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Use of Tefla as Partial Replacement of Cement in Concrete Mix

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Abstract

Abundant is tefla (Yellow Tefla, Green Tefla) in OmAlrozam, a town near the city of Derna, Libya. Cement is one of the components of concrete plays a great role in the construction industry. Higher consumption of cement in the construction industry leads to higher pollution. To make economic aspects in the construction industry and protecting the environment from pollution and also cement production emits CO_2 into the atmosphere which is harmful to nature. If we can partially replace the cement with the material with desirable properties then we can save natural material and reduce the emission of CO_2 into the atmosphere. This study aimed to investigate the suitability of using tefla in concrete. The tefla were ground to roughly cement fineness, which has been sieved and passing through 90 microns and after grinding, the chemical composition of the tefla material was determined using X-Ray Fluorescence (XRF). Four replacement levels,5%,10%,15% and 20% with a w/c ratio of 0.50. The workabilities of the fresh concrete mixes were evaluated using the slump test while compressive and splitting tensile strengths of hardened concrete were evaluated at different curing periods of 3, 7, 14 and 28 days, the workability of the concrete reduce with an increase in tefla powder content. Better result in mechanical properties (compressive strength and splitting tensile strength) and physical properties (water absorption and porosity) of the concrete was achieved at 5% cement replacement of yellow tefla, after which a decrease in strength with increasing tefla content was recorded. The use of yellow tefla of not more than 5% was recommended for concrete production.

Keywords: *Tefla, Compressive strength, Split tensile strength, Water absorption, Porosity.*

1. Introduction

Concrete is the most widely used material in the world. The concrete industry today is the largest consumer of natural resources, such as water, sand, gravel, and crushed rock, every year, there are huge demands of components of the raw materials for the production of ordinary Portland cement turning concrete into extensive exploring natural resources [1]. The manufacturing of Portland cement, which is the commonly used binder for modern concrete mixtures, also requires large amounts of natural materials. As one of the most energy intensive and polluting industries, the Portland cement industry has come under increased scrutiny from regulatory agencies and the public. Being the most important player in the infrastructure development and a major consumer of energy and natural resources, the concrete industry needs to be reoriented through the adoption of environmentally friendly and more sustainable technology [2]. However, environmental concerns are raised for the high carbon emission during the cement production, mainly from the calcination of raw materials ($CaCO_3 \rightarrow CaO + CO_2$) and the fuel and electricity consumption to generate high temperature for kilns.

The concrete technology researchers are continuously trying to improve concrete design to reach higher concrete strength and at the same time reduce the consumption of the resources by finding new alternatives. The proper mixes and proportion of cement may be important to obtain the standard quality of concrete. If we can partially replace the cement with natural material with desirable properties then we can reduce emission of CO_2 into the atmosphere and have a cleaner environment. A practical strategy to lower the environmental impact is to replace cement by locally available supplementary cementitious materials. Tefla is considered a more viable option mainly due to its abundance and wide availability.

1.1 Objective of the Study

► The use of natural material (Tefla) partially replace cement.

► Investigate the compressive and split strength when the cement partially replaced by tefla.

► To determine the physical properties of the concrete with partial replacement of cement by tefla and compare it with the normal concrete.

2. Materials and Methods

2.1 Materials

The ingredients of concrete consist of cement, coarse aggregate, fine aggregate and water. In this work tefla is used as a partial replacement for cement. The experimental program includes first the preliminary investigation on the materials used in the study, i.e., ingredients of concrete. The requirement which forms the basis of selection and proportioning of mix ingredients are:

2.1.1 Cement

The cement used is Ordinary Portland Cement (OPC) obtained from Alfataih Factory (Derna – Libya) complying with ASTM C150[3], Chemical and physical properties is given in Tab.1.

Table1 : Physical and chemical properties of cement.

