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In Vitro Evaluation of the Effect of SP200 Lubricant on Compressive Strength of Lightweight Concrete with Leca Aggregate and Powdered Silica

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ABSTRACT

In today's advanced world and due to advances in various scientific fields of the concrete, industry has also evolved, and light concrete production is a result of these advances. It has had its advantages, many efforts have been made in the past to improve the quality and efficiency of concrete, and today the use of additives helps us to achieve this goal. The additive in this study is lubricant based on polycarboxylate brand SP200 and Powdered silica. The use of silica is also widely used in advanced countries due to its pozzolanic properties. In this study of 20 mixing designs, 2 of which were used as control sample and 18 with SP200 super-lubricant and micro silica powder, the results show that in the first mixing design with 0.49 water/cement ratio the highest compressive strength of The 7 and 28 days is related to M / 35/5 sample which has 0.35% super-lubricant and 5% micro silica powder And in the second mixing scheme with water/cement ratio of 0.55, the highest compressive strength is related to the sample of M /35/10 It contains 0.35% super-lubricant and 10% Powdered silica. The use of silica and super-lubricant in the manufacture of lightweight concrete has increased the compressive strength of lightweight concrete in some of the samples.

Keywords: **Structural Lightweight Concrete, Leca Industrial shell, Powdered silica, Super lubricant**

