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Sugar beet fiber and Tragacanth gum effects on concrete

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ABSTRACT

As natural concrete supplements, waste materials obtained from food industry plants can substitute synthetic supplements in concrete to help protect the environment. This is an experimental study for examining the effects of Tragacanth gum and sugar beet fiber additives on concrete behavior. Tragacanth gum and sugar beet fiber have numerous applications in industry. Concrete specimens were prepared at six different mixing ratios of additives and subsequently tested. Tensile and compressive strengths, modulus of elasticity, slump, air voids volume and failure modes of the concrete specimens were measured to determine the changes the concrete had undergone due to the addition of sugar beet fiber and Tragacanth gum. Compressive strengths of the samples were between 32 and 37 MPa while the obtained tensile strength is between 3.43 and 3.66 MPa. The results indicated that concrete slump in the specimens exhibited considerable flowability, as in the case of self-compacting concrete. Moreover, increasing the test parameters decreased compressive strength and increased the number of air voids in the concrete. Adding a combination of Tragacanth gum and sugar beet fiber increased air voids and flowability in the concrete. Finally, given the increased concrete slump and concrete setting time, a numerical model was presented using the obtained laboratory results for examining slump variations after mixing the concrete.

1. Introduction

Sugar beet fiber (SBF) forms part of sugar plants waste. Costs of extracting the residual sugar in SBF are far greater than those of producing artificial sugar (ICDF, 2009). For this reason, SBF is discarded as waste from sugar plants (Bicer and Yilmaz, 2013). As a natural resin, Tragacanth gum has many applications. In spite of its low durability, this resin is used as a supplement in different materials (Ismail and Al-Hashmi, 2011). Today, waste recovery and reusing industrial waste is on the increase (Levanen, 2015; Murakami et al., 2015). Numerous studies have been conducted to determine the effects of adding natural substances as supplements to concrete and cement for improving the behavior of the same (Mutuk and Mesci, 2014; Pangdaeng et al., 2014; Cordeiro et al., 2012). The effect of these materials on concrete behavior before hardening (i.e., after setting) including slump, compressive strength, and resistance against sulfates attack as well as atmospheric factors was studied (Huang and Shen, 2011; Huang et al., 2010).

Cement is one of the major materials in construction. Cement production is increasing in the world. Such increase is particularly seen in India, China, and the Middle East (International Energy Agency World Business Council for Sustainable Development, 2009). CO_2 generation and energy consumption for producing cement are of the major environmental issues. New material may be used as a cement additive. As a supplement, the additives reduce some part of the consuming cement and consequently reduce cement production and environmental problems (Amrina and Vilsi, 2015; Bignozzi, 2001). Tragacanth gum and Sugar beet processing industry have high energy base which are used in different sciences like food engineering, pharmacology and chemistry industry (Krzysztof and Robert, 2014; Hwang et al., 2009). These waste materials have sugar, fiber, oil and minerals etc. So, water activity and chemical reactions of Tragacanth gum and Sugar beet in a developed format with different percentages were investigated. Many researches have investigated the natural fibers effects on the concrete's behavior,

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durability, flexural and compressive strength (Rodrigues et al., 2006; Balaguru, 1994; Castro and Naaman, 1981). Also, most of fibers are reducing plastic shrinkage cracking (Boghossian and Wegner, 2008; Sivakumar and Santhanam, 2007; Banthia and Gupta, 2006). The natural fiber can increase impact resistance of concrete (Silva et al., 2009; Robert, 2005). Tragacanth gum and Sugar beet contained the combinations of fibers, protein and sugar. So, the effects of fiber and sugar in concrete mixes were investigated.

Ash of the bagasse is resulted as a byproduct of sugar and alcohol factories, which is usually combined with silica to produce a kind of pozzolanic material. Many researches have shown that, this combination could be a good replacement instead of pure Portland cement to produce composite concrete (Cordeiro et al., 2008; Negro et al., 2006; Khayat, 1998). In many countries, adding of bagasse as a byproduct, to concrete was tested and developed. Some of these researches were about using of bagasse in its ash form (Ganesan et al., 2007; Aggarwal, 1995). Using sugar as an additive caused the increment of initial setting time in concretes (Bahurudeen et al., 2015; Li et al., 2014; Cordeiro et al., 2009). Indeed, water soluble fibers affected the increasing of concrete's hardening time (Monreal et al., 2011; Aggarwal and Singh, 1990).