Chemical	Composition %	Physical properties	
SIO_2	19.88	Fineness - Blaine (g/cm^2)	3600
AL_2O_3	5.37	Setting Time (minute)	
Fe_2O_3	2.86	Initial	118
CaO	63.09	Final	164
MgO	1.52	Specific weight	3.15
Na_2O	0.01	Compressive Strength (MPa)	
K_2O	0.95	3 days	23
SO_3	2.59	28 days	44

2.1.2 Tefla

The tefla used in this study was obtained from the eastern part of OmAlrozam, town near the city of Derna, Libya. The area of which tefla are abundant. Two types of tefla were use, Type 1 (Yellow Tefla) and type 2 (Green Tefla). The Tefla were placed in the los angeles machine to grind the sample and obtain the required smoothness. After grinding, tefla was sieved using 90 microns sieve size to determine its fineness. Tefla particles passing 90 microns sieve residue has been measured as 5.98%, used to replace portland cement to maintain the homogeneity between the tefla and cement in the concrete mixture. Sample of raw tefla type 1, tefla type 2 is shown in Fig.1. The chemical composition analysis with X-Ray Fluorescence (XRF) and Physical properties in tefla according to ASTM D4318[4] is given in Tab.2, its soil classification is unified soil classification system (USCS) according to ASTM D2487[5].

Figure 1: Sample of raw type 1 (left) and type 2 (right).

Table 2 : Chemical and physical properties of tefla.

Chemical	Composition %		Physical properties		
	Type 1 Yellow Tefla	Type 2 Green Tefla		Type 1 Yellow Tefla	Type 2 Green Tefla
SIO_2	4.942	50.263			
AL_2O_3	1.471	16.841	Specific Gravity	2.66	2.66
Fe_2O_3	2.467	5.760			
CaO	43.16	6.570	Liquid limit %	28.60	97.30
MgO	3.326	1.80			
Na_2O	0	0.280	Plastic Limit %	23.10	58.90
K_2O	0	0.847			
SO_3	3.163	0.657	Plasticity Index %	5.50	38.40
TiO_2	0.067	0.602			
Ca CO_3	77.028	10.280			
Mg CO_3	6.957	3.795			

2.1.3 Coarse Aggregate

Local coarse aggregate were used in this study, Fig.2 show the requirements for coarse aggregates according to ASTM C33[6]. Physical and mechanical is shown in Tabl3 [7-9].

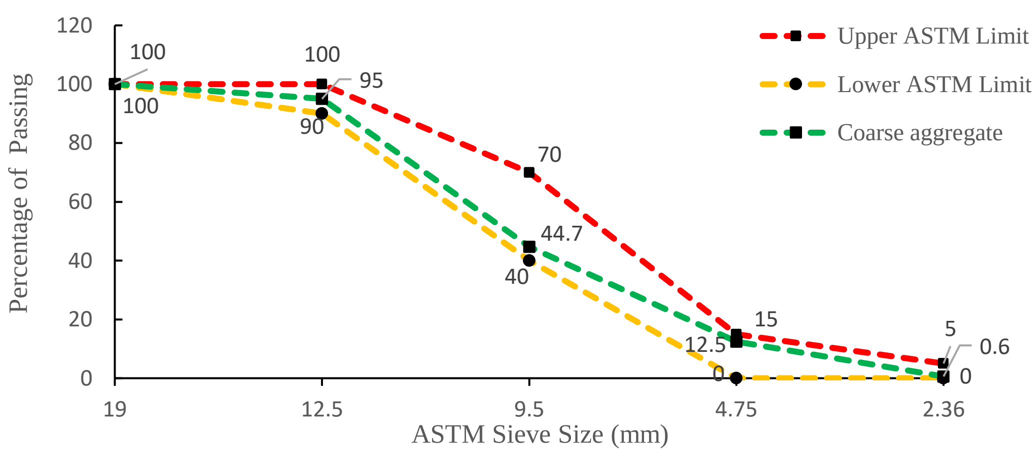

Figure 2 : Grading curve for the coarse aggregate according to ASTM C33 limits.

Table 3: Physical and mechanical tests of coarse aggregate.