1. INTRODUCTION

In today's advanced world, and with the advances made in various scientific fields of the concrete industry, light concrete production is also a result of these developments. One of the major disadvantages of concrete buildings is the high weight of the building, which is directly related to the amount of damage caused by earthquakes. Due to the large part of the country being placed in the seismic belt, special attention should be given to lightweight structures. The dead load caused by the weight of ceilings and segregation walls is a major problem in seismic design and structures, especially in high-rise buildings. Obviously, the use of lightweight materials can reduce dead load, beam weight, columns and base weight [1]. Lightweight concrete can be used in a variety of areas, such as repairing wooden floors of old buildings, constructing low heat transfer walls, bridge decks,and floating docks [2]. Weight loss with lightweight concrete is preferred, especially for structures built in seismic areas. Lightweight concrete is made of natural or synthetic materials. Depending on its strength and density, it is divided into three categories. The first batch is non-structural lightweight concrete, and the second batch is medium-lightweight concrete, the third batch is Structural-lightweight concrete, the first batch is of low density and is mostly used for insulation purposes. The second batch is of medium strength and used for filling and blocking. The third class of lightweight concrete is used for reinforced concrete [3]. The use of lightweight concrete is preferable because the dead load of concrete buildings is high. Lightweight concrete reduces building weight statically, reduces earthquake loads, minimizes load structure size, and contributes to more economical solutions to foundation problems [4]. Unlike conventional concrete weights, the density of lightweight concrete is usually less than 2000 kg / m3, and its thermal conductivity is below 1.0 W / m ℃. Therefore, lightweight concrete can be used instead of regular-weight concrete, especially where lighter and more energy-intensive concrete is needed. Since the mid-twentieth century, the Roman Empire has used lightweight concrete. Since the production of lightweight synthetic materials, they have been widely used in bridges and buildings [5]. Low-density lightweight concrete ensures constant load reduction and use of lightweight concrete with better thermal insulation properties, helping to save energy and environmentally sustainable buildings [6]. The main advantage that lightweight concrete gives to the engineer is weight loss, and it is possible to obtain lightweight concrete with a compressive strength similar to that of ordinary weight concrete [7]. The design of the lightweight concrete mix used for structural purposes is much more complex because it depends on the type of lightweight aggregate used, the use of a local product for a particular job depends on its specific characteristics and requirements. Structural lightweight concrete has its own properties [8]. Molded leca aggregates are largely a wall marker in new and high strength concrete made from water-based coatings, which produce remarkable results. Additives or substitutes for aggregates and cement are used to achieve specific properties, such as better compaction, high strength, less CO2 in mixing ductility and so. A considerable range of such compounds has been recognized and accepted in practice and today, many other types have been explored abroad [9]. Silica (or silica fume) is one of the by-products of silicon or metal silicon alloy factories. Iran also produces large quantities of silica. Although the material silica has industrial applications and due to the presence of active pozzolans, high pozzolanic properties and very fine particles have become a valuable by-product, these particles are approximately 100 times smaller than cement particles [10]. In the paper, Nanjisil et al. Investigated the effect of nano-silica on the mechanical properties of lightweight concrete by adding 1 and 2% mechanical properties of lightweight concrete. With 1% nano-silica, light concrete strength increased resistance to water and chloride ion penetration, water penetration depth. Moisture absorption, chloride migration coefficient and diffusion coefficient decreased [11]. In the paper, Yasar et al. Provide part of the results of an experimental study to design a lightweight concrete structure made with and without triple mixtures of cement, fly ash and silica fume. In this study, Scoria was used as a lightweight aggregate. One non-additive sample and the other one with 20% fly ash and 10% silica soot were used as cement substitutes. 28-day compressive strength and dry air unit weight varied from 28 to 37 MPa and 1800 to 1860 kg / m^3. However, the use of mineral additives for the production of lightweight concrete with a strength of 35 MPa and higher seems to be required [12]. Shanag explores the properties of lightweight concrete containing mineral additives in the study of properties of fresh and hardened concrete containing local lightweight natural aggregates with mineral replacement in cement, with 5 to 15% silica smoke by weight, respectively. Pressure and modulus of elasticity increased by 57% and 14% compared to silica-free mixtures. But adding up to 10% ash, as a substitute for cement in the same mixtures, reduced by about 18% the compressive strength and no change in the elastic modulus, as compared to non-fly ash mixtures. Adding 10% or more silica smoke, and 5% or more fly ash to the lightweight concrete mix works best [13]. Sajedi and Shafiq in "High-Strength Lightweight Concrete Using Leca, Silica and Limestone Soil" Ratios of Lightweight Concrete Mixed Properties Using Leca, which Reduces Concrete Weight by Using Mineral and Chemical Additives Along with limestone has been used that reduces porosity and increases resistance. Specific gravity tests and tensile, indirect tensile and flexural strength tests were performed on the specimens. The results showed that using Leca, light density concrete with dry density in the range of 1965 to 1610 kg / m3, and compressive strength in the range of 34-67 MPa can be obtained [14]. Szegol et al., In the study of the effect of expanded perlite on the mechanical properties and thermal conductivity of lightweight concrete, provided further information on the effects of perlite on the mechanical properties and thermal conductivity of concrete. Compressive strength, modulus of elasticity, water absorption, and capillary coefficient of the mixtures were determined. The thermal conductivity of the samples also showed that the results showed that with increasing perlite content, the compressive strength and modulus of elasticity decreased. Consideration is given to the strong relationship between thermal conductivity and unit weight [15]. Wang et al., In the "Impact of Nano SiO2 on Strength, Shrinkage and Cracking Sensitivity of Lightweight Concrete" investigates the effect of nano SiO2 on compressive strength, shrinkage and sensitivity to early cracking of lightweight. In this study, different doses of nano SiO2 (1%, 2%, 3%) in lightweight were compared with the control sample. The results showed that the incorporation of 3% nano-SiO2 increases the compressive strength. The level of total cracking decreased with increasing doses of nanocrystalline SiO2 from 1% to 3% by the total mass of binders at an early age [16]. Qasimzadeh Mousavi Nejad and Shamshad Sera in the study "Experimental study of the effect of silica fume and synthetic fiber on the mechanical properties of lightweight concrete" investigated these additives on the mechanical properties of lightweight concrete. Silica fume with 10 and 15% cement replacement and steel and polypropylene fiber values in this study (0.4-0.8) and (0.2%) concrete volume, compressive strength, tensile strength split, flexural strength, elastic modulus, adsorption Water and density were also tested. The results show that the optimum SF value is 10%. Also, steel fiber has a better effect on the mechanical properties of lightweight concrete compared to polypropylene fibers [17]. Khaled et al. Evaluated the use of cane fiber waste in their research on the properties of sugarcane in conventional and lightweight concrete. Three percent (0.5%, 1%, 1.5%) of sugar cane fiber was added to the concrete and compressive and tensile strength were tested on days 7 and 28. The results showed. It does not have a significant effect on compressive strength, but it increases the tensile strength of ordinary concrete and lightweight concrete, but in lightweight concrete provided that the use of cane fiber does not exceed 5% of the concrete mixture. The tensile strength of concrete increases with increasing sugar content, especially for ordinary concrete, but increasing the sugar content in lightweight concrete decreases the tensile strength of lightweight concrete [18].

