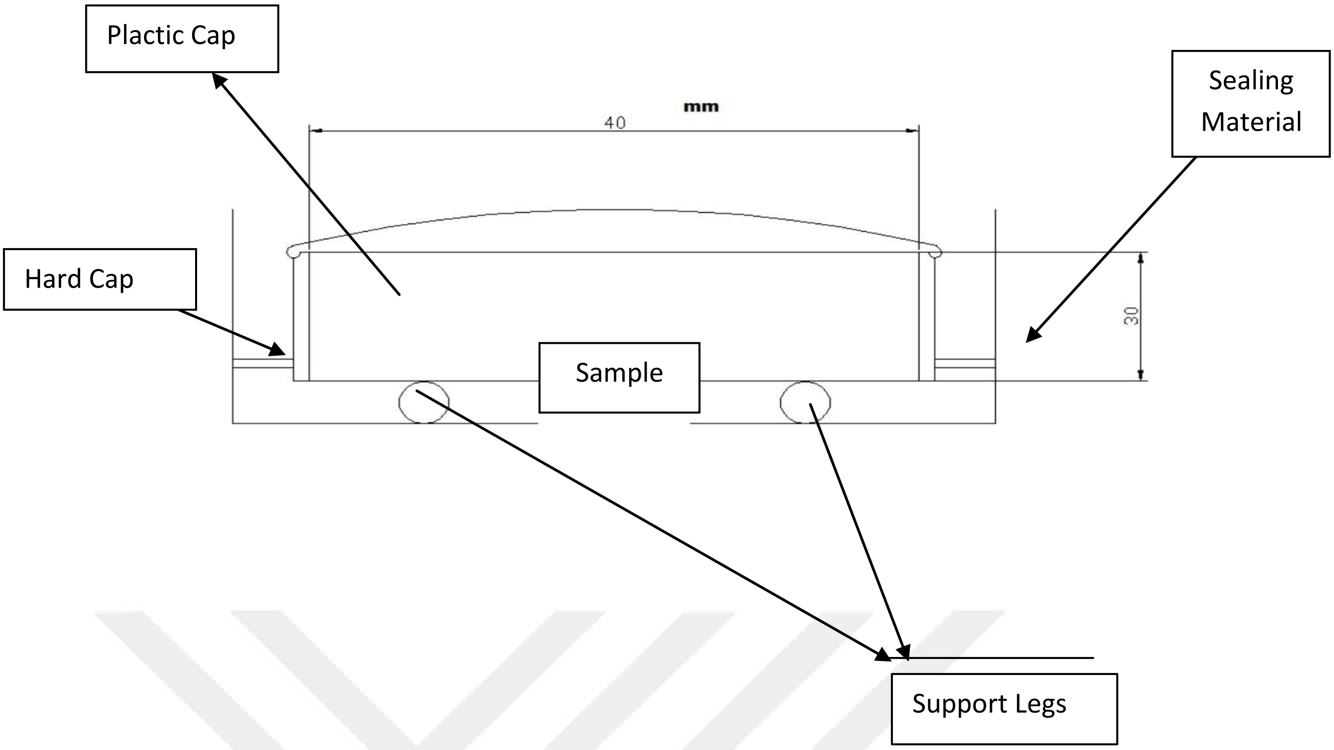

Figure 3.7: Capillary Water Absorption Experiment Setup

Figure 3.8: Capillary Water Absorption Test

3.6.4 Cube Specimen Compressive Strength Test

The 40x40x160 mm concrete specimens, which were subjected to the bending test, were subjected to a pressure test after the bending test at three points. The test results of the Specimens at the end of the experiment are given in Table Chapter 4.

In the experiment, the cube compressive strength test could not be performed because the AB3-8 sample decomposed as in Figure 3.9

Figure 3.9: AB3-8 Test Specimen

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Effect of Change in Unit Weight Waste Paint/Cement Ratio

As a result of the unit weight test carried out to determine the properties of fresh concrete, the data in the table below were obtained. The closest result to the reference sample was obtained at the lowest percentage of dye. The samples with 1% dye added according to the cement ratio reached the closest result to the reference. For all dye types, the unit weight of the mixture decreased as the percentage of dye added to the mixture increased.

Table 4.1: Unit Weight Values

Mixture No	Spread Value (Initial Castings) kg/dm^3	Spread Value (Second Castings) kg/dm^3
AB11-1	2,29	2,21
AB11-3	2,28	2,29
AB11-8	2,26	2,28
AB12-1	2,30	2,29
AB12-3	2,26	2,25
AB12-8	2,23	2,26
AB13-1	2,29	2,27
AB13-3	2,23	2,22
AB13-8	2,2	2,20
AB21-1	2,27	2,25
AB21-3	2,26	2,24
AB21-8	2,24	2,23
AB22-1	2,23	2,21
AB22-3	2,17	2,15
AB22-8	2,13	2,0
AB3-1	2,12	2,15
AB3-3	2,07	2,22
AB3-8	2,03	1,99
KKB3	2,20	-
RB	2,32	2,32

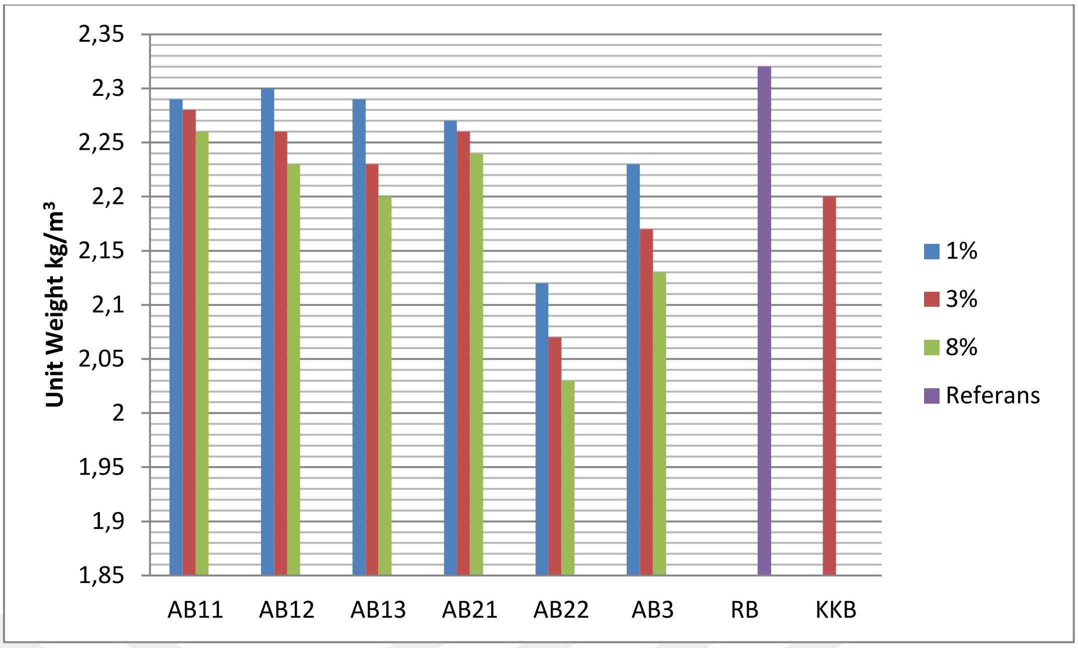

Figure 4.1: Unit Weight Graph Based on Waste Paint Amount

4.2. Effect of Waste Paint Percentage Change on Spread Amount

The results of the spreading test, in which the workability of fresh concrete was measured, are given below. It was observed that the consistency of the concrete decreased as the waste paint/cement ratio increased. On the other hand, it was observed that the fresh concrete was segregated in the sample with the cellulosic based paint additive numbered AB3. It was observed that the consistency of the concrete decreased as the waste paint/cement ratio increased in all mixtures except the AB3 coded cellulosic dye added sample. The opposite situation was observed in AB3 waste paint. As the amount of dye increased, the spreading values decreased.

Table 4.2: Expansion Table Experiment Results

Mixture No	Spread Value (Initial Castings) mm	Spread Value (Second Castings) mm
AB11-1	120	125
AB11-3	135	140
AB11-8	160	160
AB12-1	125	130
AB12-3	190	185
AB12-8	210	200
AB13-1	125	115
AB13-3	190	170
AB13-8	170	180

AB21-1	125	120
AB21-3	200	190
AB21-8	210	200
AB3-1	140	130
AB3-3	125	125
AB3-8	105	110
AB22-1	125	120
AB22-3	145	140
AB22-8	160	160
KKB	160	-
RB	120	125

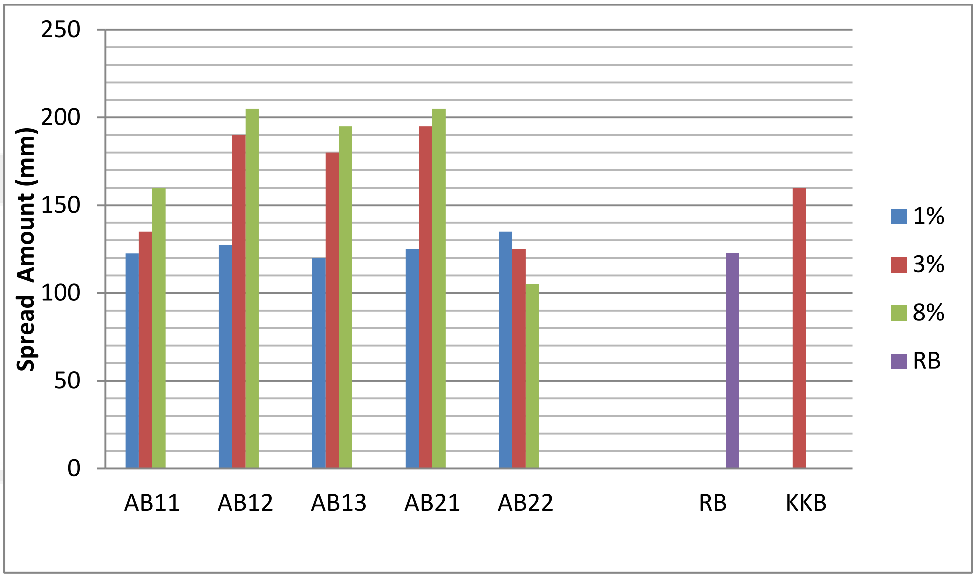

Figure 4.2: Spread Amount Graph Based on Waste Paint Amount

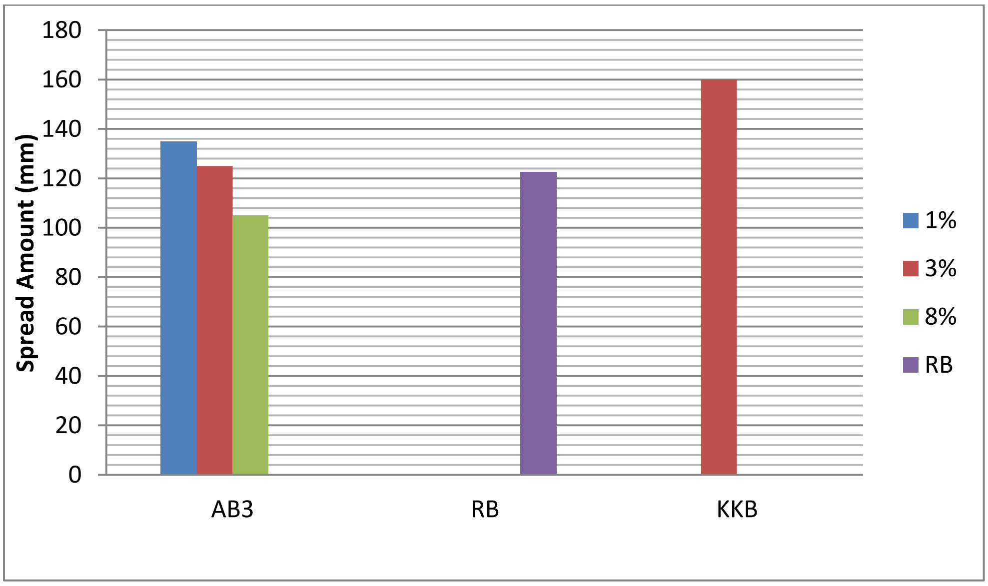

Figure 4.3: AB3 Spread Amount Graph Based on Solvent Dye Amount

4.3. Effect of Waste Paint Ratio on 7-Day Compressive Strength

The table below shows the change in the 7-day compressive strength of 18 different samples for 1% 3% 8% waste paint ratios. According to the experimental study, the maximum compressive strength of concrete samples is observed between 1% and 3% of waste paint/cement. It was observed that the compressive strength decreased when the waste paint/cement ratio increased to 8%.

The results of the AB3-8 sample in the test are not included in the table because the test sample decomposed. Figure 4.4.