PROPERTIES OF COARSE AGGREGATE	RESULT TEST
Aggregate impact value	18.66 %
Abrasion resistance of aggregate in los angeles machine	28.53%
Absorption	2.88 %
Moisture	0.30%
Specific gravity	2.60
Maximum size	12.50 mm

2.1.4 Fine Aggregate

Fine aggregate from local source was used, Fig.3 show the requirements for fine aggregates according to ASTM C33[6]. The basic physical tests were conducted and given in Tab.4[10, 11].

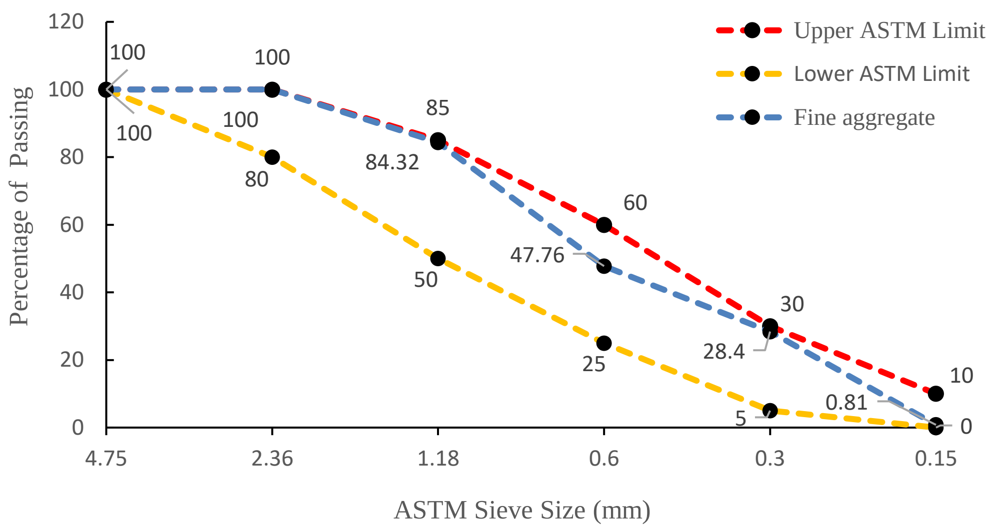

Figure 3 : Grading curve for the fine aggregate according to ASTM C33 limits.

Table 4: Physical test of fine aggregate.

PROPERTIES OF FINE AGGREGATE	RESULT TEST
Specific gravity	2.57
Fineness modulus	2.40
Absorption	2.28 %
Moisture	0. 31%

2.1.5 Water

Drinking water was used for mixing and curing all concrete samples in accordance with ASTM C1602 standard[12]. Mixing water is free from impurities that could adversely affect the process of hydration and, consequently, the properties of concrete[13].

2.1 Methods

Mix design was performed by using American method of selection of mix with W/C ratio of 0.50[14]. The replacement levels of cement by tefla were used in terms of 5%, 10%,15%, and 20% in concrete at the age of 3, 7, 14 and 28 days. Proportioning of concrete mixtures is shown in Tab.5. The effects of replacing percentage of cement with tefla on the physical and mechanical properties of concrete wase studied. The yellow tefla mixtures were denoted as Y (for yellow), the green tefla mixtures as G (for Green). The number at the end represents the amount of replacement by cement weight. All concrete specimen were obtained with fair casting, the cubes were covered with plastic 24 hours at room temperature. After 24 hours, they were demolded with care so that no edges were broken and were placed in the curing tank.

Table 5 : Mix proportions of the concrete mixtures per cubic meter.

Materials	Weight (Kg / m³) for each % of tefla powder								
	CC 0%	CY 5%	CY 10%	CY 15%	CY 20%	CG 5%	CG 10%	CG 15%	CG 20%
Cement	432	410.4	388.8	367.2	345.6	410.4	388.8	367.2	345.6
Yellow Tefla	0	21.6	43.2	64.8	86.4	0	0	0	0
Green Tefla	0	0	0	0	0	21.6	43.2	64.8	86.4
Water content	216	216	216	216	216	216	216	216	216
Fine aggregate	655.25	653.9	652.6	651.3	649.9	653.9	652.59	651.3	649.9
Coarse aggregate	953.9	951.9	950.1	948.1	946.2	951.9	950.1	948.1	946.2