Furthermore, some plasticizers and natural fibers could scale down the concrete compressive strength, by the various amounts of addition. Many other fiber materials such as, wheat straw, rise husk ash, coconut coir and bamboo were tested in different studies (Heber et al., 2014; Sata et al., 2012; Negro et al., 2006). In these studies, admixture materials were added to the mortar in different percentages. The internal air, resistance to sulfate attack and affected on the other mechanical characteristics of concrete (Mahoutian et al., 2015; Jin et al., 2013; Zhang and Ansari, 2006).

Many studies investigated the effects of mineral admixtures to improve concrete resistance subjected under sulfate attack. Some of these materials have reduced the level of damage and sheet washing in exposure of sulfate attack. Most of these researches were based on laboratorial tests with investigating the external sulfate attack (Sotiriadis et al., 2012; Brown and Hooton, 2002).

Results of the previous studies showed the advantages of adding natural fiber contain sugar and gums to the concrete. So, the effects of sugar beet fiber and Tragacanth gum were investigated.

2. Materials and methods

Constituents of concrete mixes such as micro silica, Tragacanth gum, sugar beet, water and crushed stone were collected from local materials (Table 1).

Sugar beet slag is the whole thing which remains after sucrose extraction. Dry matter of sugar beet fiber (SBF) is containing ash, fiber, sugar, protein and etc. (Table 2). In an industrial pectin extraction a pH between 1–1.5 and 80–90 °C heating is applied, and pectin can be released from the plant tissue in less temperatures and moderate pH solution. So, it can improve the concrete resistance in exposer to sulfate attack.

Table 1
Specifications of the materials used in the prepared concrete mix.

Materials name	Materials type	Qualifications
Aggregate	Gravel (crashed stone)	Dried Bulk: 1650 kg/m^3
	Stone powder	Alabaster powder
Water	Normal	PH: 7
Cement	Type 1	Setting time: 135 min, compressive strength: 325 kg/cm^2
Additives	Plasticizer	Sugar beet fiber
	Fiber	Tragacanth gum

Table 2
The materials analysis is related to the dried sugar beet used in the tests.

Material	Percent	Material	Percent
Dry matter	25%	Ash	8%
Protein	7%	Sugar	51%
Oil	1%	Calcium	0.5%
Fiber	7%	Magnesium	0.5%

Table 3
The percentage of materials is related to the Tragacanth gum used in the tests.

Material	Percent	Material	Percent
Pectinous	60%	Cellulose	6%
Soluble gum	10%	Water	20%
Mineral	3%	Lignin	1%

The chemical composition of Tragacanth has not been clearly investigated. But, the chemical analyses were showing the acid formation for Tragacanth in the wastewater (Table 3). Polysaccharides are obtained from the sap of Tragacanth, drained from the root of the plant. Gum Tragacanth can be considered as a heterogeneous, hydrophilic and highly branched polysaccharide. The main sugar component of Tracagacanthin is L-arabinose that can form a highly branched chain to grape water phase.

Tragacanth gum solutions are fairly stable over a wide range of pH down to extremely acidic conditions near to pH = 2. Unlike many other natural gums, Tragacanth has a very long shelf-life without loss of viscosity. The molecular weight of the average gum is approximately 840,000 Da and forming a molecular shape of elongated needle polymer (Fig. 1).

Pectin and Tragacanth gum have the synergistic effect on gelling power of each other. So, it is expected that the combination of these two extracts increase the intensity of the objectives, such as water holding capacity, durability and sheet washing protection. The needle-looking shape of Tragacanth gum particles led to increased water retaining properties, surface brilliance, and increased volume through producing micro air voids in the concrete laitance.

2.1. Concrete mixes

Concrete mixes were categorized in six groups (Table 4). These mixes have equilibrium volume of sand and gravel in the percentage. Water/cement ratio was constant in these mixes to make the additive materials to be the test parameters. The added

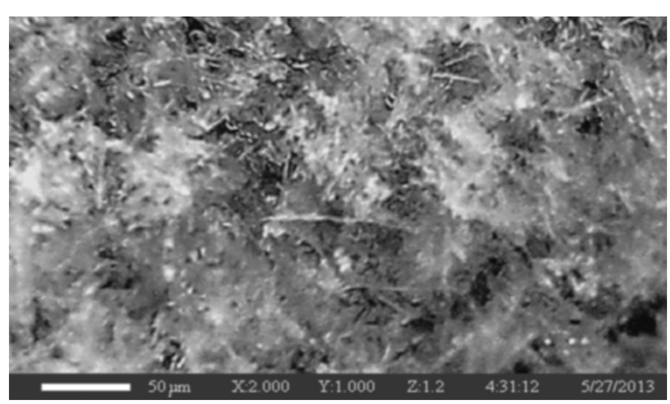

Fig. 1. Tragacanth gum particles have a needle-shaped structure.

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