Figure 4.4: Cylinder Sample Obtained with AB3 Solvent Paint

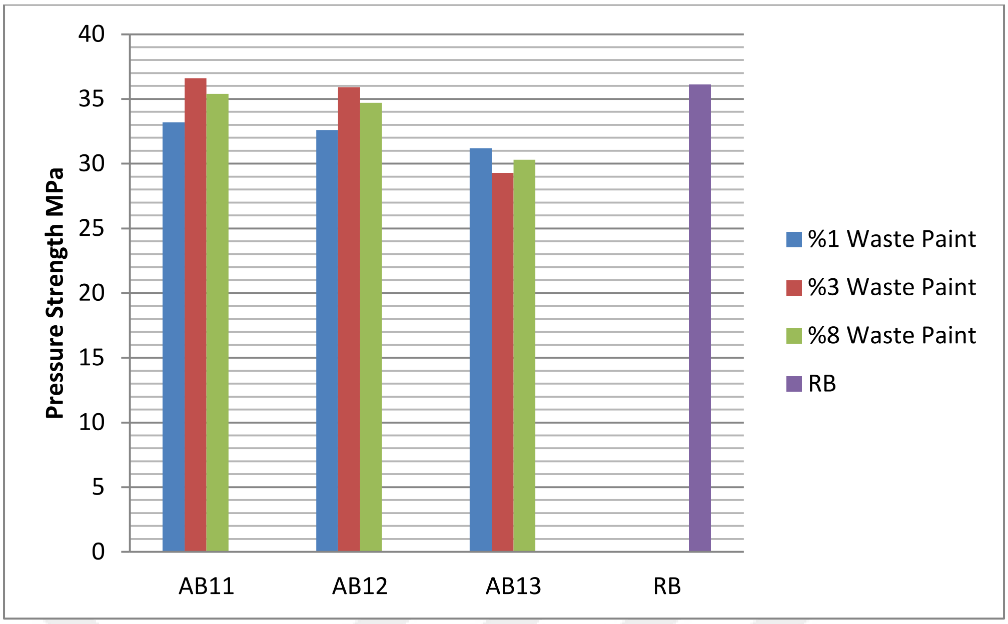

Figure 4.5: 7-Day Pressure Change Graph Based on Latex Paint Amount

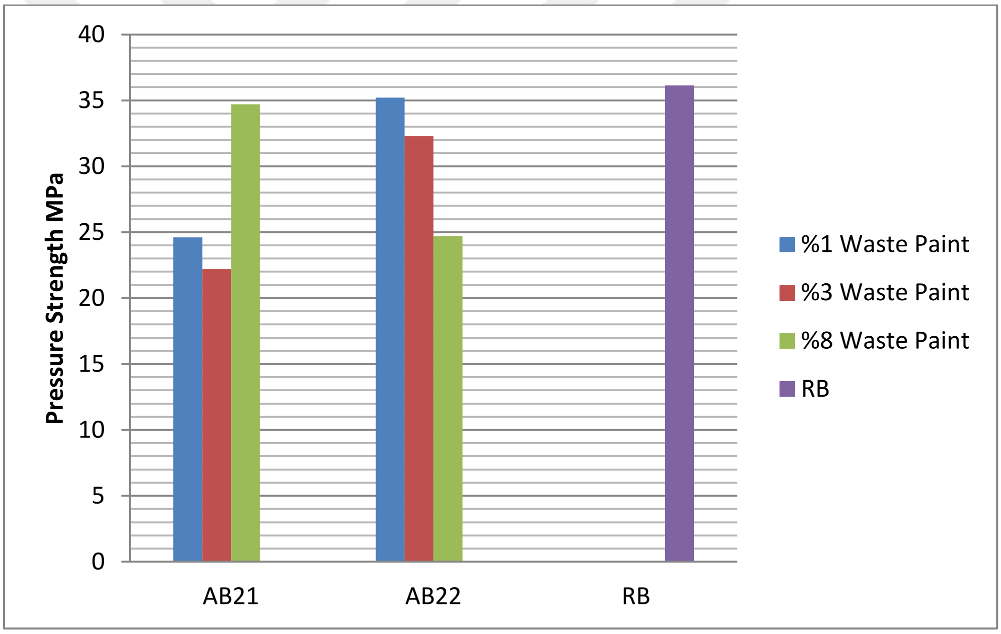

Figure 4.6 : 7-Day Compressive Strength Graph Based on Acrylic Paint Amount

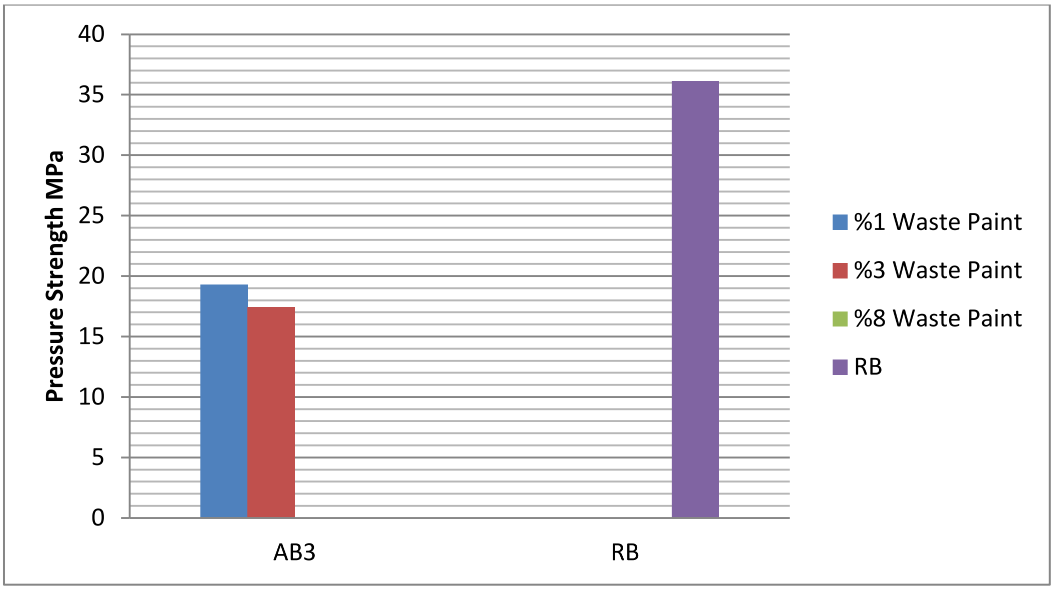

Figure 4.7: 7-Day Pressure Change Graph Based on Solvent Based Paint Amount

4.4. Effect of Waste Paint Ratio on 28-Day Cylinder Sample Compressive Strength

When the graph below is examined, it has been observed that the compressive strength of the concrete mixture containing waste paint in samples with a paint content of 3% according to the cement ratio is the same as the reference concrete and even higher in some samples.

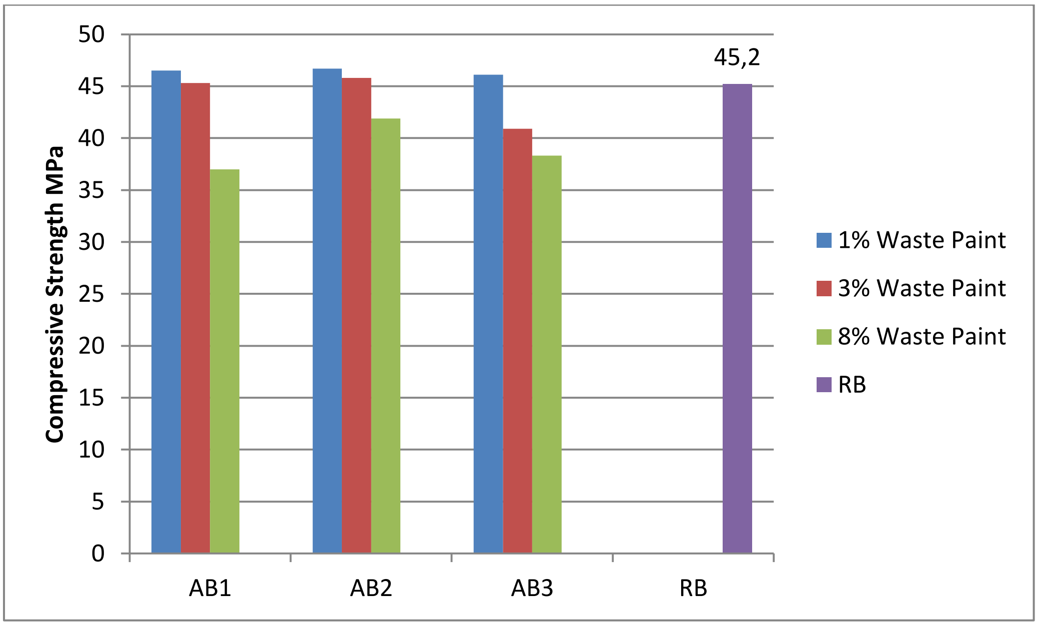

Figure 4.8: Graph of Compressive Strength Depends on the Amount of Latex Paint in a Cylinder Sample at 28 Days

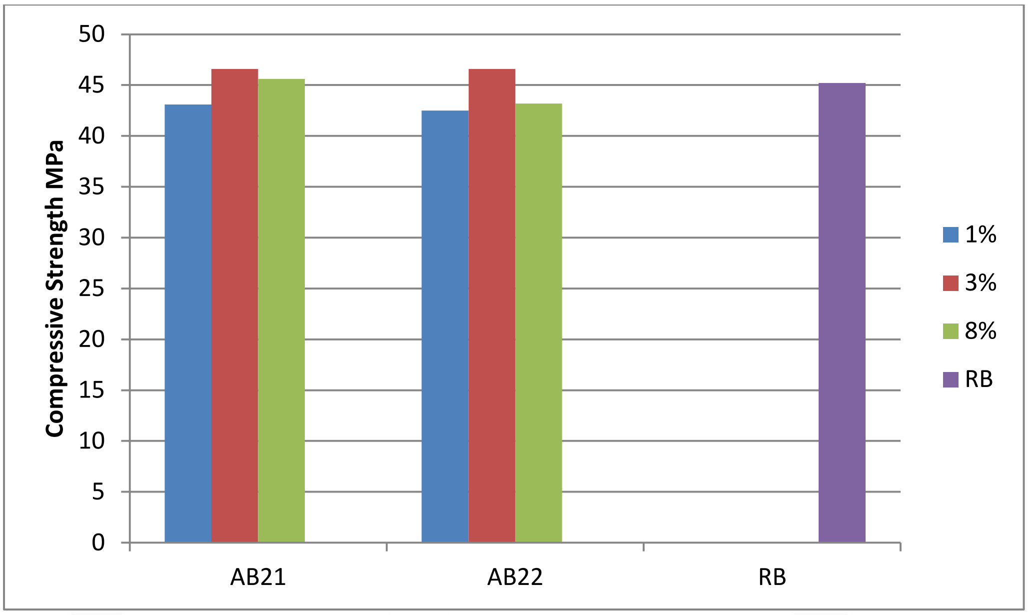

Figure 4.9: Compressive Strength Graph Based on Acrylic Paint Amount in a Cylinder Sample for 28 Days

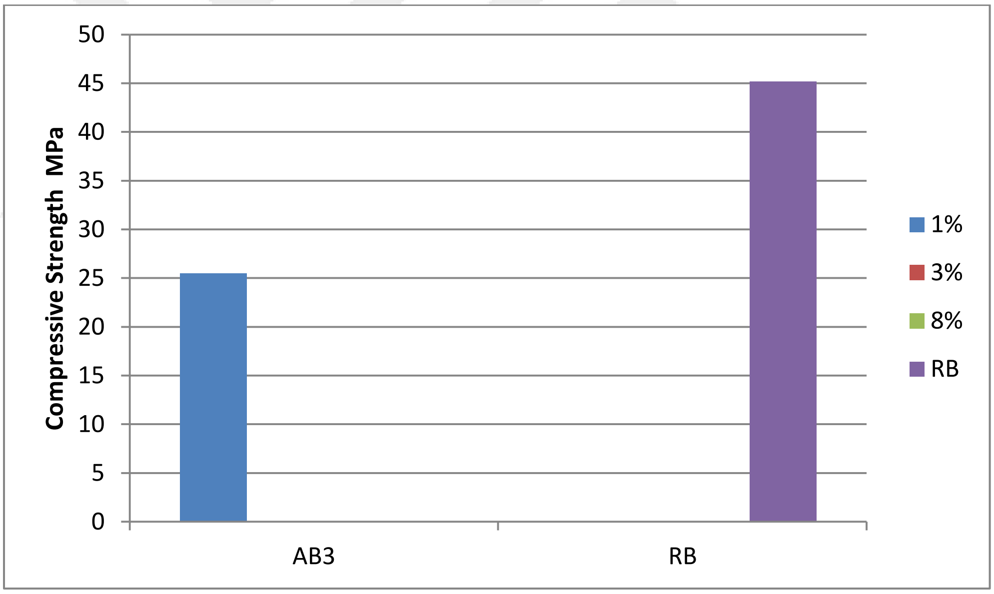

Figure 4.10: Compressive Strength Depending on AB3 Solvent Paint Amount in a Cylinder Sample of 28 Days

4.5 Effect of Waste Paint on 28-Day Cube Sample Compressive Strength

When the cube sample pressure test results were examined, it was observed that water-based polymer paints gave good results on the same line with the reference concrete when 1% paint was added. It was observed that the concrete strength decreased as the paint percentage increased.

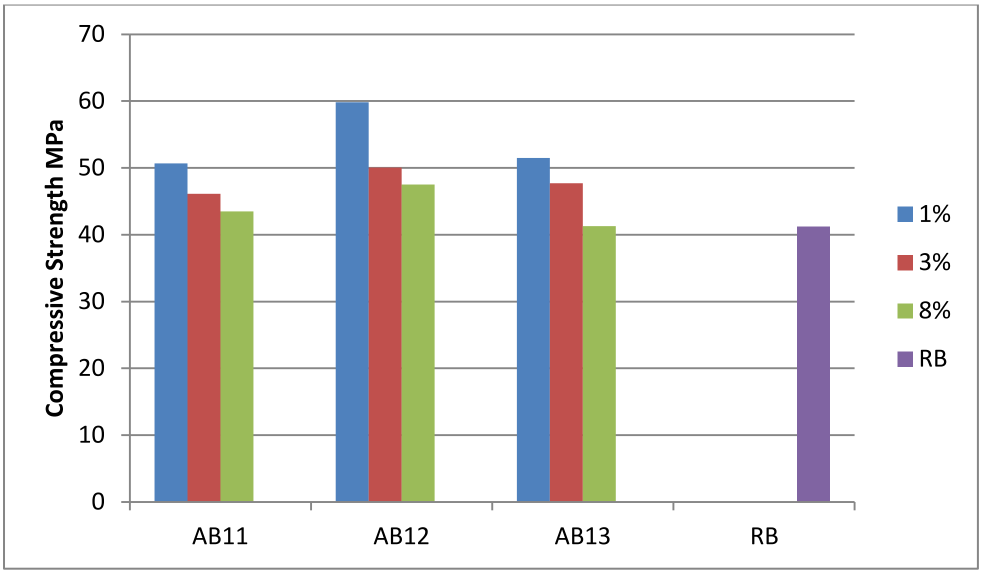

Figure 4.11: Compressive Strength Depends on the Amount of Latex Paint in a Cube Sample of 28 Days