3. Results and Discussion

Workability

The results of slump according to ASTM C143[15] of all concrete mixes is shown in Fig.4. As Fig.4 shown, the slump value decreases as the replacement of cement by tefla increases, and thus the workability of the concrete mix decreased with increasing the tefla percentage in the mix. Further decrease in slump since type 2 (green tefla) has higher water absorption than type 1 (yellow tefla), resulting in a lower slump, this negative effect of green tefla exhibited on the workability of concrete, where at the replacement rate of 20%, the concrete was not mixed due to the higher water absorption in green tefla. In general, the workability reduction caused by addition of tefla in concrete mix.

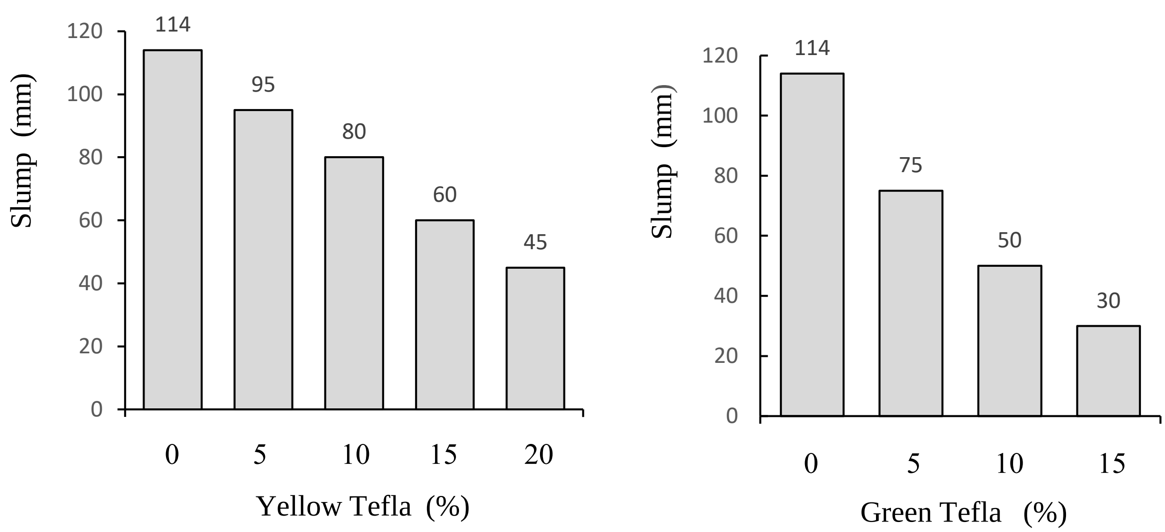

Figure 4 : Slump of concrete mixtures.

Compressive Strength Test

The study was conducted based on 3, 7,14 and 28 days of curing time for the different concrete in order to establish their compressive strength development. This test is performed in accordance to ASTM C39[16], 100 × 100 × 100 mm specimens were tested. The influence of yellow tefla addition on compressive strength of concrete mixes at different ages of curing is shown in Fig.5. An increase in compressive strength for early ages of yellow tefla concrete is obtained with the addition of 5% at 3 and 7 days of curing, while on the 28th day, the strength is approximately the same for mixes (CC 0% - CY 5%) This means that up to 5% of cement can be replaced by yellow tefla as an addictive material in the production of concrete, without adverse effect on the compressive strength of the concrete.