2. MATERIALS AND METHODS

After selecting the type of material, we determine the optimal ratio for the mixing design. In this research, two additive mixing schemes with two different water to cement ratios (0.49 and 0.55) based on the results of previous experiments and two identical ratios of industrial sand and shell Leca (sand = 27 kg and shell = 13/5 kg) was used as a control sample. Then, from each control design, 9 mixing schemes with different percentages of lubricant in the amount of 0.25%, 0.30% and 0.35% by weight of cement and silica powder with 5%, 10%, 15% by weight of cement Mixing scheme added. The design was reduced by adding cement to the powder. For mixing lightweight concrete, first mix dry material including shell, cement, sand and micro-silica for 1 minute and then add water with lubricant gradually for 2 to 4 minutes until the contents of the mixer are thoroughly mixed. See details of mixing schemes in Tables 1 and 2.

2.1. MATERIALS USED

2.1.1. CEMENT

The cement industry contributes about 5% to global anthropology, making CO2 emission reduction strategies an important part of the cement industry.CO_2 is emitted by the calcination process of limestone through combustion in the furnace [19]. Portland cement is divided into five types. In this study, the portland cement type II Sepehr Firoozabad factory was used.

2.1.2. MICROSILICA

Silica soot, also known as micro-silica, is amorphous (non-crystalline). Silica smoke is a material with spherical particles. Micro-silica in concrete contributes to strength and durability in two ways: as a pozzolanic material and a larger volume of micro-silica hydration products provides more uniform distribution. The efficacy of micro-silica as a pozzolanic material and as a filler largely depends on the composition and size of its particles, which in turn depends on the design of the furnace and the composition of the raw materials with it [20]. Amorphous silica is useful as a filler and denser concrete production. The advantages of adding silica can be the production of high strength concrete, corrosion resistance, low permeability, durability and less interaction between alkali cement and aggregates. The amount of micro-silica instead of cement provides about 10 to 15 percent higher quality and strength replacement [21]. The mineral additive used in this study is a by-product of electric arc furnaces during the production of Frosilis alloys.

2.1.3. SUPER-LUBRICANT

Different chemicals are used to enhance the properties of concrete; one of the most important additives in concrete is called water reducer. It is essentially a cement dispersing chemical that neutralizes cement grains so that the cement paste becomes more fluid. Water-reducing materials allow lower amounts of water in concrete without damaging performance or capability, resulting in greater strength and durability [22]. In this study, the lubricant is based on polycarboxylate ether brand SP200. And the manufacturer of this super lubricant is Sivan Sazan Company.

2.1.4. LECA STRUCTURAL LIGHTWEIGHT

Expandable aggregates are formed with lightweight. The ability of clay and clay specific to it was first discovered in 1908 by British brickmaker Stephen Hayde, and showed the potential for the use of expanded clay as a lightweight material. Leca has been used in structural concrete worldwide for many years [23]. It is produced by the expansion of a type of clay and swells inside the mass due to the performance of gases created at temperatures of 1000 to 1200 ° C [24]. In this study, the grain size of this industrial shell is from 0 to 12. The water absorption rate is 18%, and the specific gravity is between 0.6 and 0.7.

2.1.5. SAND

Smaller sandstone than sand is said to be commonly found on the coast and in the river. The sand used in this study is Khorram Dareh Kavir mine with a specific gravity of 2590 kg / m3 and water absorption of 0.04% and moisture content of 0.5%.