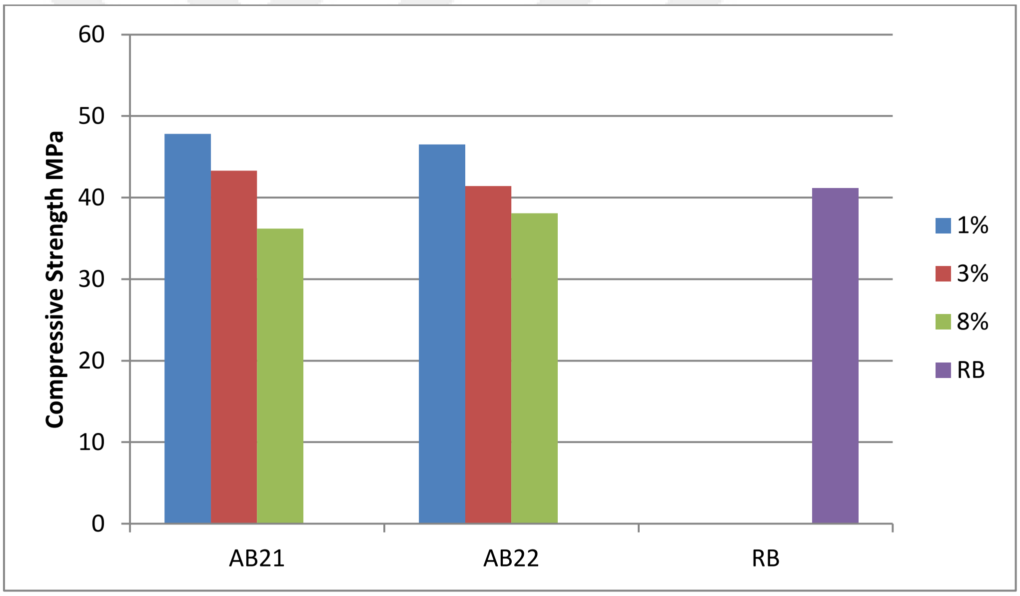

Figure 4.12: Compressive Strength Depending on Acrylic Paint Amount in a Cube Sample of 28 Days

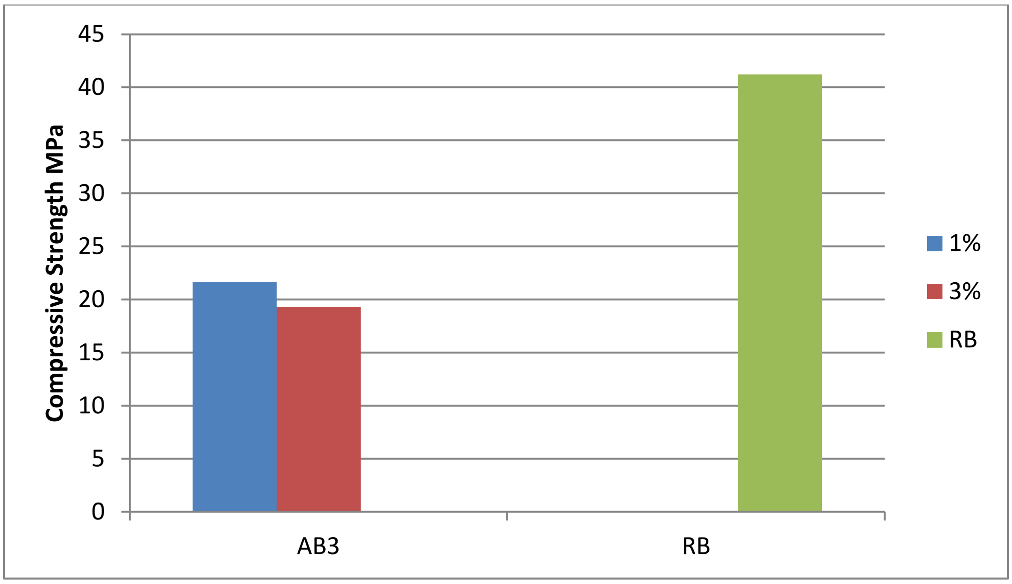

Figure 4.13: Compressive Strength Depends on the Amount of Solvent Based Paint in a Cube Sample of 28 Days

4.6 Modulus of Elasticity

An elasticity test was performed on concrete samples after 28 days of curing. Obtained test results are shown in Table 4.1. Experiment results for 1%, 3%, 8% dye ratios with 6 different dyes are given in the appendices.

Table 4.3: Modulus of Elasticity Values

Specimen Code	Modulus of Elasticity (Mpa)
RB	25616
AB11-1	23508
AB11-3	24359
AB11-8	20496
AB12-1	23102
AB12-3	24202
AB12-8	25459
AB13-1	24097
AB13-3	21674
AB13-8	21740
AB21-1	22329
AB21-3	22421
AB21-8	19644
AB22-1	23259

AB22-3	22329
AB22-8	19710
AB3-1	21458
AB3-3	20103
AB3-8	19251

4.7. Capillary Water Absorption

As a result of the capillary water absorption design, three of each sample with different waste paint/cement ratios of reference concrete, waste paint added concrete, and chemical additive concrete, 20 water absorption time graphs were drawn according to ASTM C 1585 standard. The graphs drawn are shown in the appendix.

Table 4.4: Capillary Coefficient Values

Specimen Code	**Capillary Coefficient Values ($mm/sn^{1/2}$)**
RB	$4,84x10^{-4}$
AB11-1	$2,78x10^{-4}$
AB11-3	$1,02\ x10^{-4}$
AB11-8	$1,78\ x10^{-4}$
AB12-1	$1,67\ x10^{-4}$
AB12-3	$4,65\ x10^{-4}$
AB12-8	$1,81\ x10^{-4}$
AB13-1	$2,39\ x10^{-4}$
AB13-3	$4,85\ x10^{-4}$
AB13-8	$1,76\ x10^{-4}$
AB21-1	$1,29\ x10^{-4}$
AB21-3	$2,05\ x10^{-4}$
AB21-8	$2,34\ x10^{-4}$
AB22-1	$4,9x10^{-4}$
AB22-3	$3,71\ x10^{-4}$
AB22-8	$5,3\ x10^{-4}$
AB3-1	$4,22\ x10^{-4}$
AB3-3	$8,1\ x10^{-4}$
AB3-8	$13,68\ x10^{-4}$
KKB	

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Various mixes were created to test the recycling adequacy of waste latex paint in the mortar mix. The water/cement ratio was kept constant in all mixtures. The mixtures were tested for unit weight, spreading, capillary water absorption, bending, compressive strength. The following conclusions can be drawn as a result of these experiments.

- An increase in the amount of paint reduces the compressive strength.
- The increase in the amount of waste paint has reduced the unit weight.
- As the percentage of waste dye in the Specimens increased, the spread increased. The workability of the mortar mixture has increased.
- The increase in the amount of waste paint has decreased the amount of capillary water absorption.
- Compared to chemical additives, it has been observed that it meets the required properties and even gives better results. Therefore, it has been confirmed that waste paint can be used instead of conventional chemical additives.
- Machine paint, that is, solvent-based paints, has damaged the structure of the mortar mixture and the Specimens have been segregated.
- The optimum dye ratio to be used, excluding solvent dyes, should be %3.

5.2 Recommendations

The recommendations given below may be useful for future work.

- Additional tests and analyzes should be carried out to confirm the results given above and also to investigate other performances of the waste paint such as long-term durability.
- In other studies on waste paint, the proportion of cement in the Specimens can be reduced and even the displacement of cement with waste paint can be tested.

- This study can be verified by working on different types of cement.
- In this study, waste dyes were not taken from the collection center, and in a controlled manner, expired dyes with expired shelf life were used. In a future study, the effect of more heterogeneous waste paints from a waste paint collection center on the mortar mix can be examined.
- Can waste paint be used instead of construction chemicals? Waste paint can be used instead of which chemical additive? Another study can be done to answer their questions.
- Depending on the change in aggregate size, different experiments can be studied.