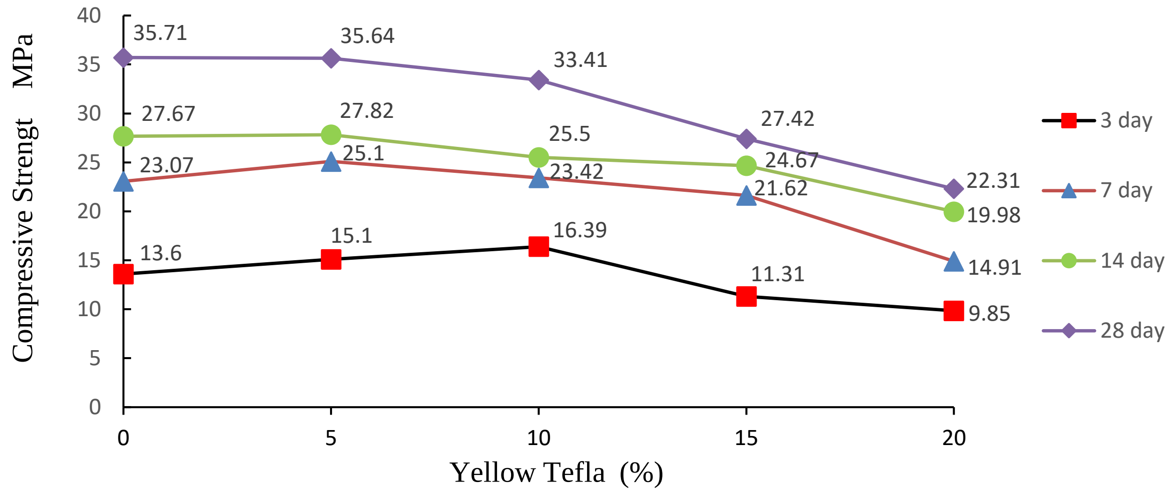

Figure 5 : Effect of yellow tefla on the concrete compressive strength.

As for the effect of the use of green tefla as partial replacement of cement in concrete mix, the green tefla has a negative effect on compressive strength for early and late ages, reduction in compressive strength increases with increasing green tefla content in concrete as shown in the Fig.6.

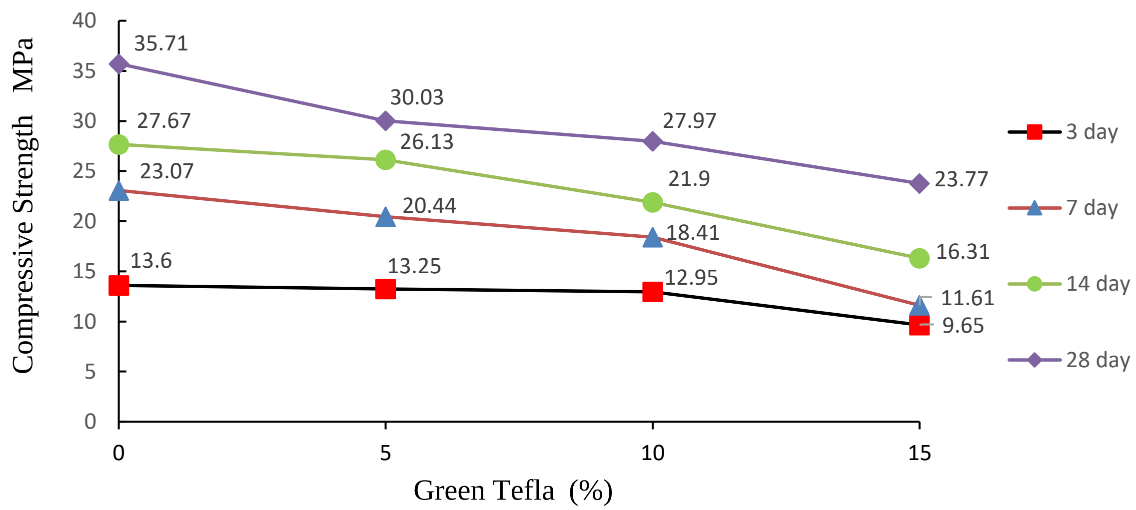

Figure 6 : Effect of green tefla on the concrete compressive strength.

Splitting Tensile Strength

According to ASTM C 496[17] the splitting tensile strength was done on 100 × 200 mm control and partially replaced cement concrete cylinders. The test results are shown in Fig.7. A noticeable growth in split tensile strength of concrete at early ages of curing (3 and 7 days) is observed with the addition of 5% yellow tefla compared to control concrete. concrete samples with the addition of 10,15 and 20% show a decrease in split tensile strength. This reduction in split tensile strength increases with increasing yellow tefla content in concrete.