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APPENDICES

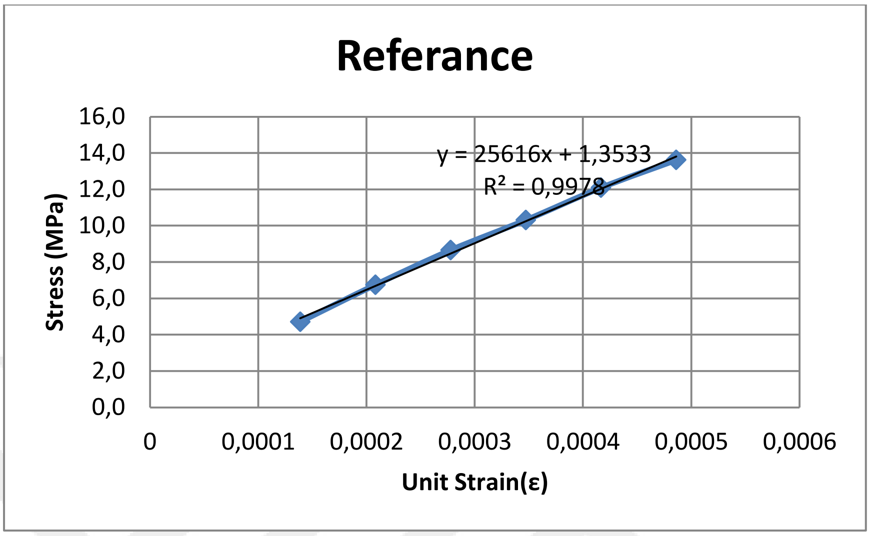

Figure A.1: Stress- Strain Curve in Reference Specimen

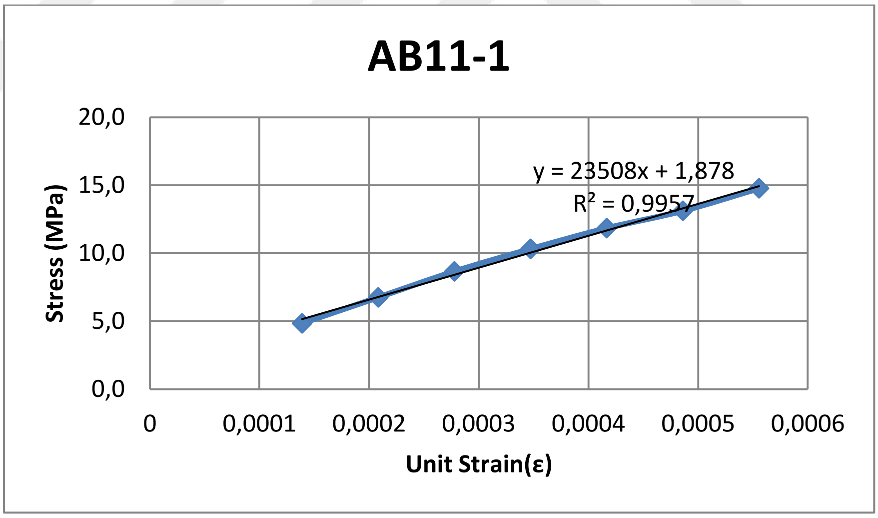

Figure A.2: Stress-Strain Graph for AB11-1 Latex Paint Additive Sample

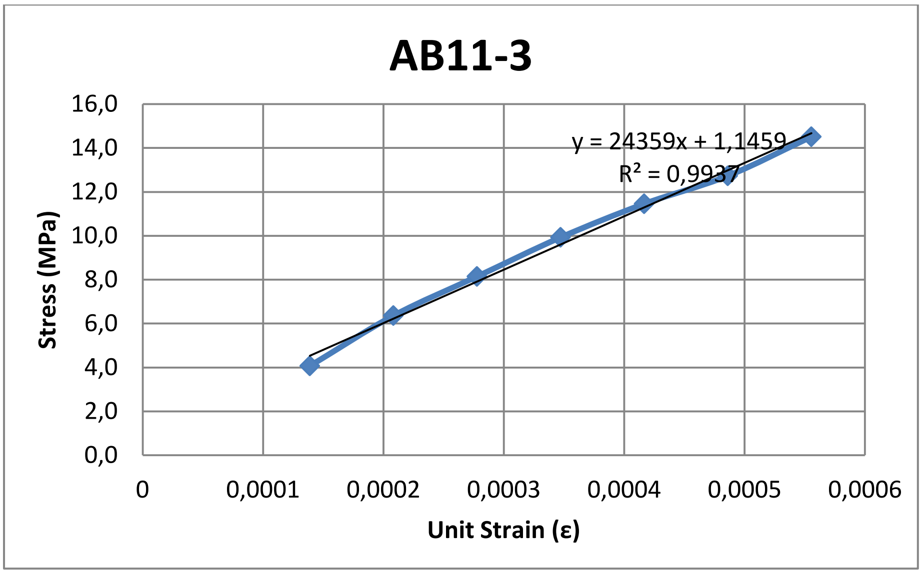

Figure A.3: Stress-Strain Graph for AB11-3 Latex Paint Additive Sample

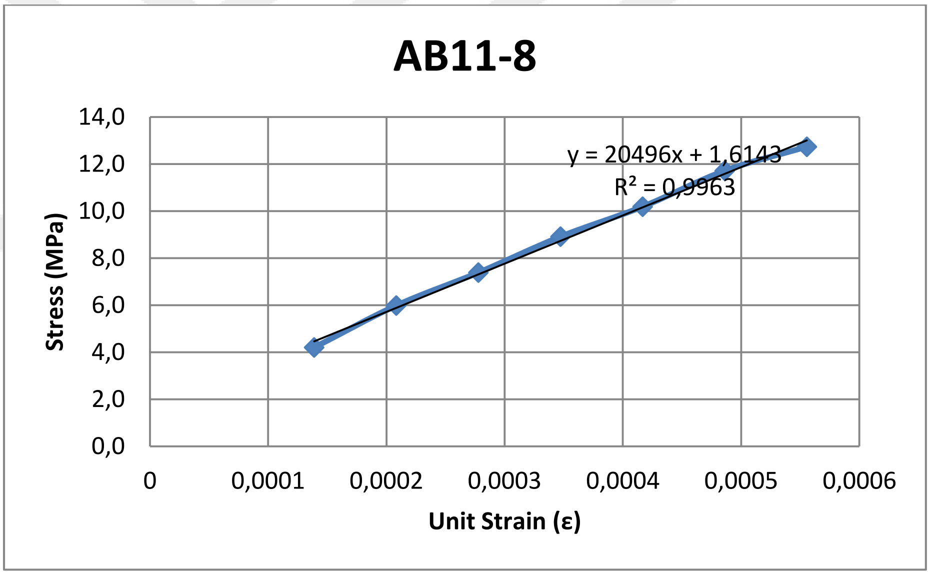

Figure A.4: Stress-Strain Graph for AB11-8 Latex Paint Additive Sample

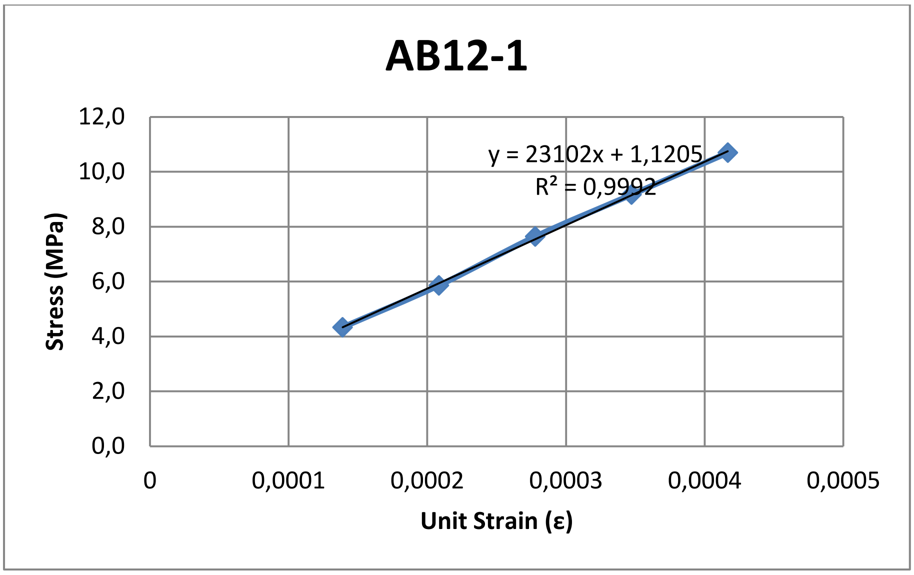

Figure A.5: Stress-Strain Graph for AB12-1 Latex Paint Additive Sample

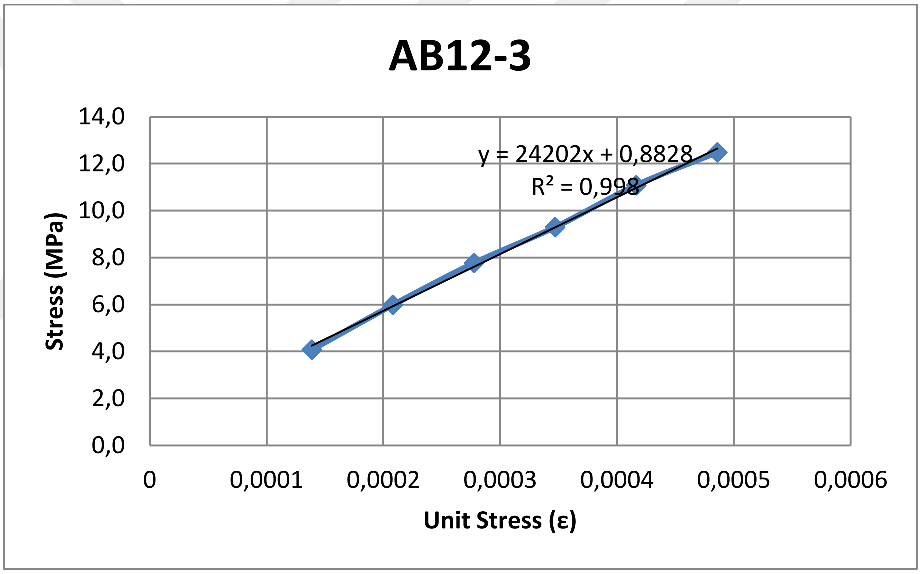

Figure A.6: Stress-Strain Graph for AB12-3 Latex Paint Additive Sample

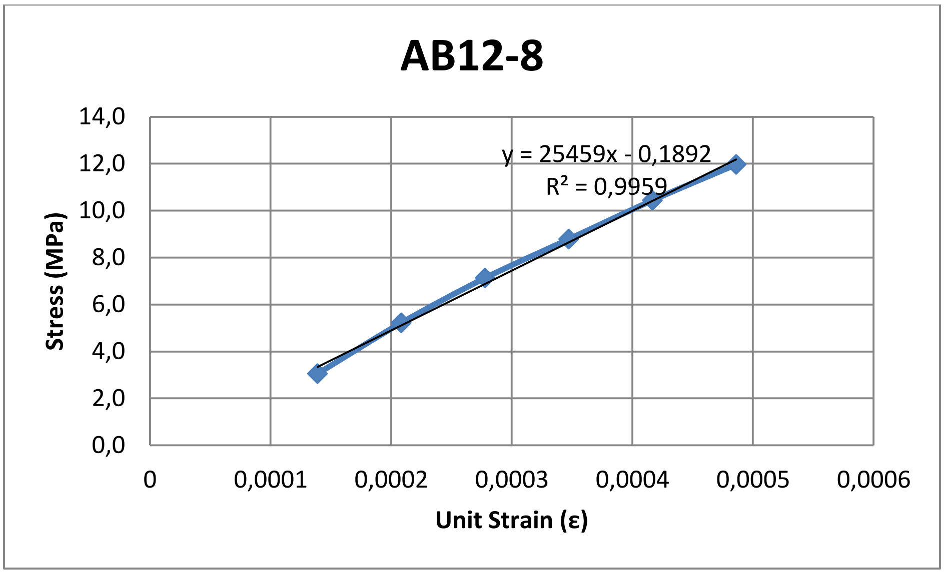

Figure A.7: Stress-Strain Graph for AB12-8 Latex Paint Additive Sample

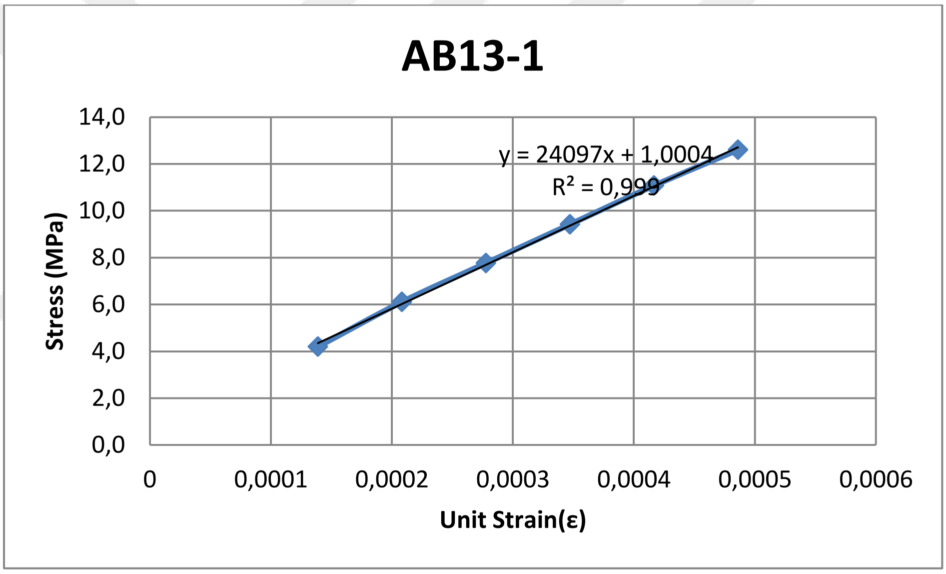

Figure A.8: Stress-Strain Graph for AB13-1 Latex Paint Additive Sample

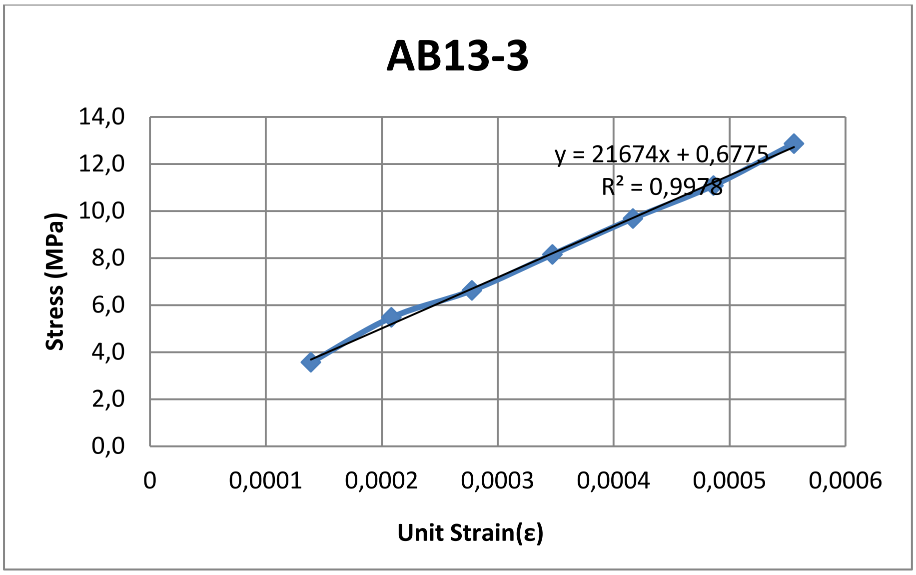

Figure A.9: Stress-Strain Graph for AB13-3 Latex Paint Additive Sample

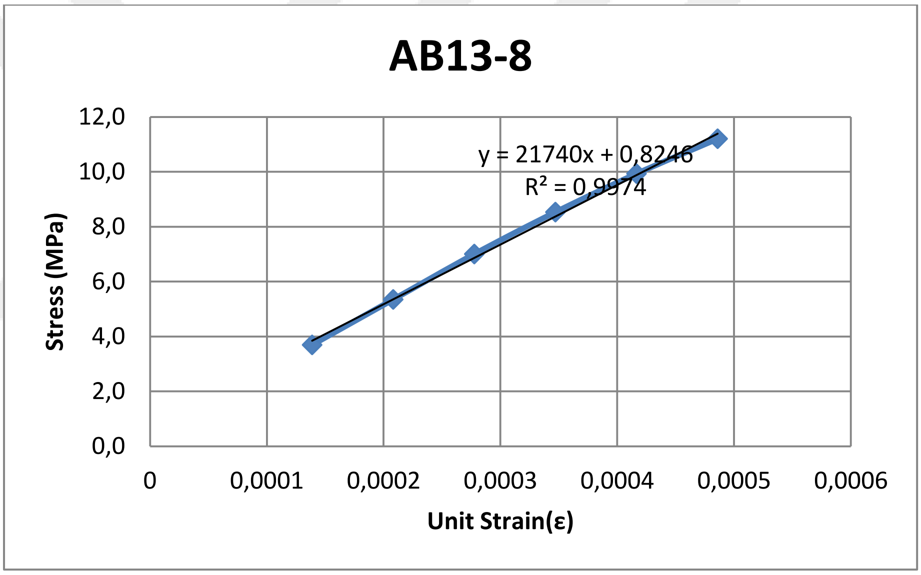

Figure A.10: Stress-Strain Graph for AB13-8 Latex Paint Additive Sample

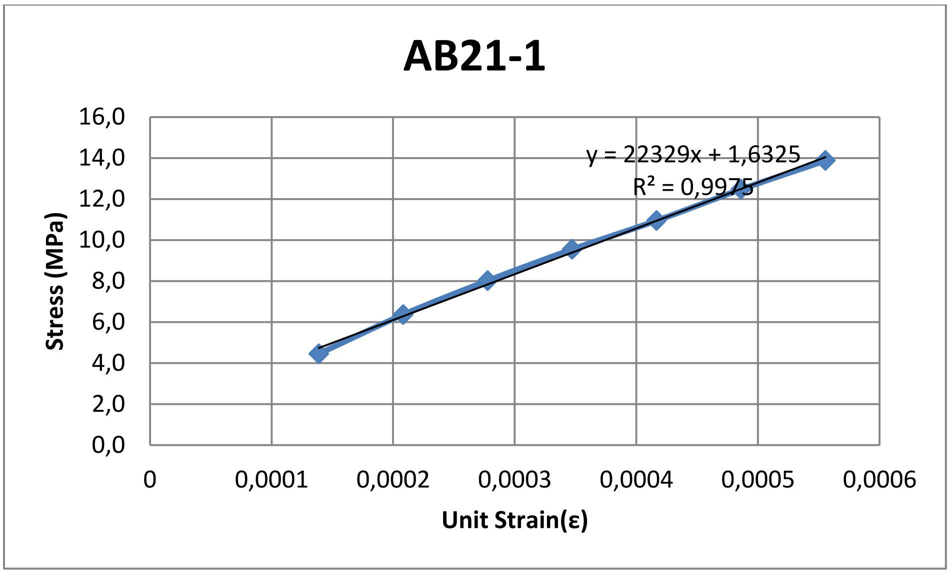

Figure A.11: Stress-Strain Graph for AB21-1 Acrylic Paint Additive Sample

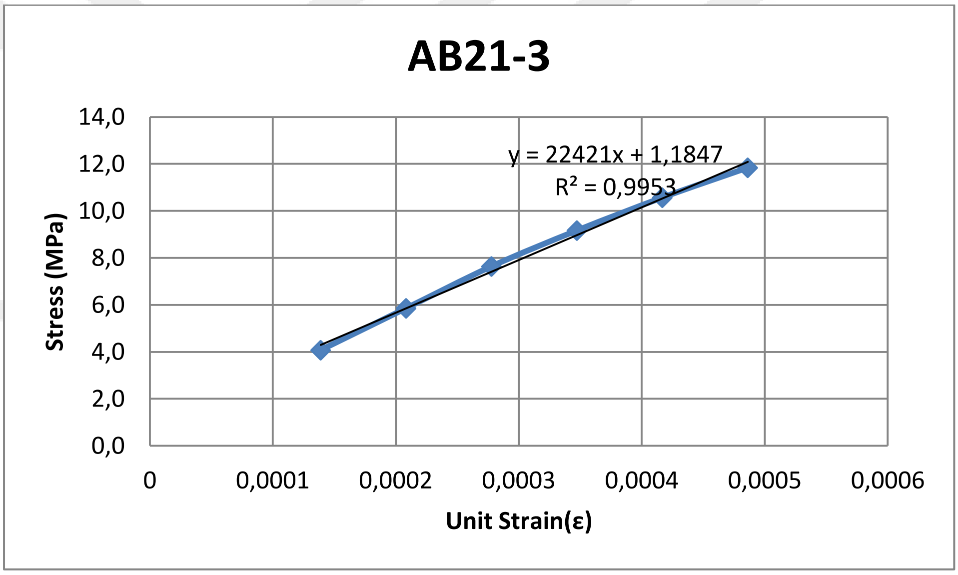

Figure A.12: Stress-Strain Graph for AB21-3 Acrylic Paint Additive Sample

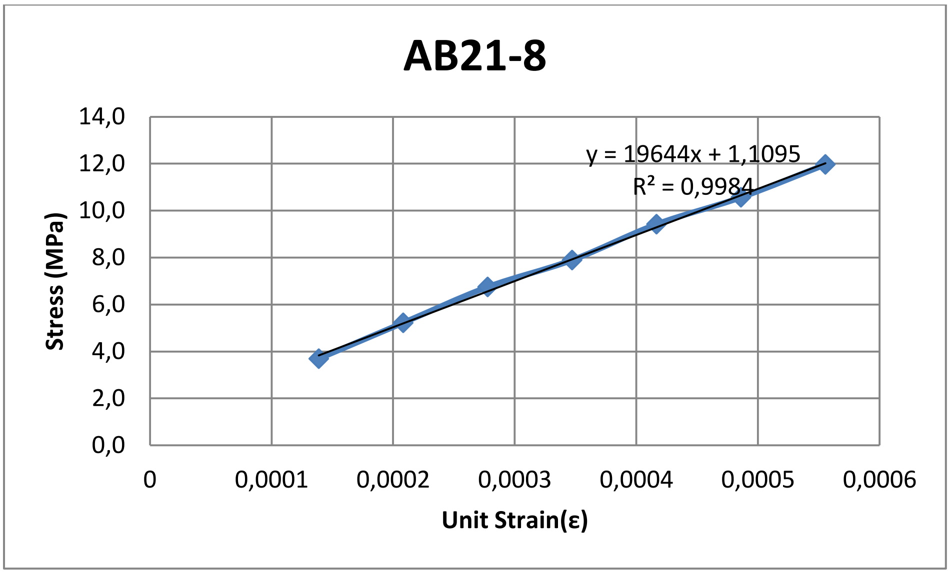

Figure A.13: Stress-Strain Graph for AB21-8 Acrylic Paint Additive Sample

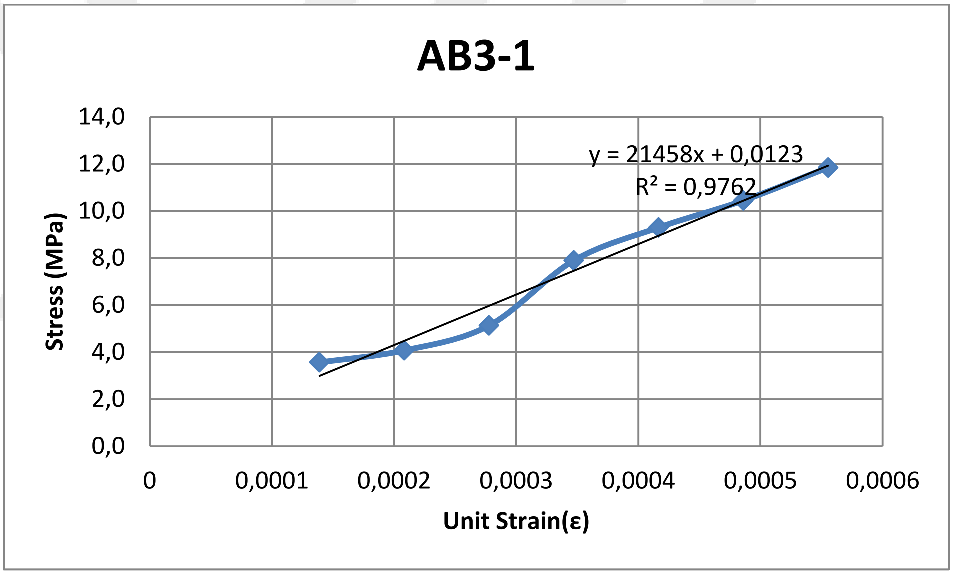

Figure A.14: Stress-Strain Graph for AB3-1 Solvent Paint Added Sample

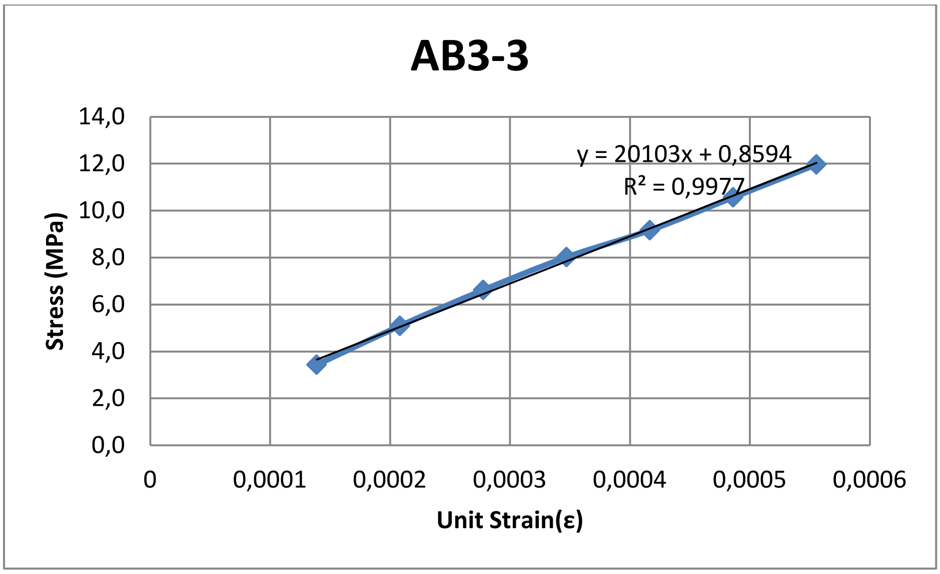

Figure A.15: Stress-Strain Graph for AB3-3 Solvent Paint Added Sample

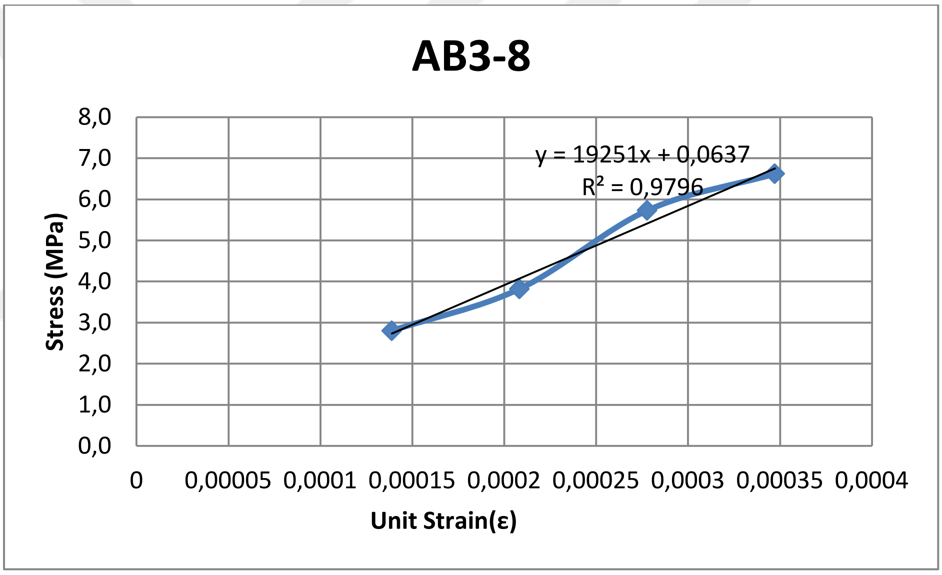

Figure A.16: Stress-Strain Graph for AB3-8 Solvent Paint Added Sample

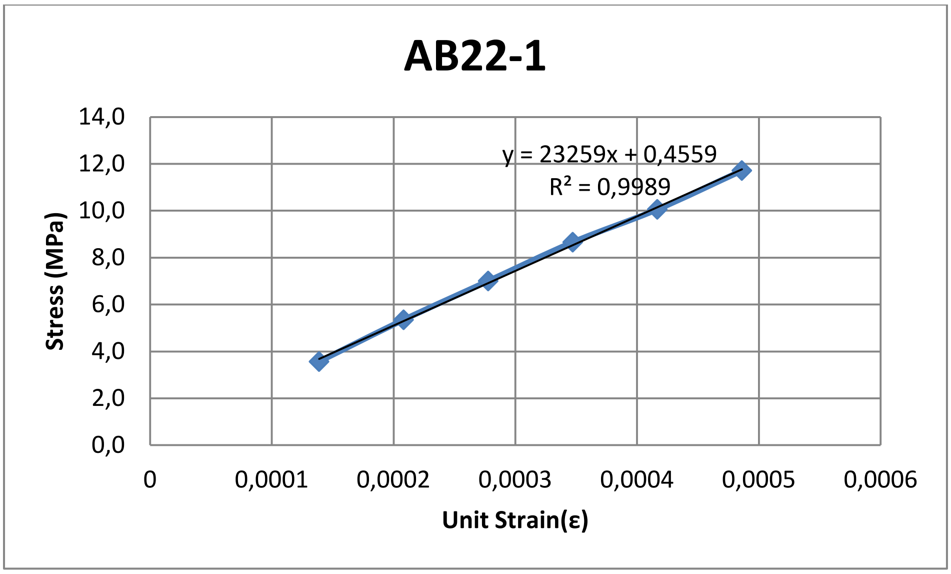

Figure A.17: Stress-Strain Graph for AB22-1 Acrylic Paint Additive Sample

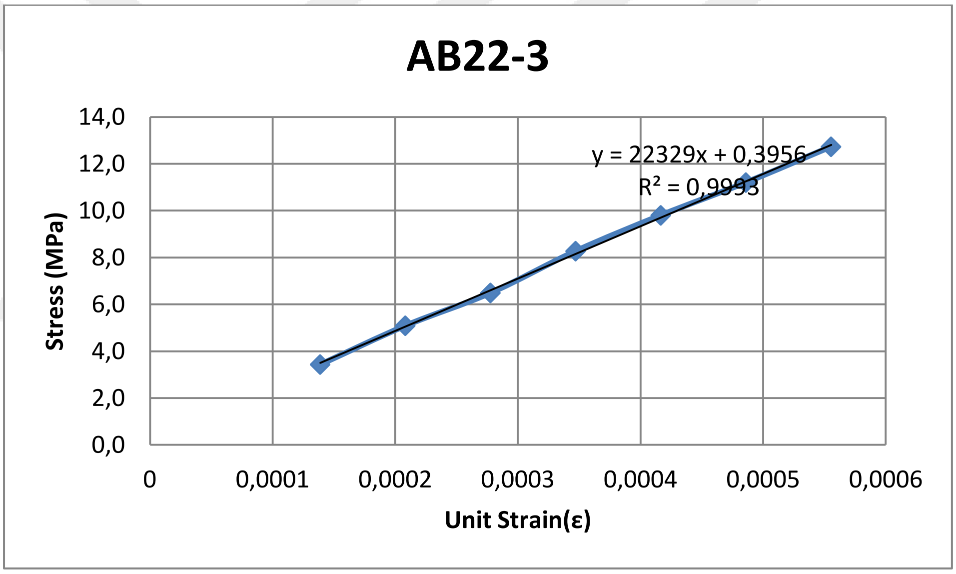

Figure A.18: Stress-Strain Graph for AB22-3 Acrylic Paint Additive Sample