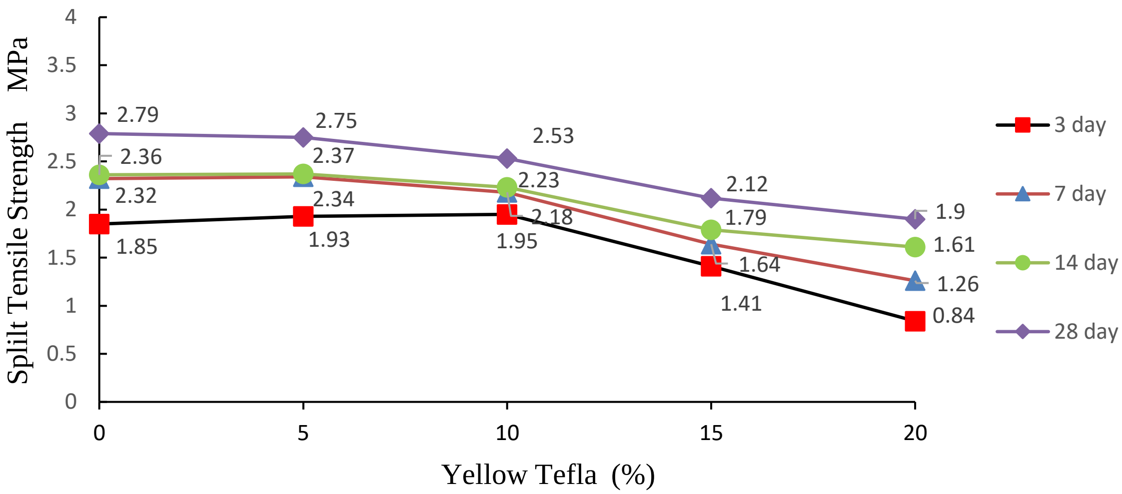

Figure 7 : Effect of yellow tefla on the concrete split tensile strength.

A green tefla replacement at 5,10 and 15% leads to a reduction in tensile strength at different ages of curing compared to control concrete as shown in the Fig.8.

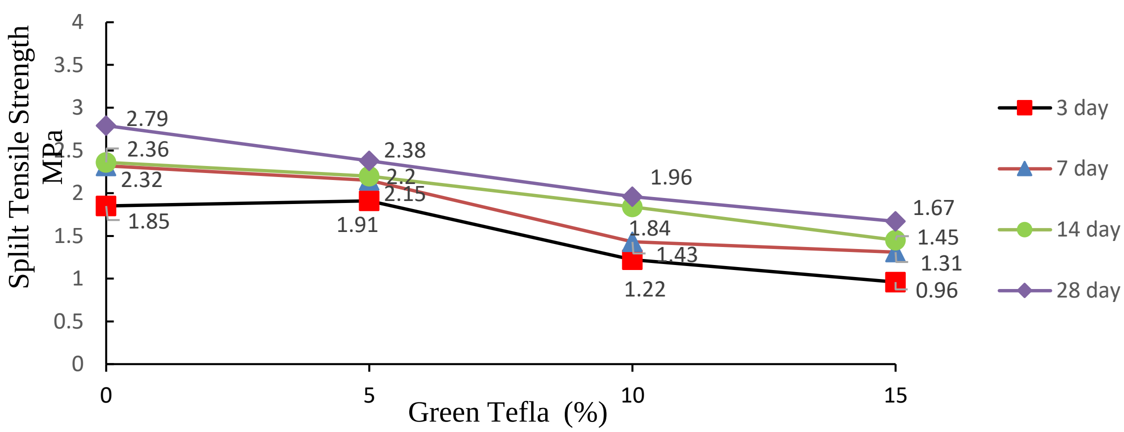

Figure 8 : Effect of green tefla on the concrete split tensile strength.