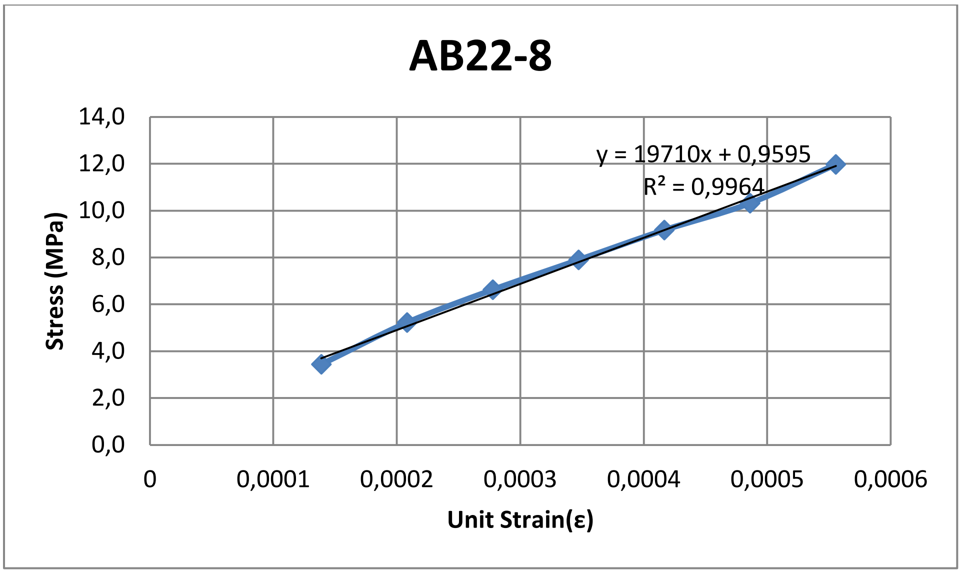

Figure A.19: Stress-Strain Graph for AB22-8 Acrylic Paint Additive Sample

Capillary Water Absorption

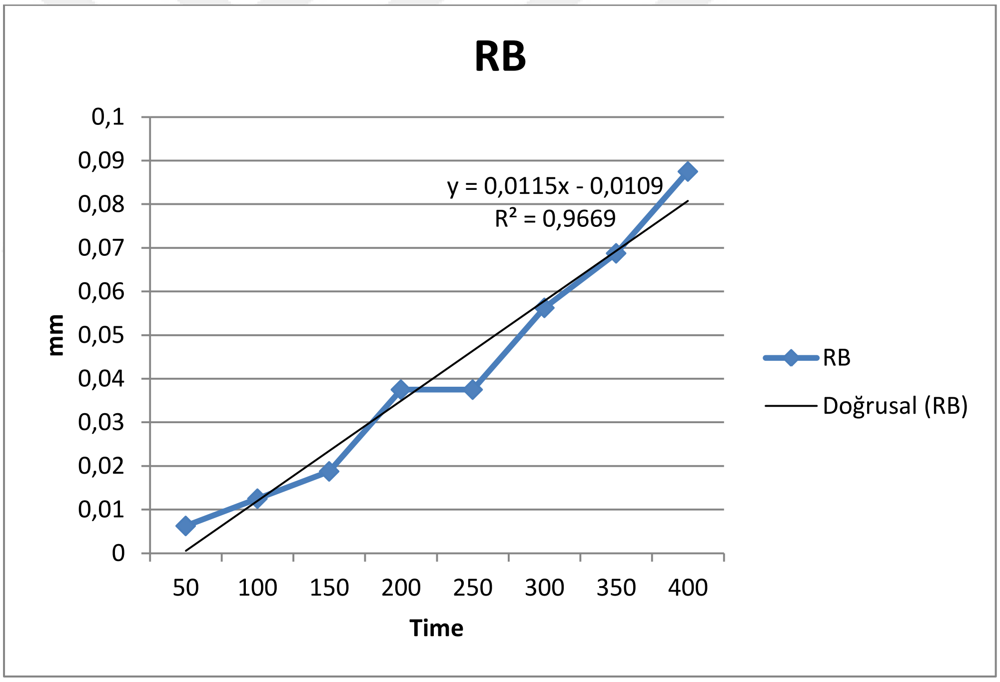

Figure B.1: Capillary Water Absorption-Time Curve in the Reference Specimen

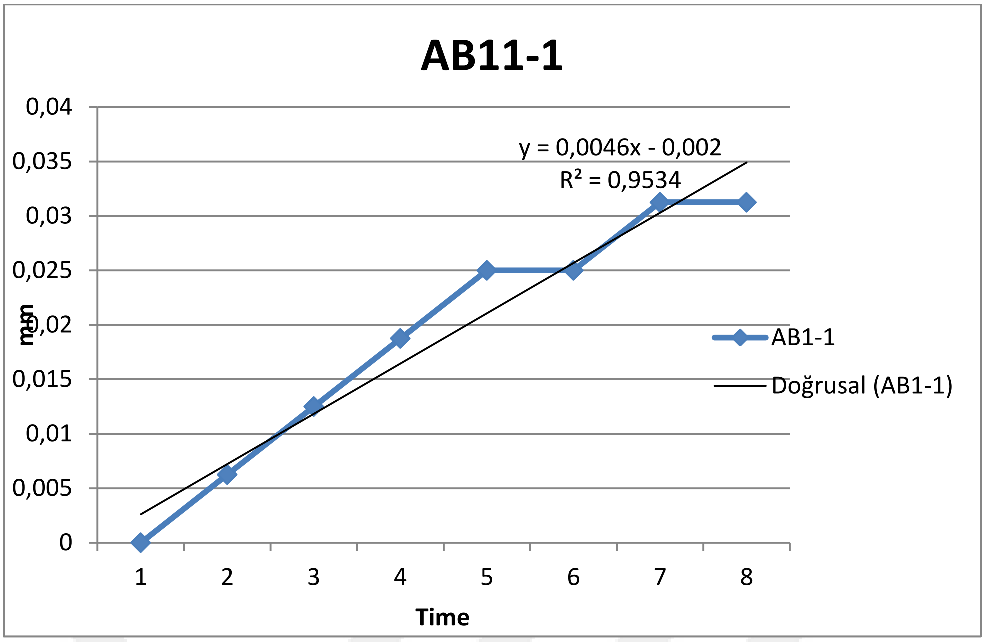

Figure B.2: Capillary Water Absorption-Time Graph in AB11-1 Latex Paint Additive Sample

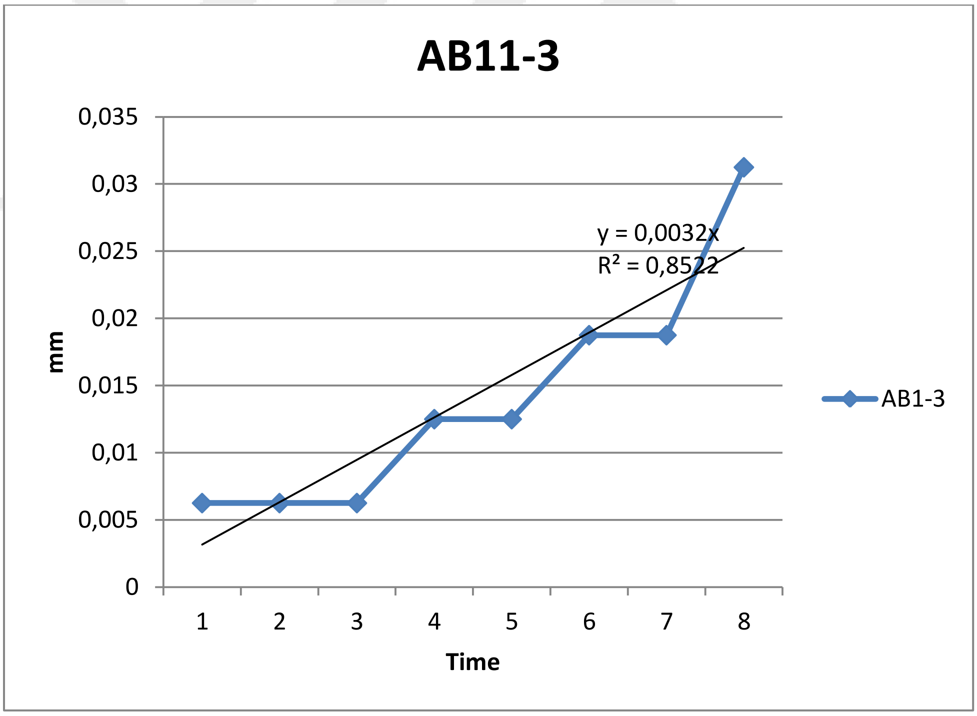

Figure B.3: Capillary Water Absorption-Time Graph in AB11-3 Latex Paint Additive Sample

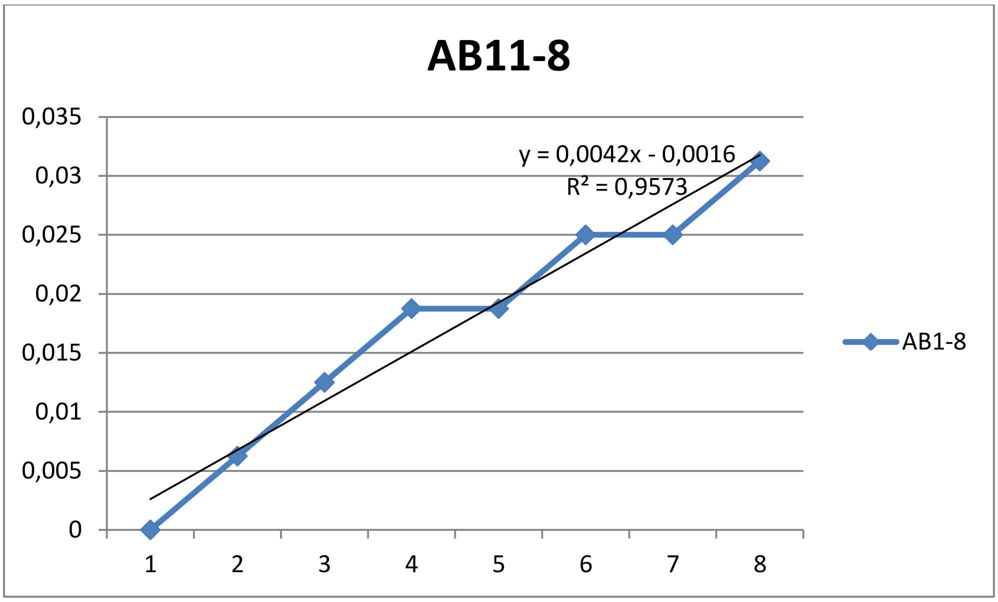

Figure B.4: Capillary Water Absorption-Time Graph in AB11-8 Latex Paint Additive Sample

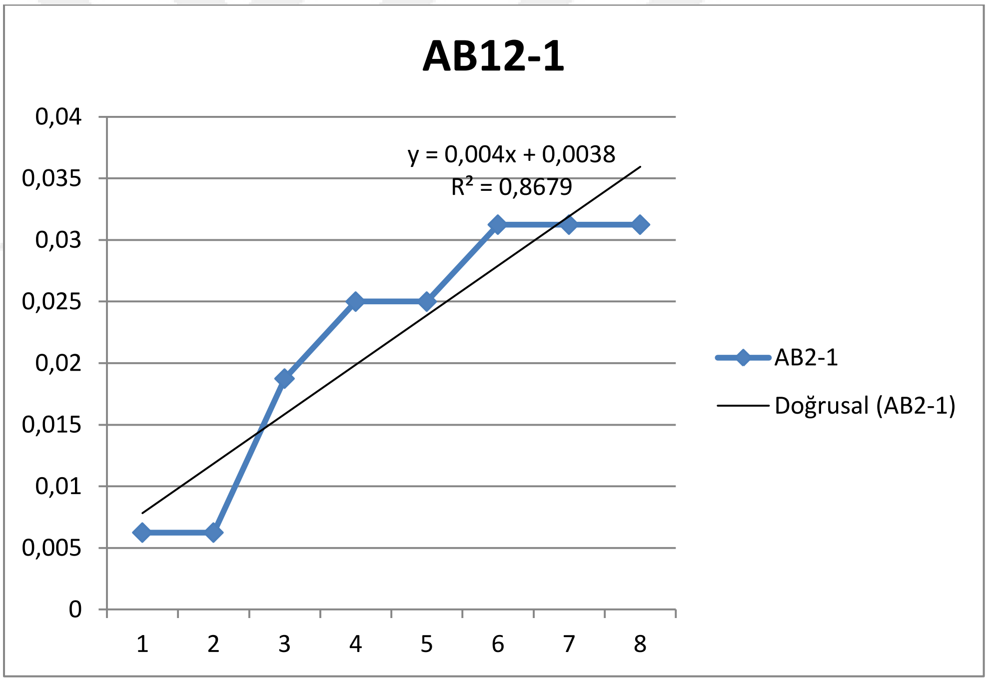

Figure B.5: Capillary Water Absorption-Time Graph in AB12-1 Latex Paint Additive Sample

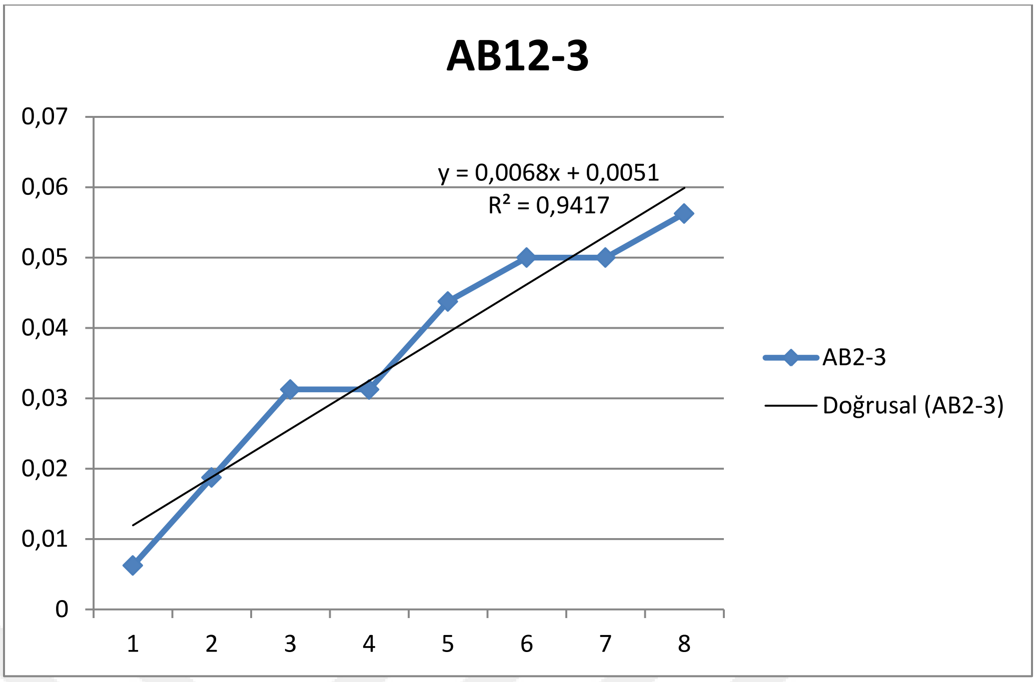

Figure B.6: Capillary Water Absorption-Time Graph in AB12-3 Latex Paint Additive Sample

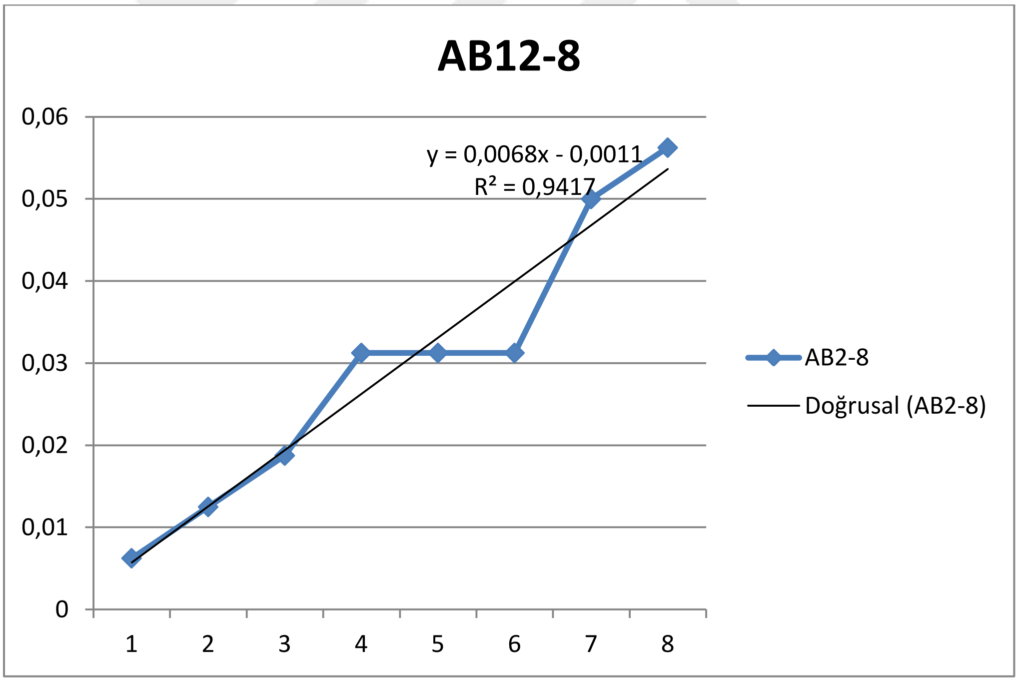

Figure B.7: Capillary Water Absorption-Time Graph in AB12 -8 Latex Paint Additive Sample

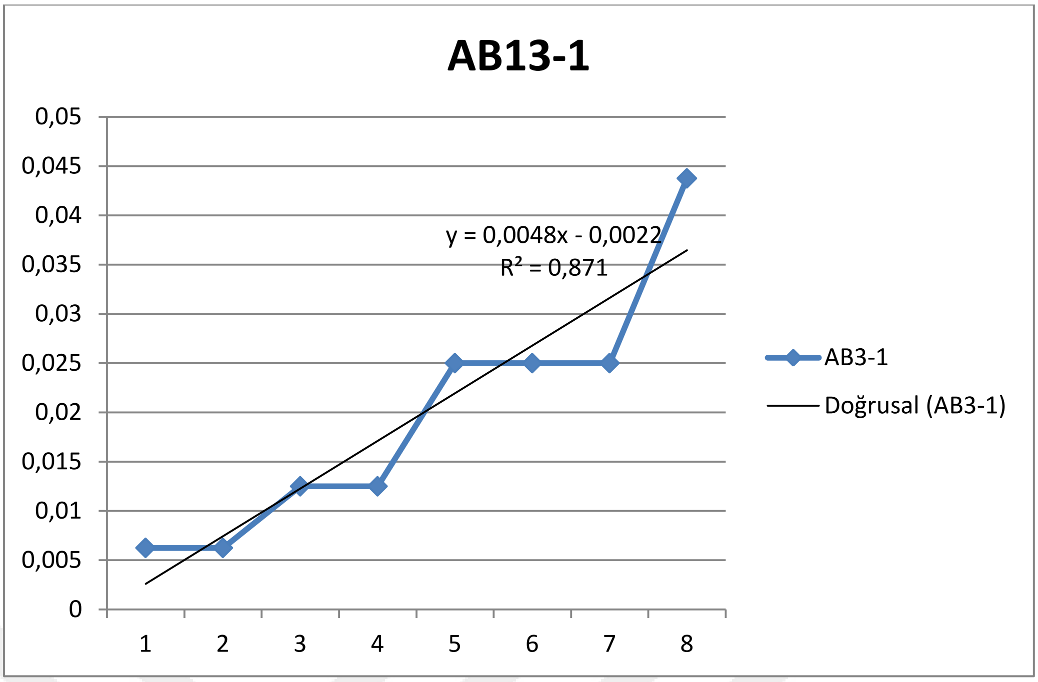

Figure B.8: Capillary Water Absorption-Time Graph in AB13-1 Latex Paint Additive Sample

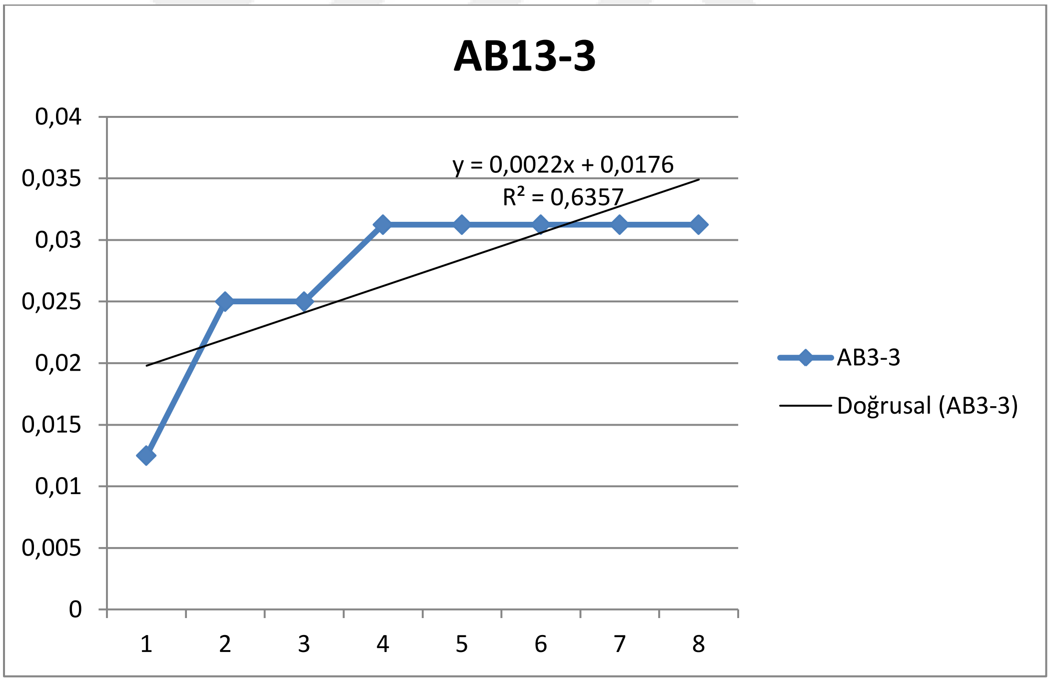

Figure B.9: Capillary Water Absorption-Time Graph in AB13-3 Latex Paint Additive Sample

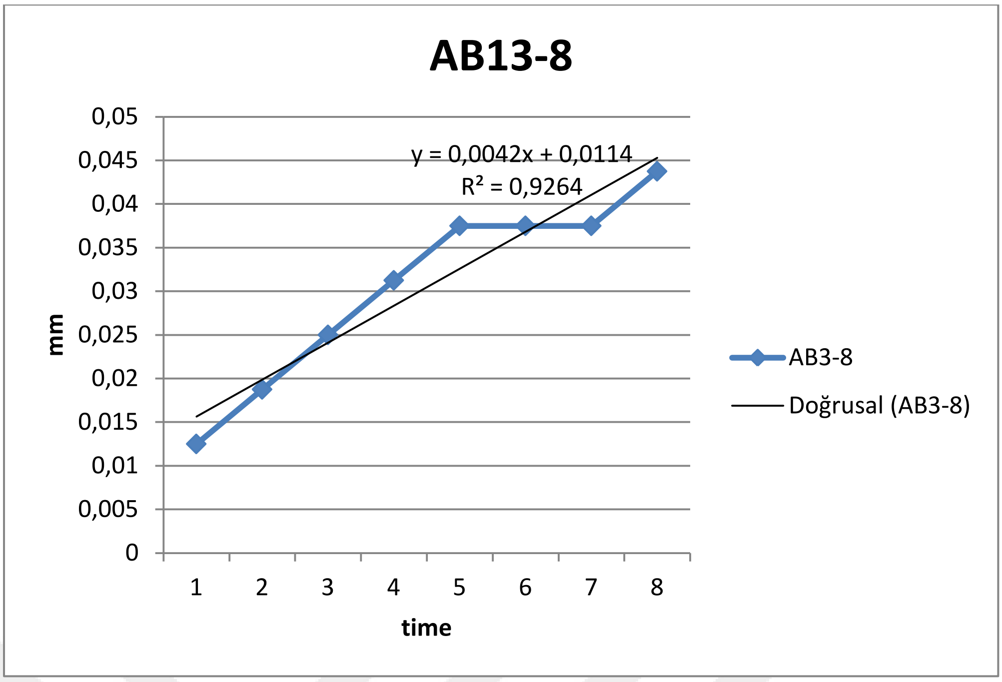

Figure B.10: Capillary Water Absorption-Time Graph in AB13-8 Latex Paint Additive Sample

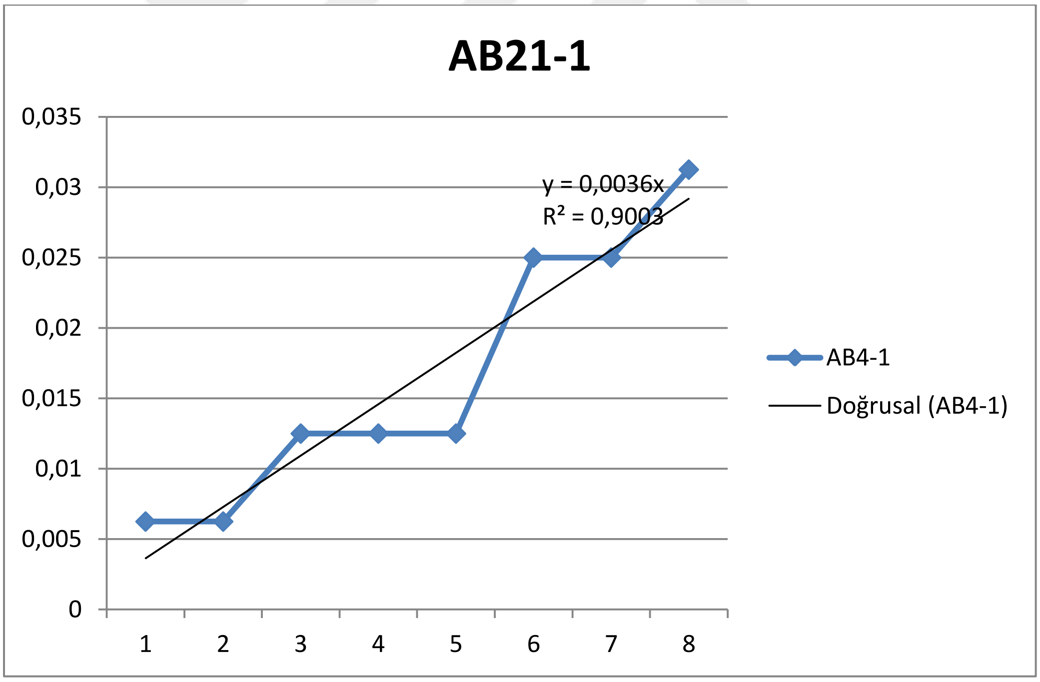

Figure B.11: Capillary Water Absorption-Time Graph in AB21-1 Acrylic Paint Additive Sample

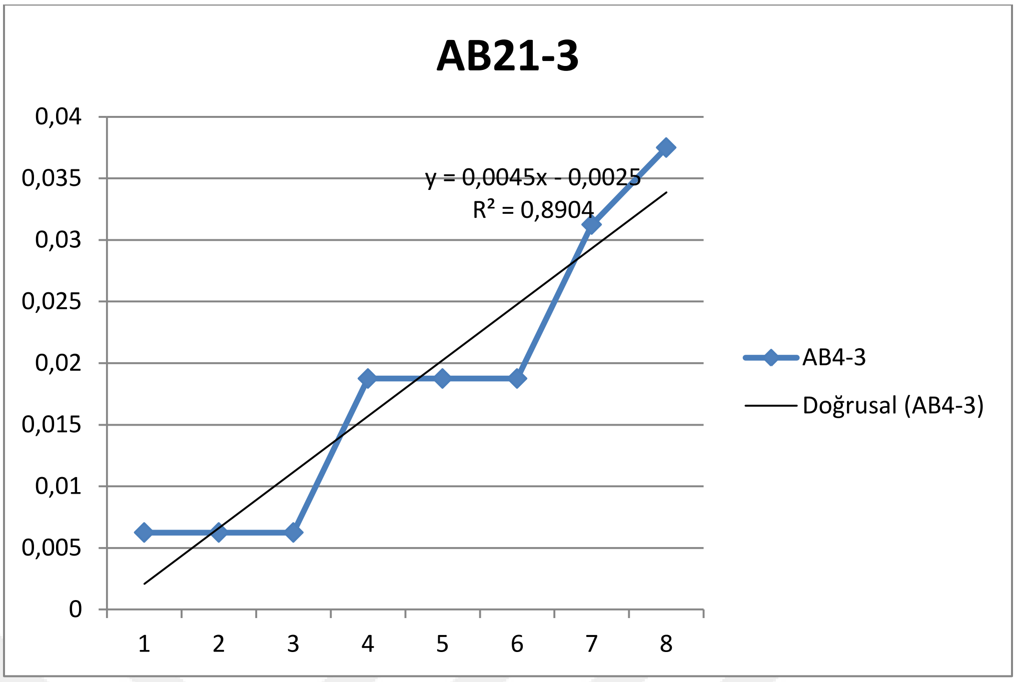

Figure B.12: Capillary Water Absorption-Time Graph in AB21-3 Acrylic Paint Additive Sample

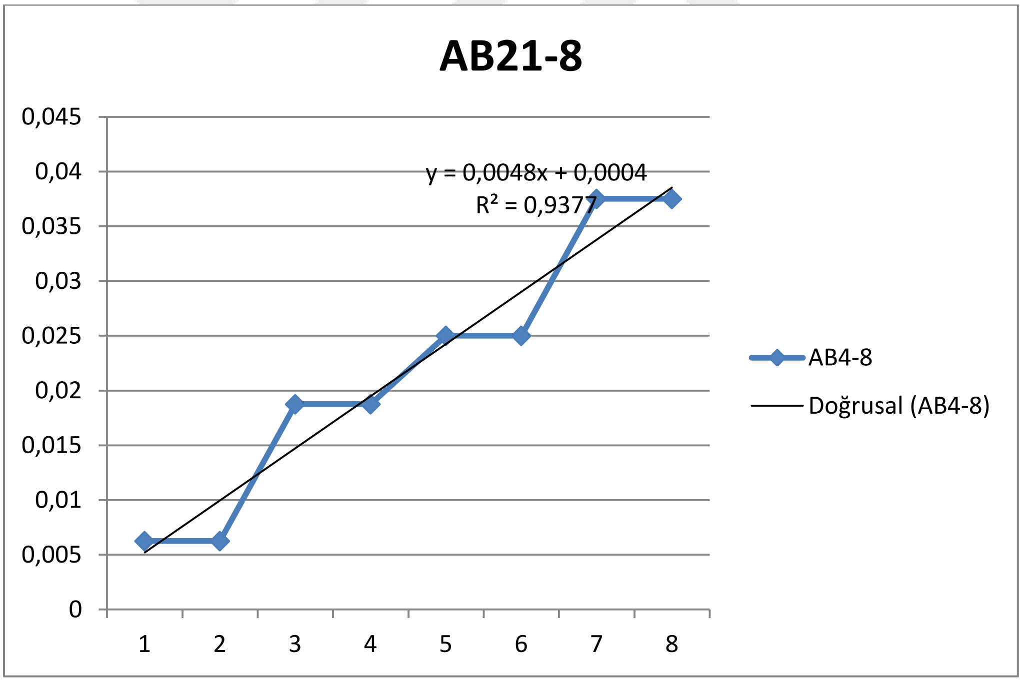

Figure B.13: Capillary Water Absorption-Time Graph in AB21-8 Acrylic Paint Additive Sample