Water Absorption and Porosity of concrete

The water absorption and total porosity were evaluated according to ASTM C 642[18], 100 × 200 mm cylinders specimens were tested. The water absorption and total porosity of effect use of tefla as partial replacement of cement in concrete mix at 28 days are presented in Fig.9.The concrete control (CC) displayed the lowest water absorption 8.08% and porosity of 13.87% as compared to other mixes. It shows that the porosity affects the water absorption. When the porosity decreased, the water absorbed also decreased. The porosity of concrete, is an important characteristic, which determines to a large extent their mechanical properties. High porosity is strongly detrimental to the strength of a concrete.

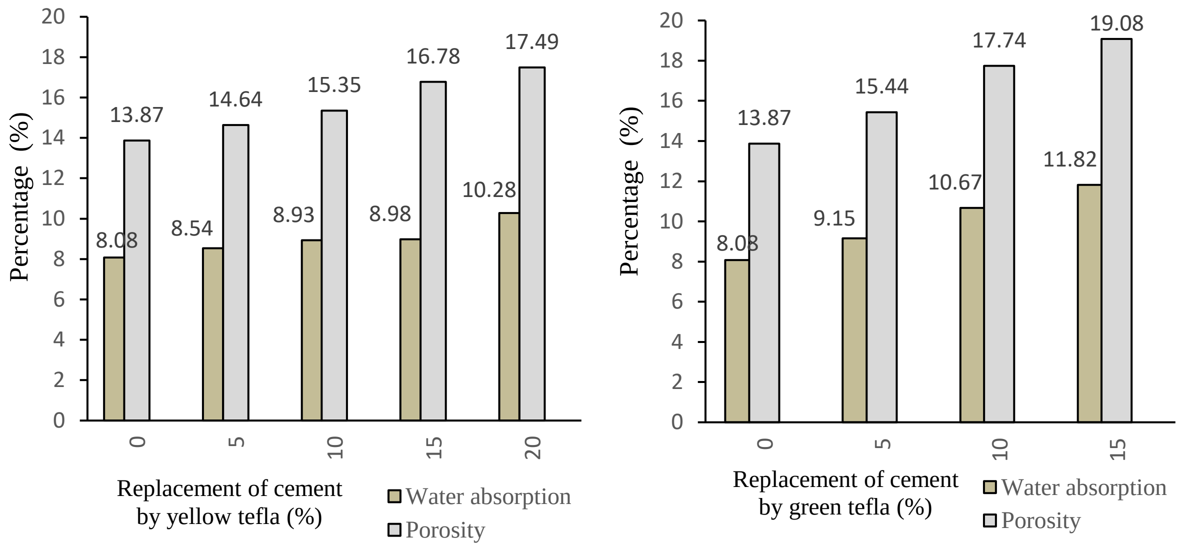

Figure 9 : Water absorption and porosity with tefla in concrete mix

Water Permeability Test

In this investigation, the water penetration depth of concrete samples is measured in accordance with BS EN 12390-8[19]. A set of three cubes of 150 x 150 x 150 mm size were tested for each mix. The water penetration depth of different mixes at 28 days are presented in Fig.10. The results given in this paper are maximum depth of penetration obtained from three specimens per mix, expressed in mm. As Fig.9 shown, Porosity and water absorptions are indication of pores or voids in concrete through which water permeates. Therefore, increase in these parameters results in corresponding increase in water permeability[20].

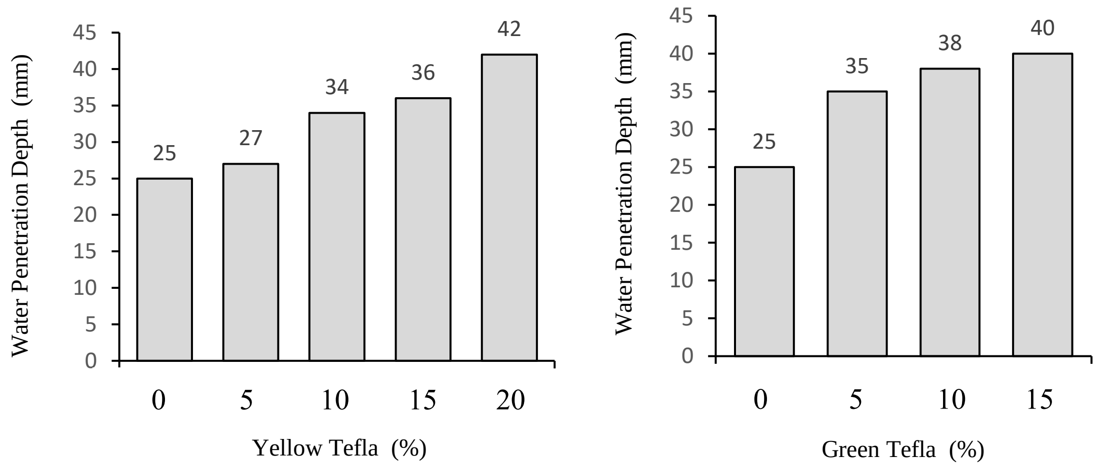

Figure 10 : Water penetration depth of concrete mixes.

Conclusions

Based on the experimental results, the following conclusions can be deduced:

- A decrease was verified in the slump of the freshly prepared concrete as the percentage of tefla replacement of cement increases as compared to control mix.
- Better result in compressive strength and split tensile strength when cement is replaced with yellow tefla at 5% ‹The concrete compressive strength and split tensile strength decreased as the percentage of tefla powder increased.
- The optimum replacement at 5% with yellow tefla content was efficient regard water absorption and porosity as compared to control mix.
- Porosity and water absorptions are indication of pores or voids in concrete, rises in porosity and water absorption in concrete with yellow tefla result in a corresponding increased water penetration depth.
- It is also concluded that green tefla effects the mechanical properties as wells as physical properties of concrete in a harmful manner as seen in results.
- Based on the investigation the use of yellow tefla as partial replacement of cement in concrete mix, is at optimum replacement level of 5%.

Acknowledgment

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References

[1] R. Mehta, "Concrete technology for sustainable development-an overview of essential principles," 1998.

[2] Karen L. Scrivener, "Options for the future of cement," vol. 88, no. 7, pp. 11-21, 2014.

[3] ASTM C150-17 "Standard specification for Portland cement," West Conshohocken, PA, USA., (2017).

[4] ASTM D4318-98 "Standard test methods for liquid limit ,plastic limit ,and plasticity index of of soils " International, West Conshohocken.

[5] ASTM D2487-98 "Standard practice for classification of soils for engineering purposes (Unifled Soil Classification System)," International, West Conshohocken.

[6] ASTM C33-16 "Standard Specification for Concrete Aggregates," International, West Conshohocken.

[7] ASTM C127-15 "Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate," International, West Conshohocken.

[8] ASTM C131-14 "Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine,".

[9] ASTM C29-17 "Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate," International, West Conshohocken.

[10] ASTM C70 "Standard Test Method for Surface Moisture in Fine Aggregate," International, West Conshohocken.

[11] ASTM C128-15 "Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate," International, West Conshohocken.

[12] ASTM C1602-12 "Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete," International, West Conshohocken.

[13] A. M. Neville, "Properties of concrete. Longman London,," 1995.

[14] ACI 211.1-91 ""Standard practice for selecting proportions for normal, heavyweight and mass concrete," ", American Concrete Institute, Famington Hills, Mich, USA.

[15] ASTM C143-15 "Standard Test Method for Slump of Hydraulic-Cement Concrete," International, West Conshohocken.

[16] ASTM C39-12 "Standard test method for compressive strength of cylindrical concrete specimens," ed, 2012.

[17] ASTM C496-11 "Standard test method for splitting tensile strength of cylindrical concrete specimens," ed, 2011.

[18] ASTM C642-13 West Conshohocken, "Standard test method for density, absorption, and voids in hardened concrete," 2013.

[19] BS EN 12390-8 "Testing hardened concrete, Part 8: depth of penetration of water under pressure," ed: AENOR Spain, 2009.

[20] Valenta. O. "“The Permeability of Concrete in Aggressive Condition,”in Proceedings of the 10th International Congress on Large," pp. 103–117.