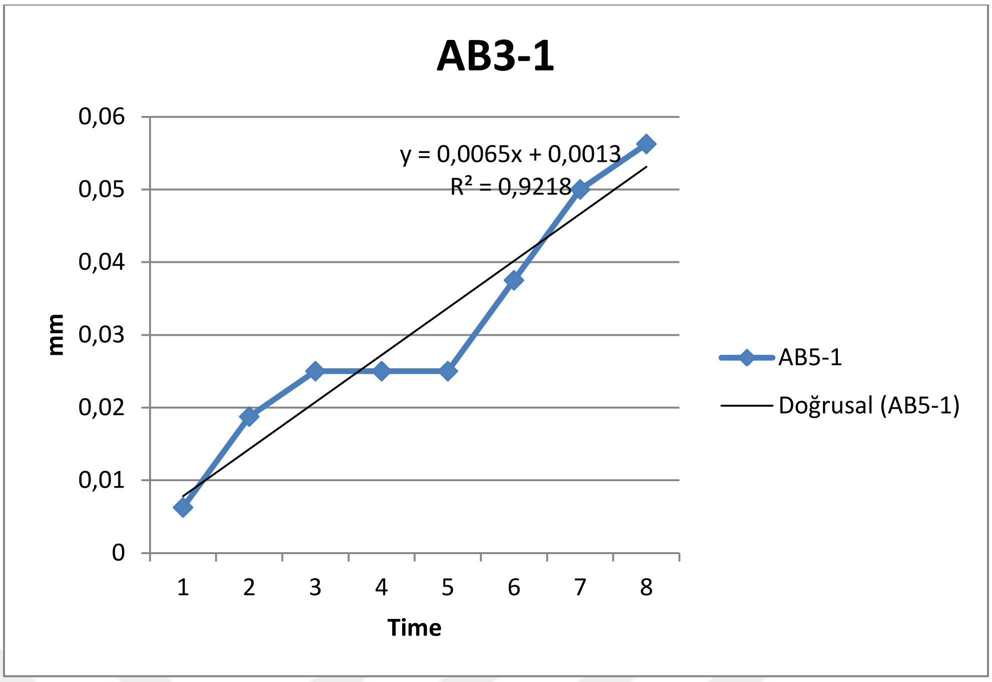

Figure B.14: Capillary Water Absorption-Time Graph in AB3-1 Solvent Dye Additive Sample

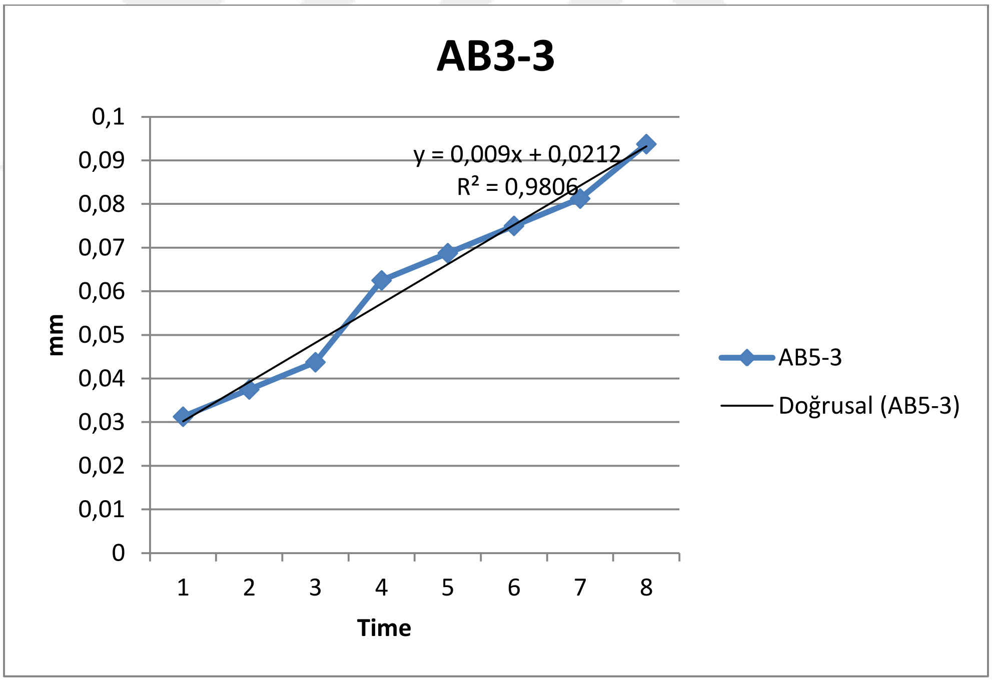

Figure B.15: Capillary Water Absorption-Time Graph in AB3-3 Solvent Dye Additive Sample

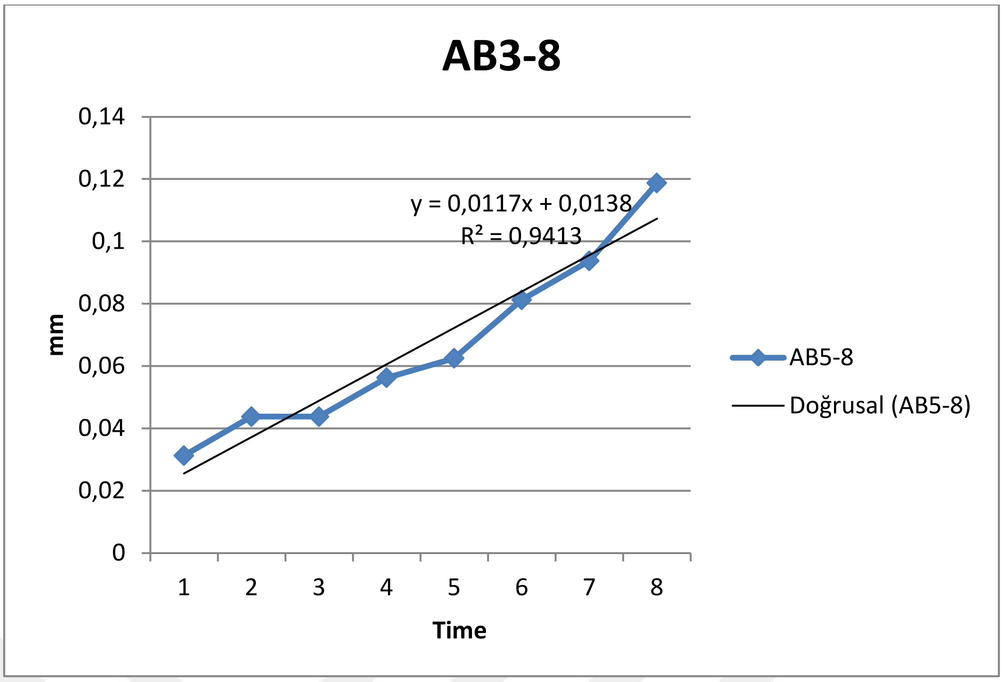

Figure B.16: Capillary Water Absorption-Time Graph in AB3-8 Solvent Dye Additive Sample

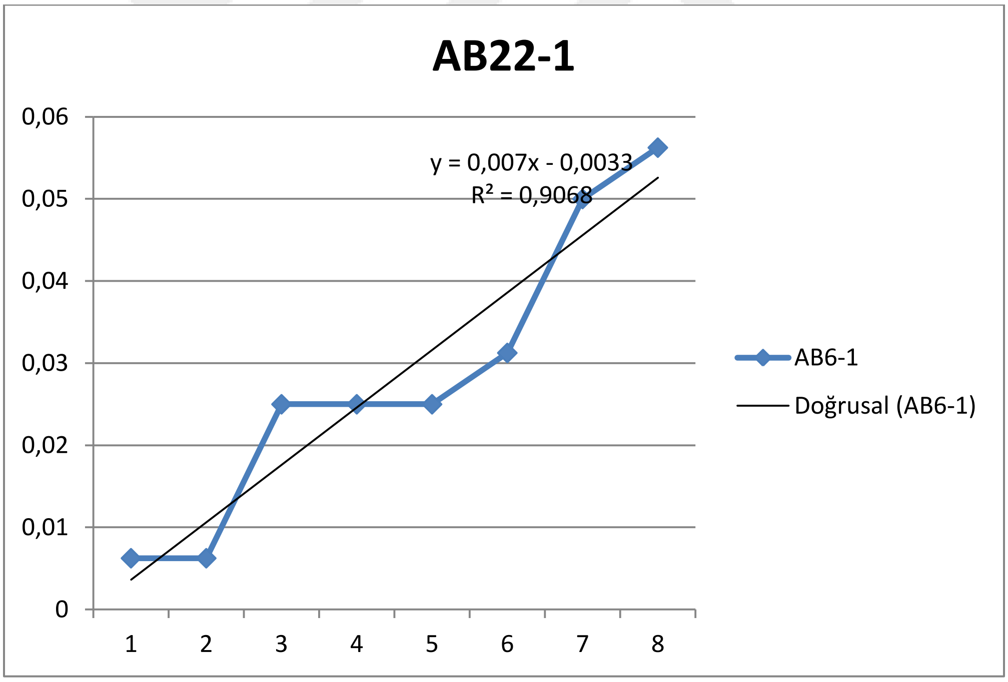

Figure B.17: Capillary Water Absorption-Time Graph in AB22-1 Acrylic Paint Additive Sample

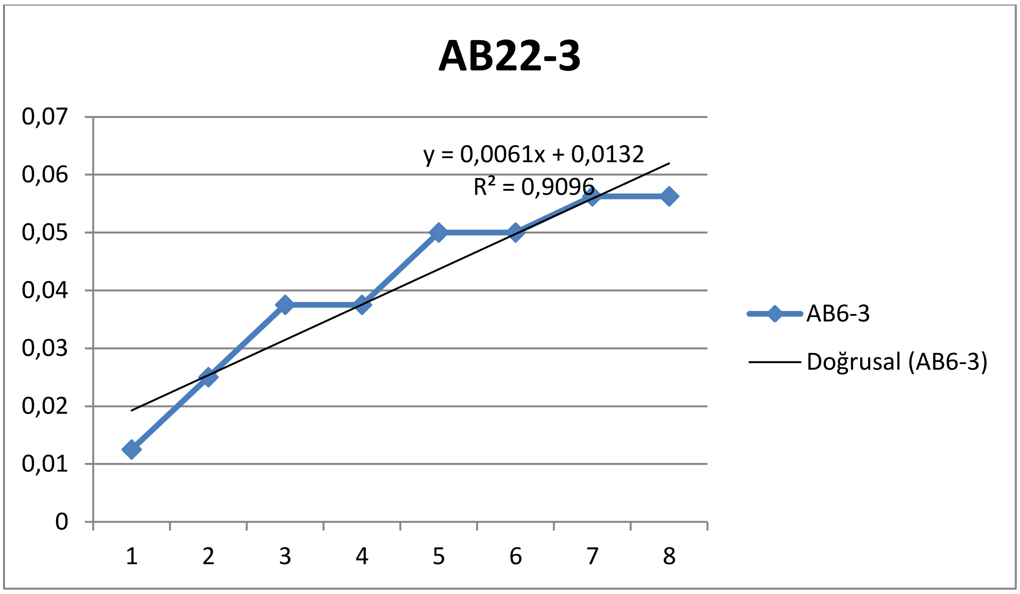

Figure B.18: Capillary Water Absorption-Time Graph in AB22-3 Acrylic Paint Additive Sample

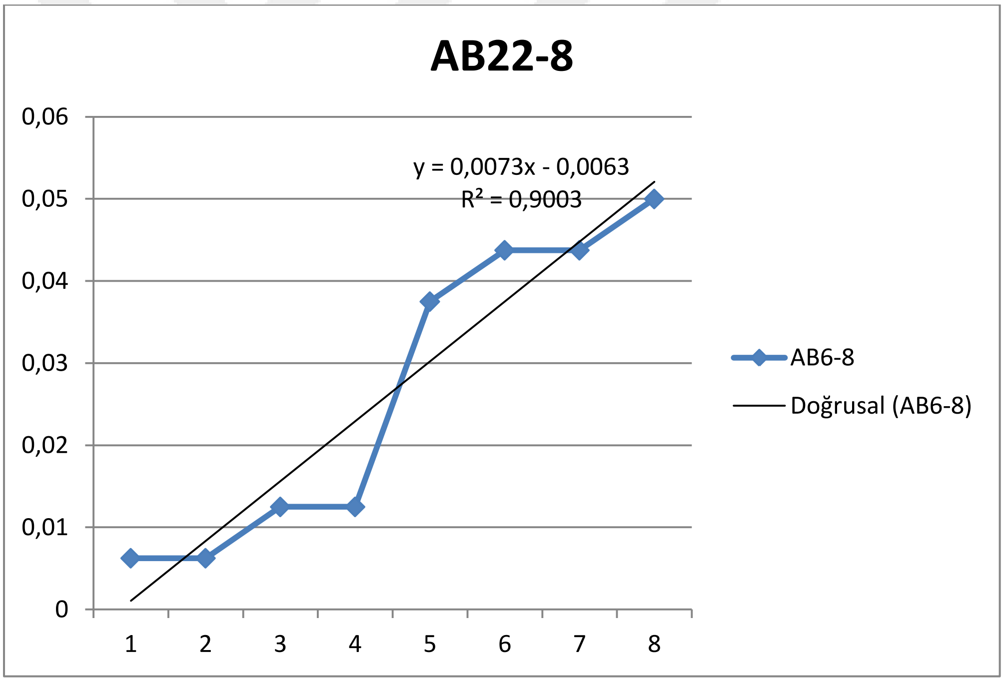

Figure B.19: Capillary Water Absorption-Time Graph in AB22-8 Acrylic Paint Additive Sample