Table1. Amount of consumables for initial mix design with water to cement ratio of 0.49 **Province**

Water to cementitious materials	Silica (kg/m3)	Cement (kg/m3)	Water (kg/m3)	Sand (kg/m3)	Poke (kg/m3)	Silica %Cement	Super lubricant %Cement	Design Name	Number
0/49	0	350	171	771	385	0	0	Witness	1
0/49	17/5	332/5	171	771	385	5	0/35	M/35/5	2
0/49	35	315	171	771	385	10	0/35	M/35/10	3
0/49	52/5	297/5	171	771	385	15	0/35	M/35/15	4
0/49	17/5	332/5	171	771	385	5	0/30	M/30/5	5
0/49	35	315	171	771	385	10	0/30	M/30/10	6
0/49	52/5	297/5	171	771	385	15	0/30	M/30/15	7
0/49	17/5	332/5	171	771	385	5	0/25	M/25/5	8
0/49	35	315	171	771	385	10	0/25	M/25/10	9
0/49	52/5	297/5	171	771	385	15	0/25	M/25/15	10

Table 2. Quantity of consumables for secondary mixing scheme with water / cement ratio of 0.55.

Water to cementitious materials	Silica (kg/m3)	Cement (kg/m3)	Water (kg/m3)	Sand (kg/m3)	Poke (kg/m3)	Silica %Cement	Super lubricant %Cement	Design Name	Number
0/55	0	320	174	771	385	0	0	Witness	1
0/55	16	304	174	771	385	5	0/35	M/35/5	2
0/55	32	288	174	771	385	10	0/35	M/35/10	3
0/55	48	272	174	771	385	15	0/35	M/35/15	4
0/55	16	304	174	771	385	5	0/30	M/30/5	5
0/55	32	288	174	771	385	10	0/30	M/30/10	6
0/55	48	272	174	771	385	15	0/30	M/30/15	7
0/55	16	304	174	771	385	5	0/25	M/25/5	8
0/55	32	288	174	771	385	10	0/25	M/25/10	9
0/55	48	272	174	771	385	15	0/25	M/25/15	10

2.2. CONCRETE PROCESSING

Cubic specimens are manufactured according to BS1881-108 [25] to 15 x 15 x 15 cm, Put the concrete mixture into three layers in cubic molds and press the compression rod into each of the 35 strokes to remove the mixed air. After filling the third layer, we smooth out the concrete surface with a knife and release the molds for 24 hours, then remove the specimens after 24 hours and enter the treatment stage in the pool. According to the standard operating temperature (water pool) is from 18 to 22 ° C. After molding and processing in the laboratory, we obtain

7 and 28-day compressive strength. Concrete compressive strength test In this study, the compressive strength test was performed on cubic molds with dimensions of 15 × 15 × 15 cm, according to Bs 1881 part 116 [26]. Extract the concrete samples into the water, allow them to cool for some time in the open air to remove excess water. Finally, each sample is placed inside a hydraulic press with 0.68 MPa loading control, keeping the device under uniform loading. , As soon as part of the sample is broken, the loading of the device is stopped and the maximum applied force on the surface of the specimen's contact with the metal plates is shown on the unit display in Newton, having the maximum applied force and the loading surface of the specimen. Each sample consists of 4 cubic samples, 2 of which are broken for 7 days and averaged, and the other two are broken for 28 days and averaged.

3. DISCUSSION AND RESULTS

Table 3. Results of initial mixing design experiments with water to cement ratio of 0.49

28day compressive strength of cubic specimen(Mpa)	7day compressive strength of cubic specimen(Mpa)	Design Name	Number #
16/5	16/15	Witness	1
22/30	21/48	M/35/5	2
20/96	20/29	M/35/10	3
20/32	19/5	M/35/15	4
21/04	19/92	M/30/5	5
19/94	18/69	M/30/10	6
19/16	18/4	M/30/15	7
20/83	19/07	M/25/5	8
19/23	18/1	M/25/10	9
18/43	17/24	M/25/15	10

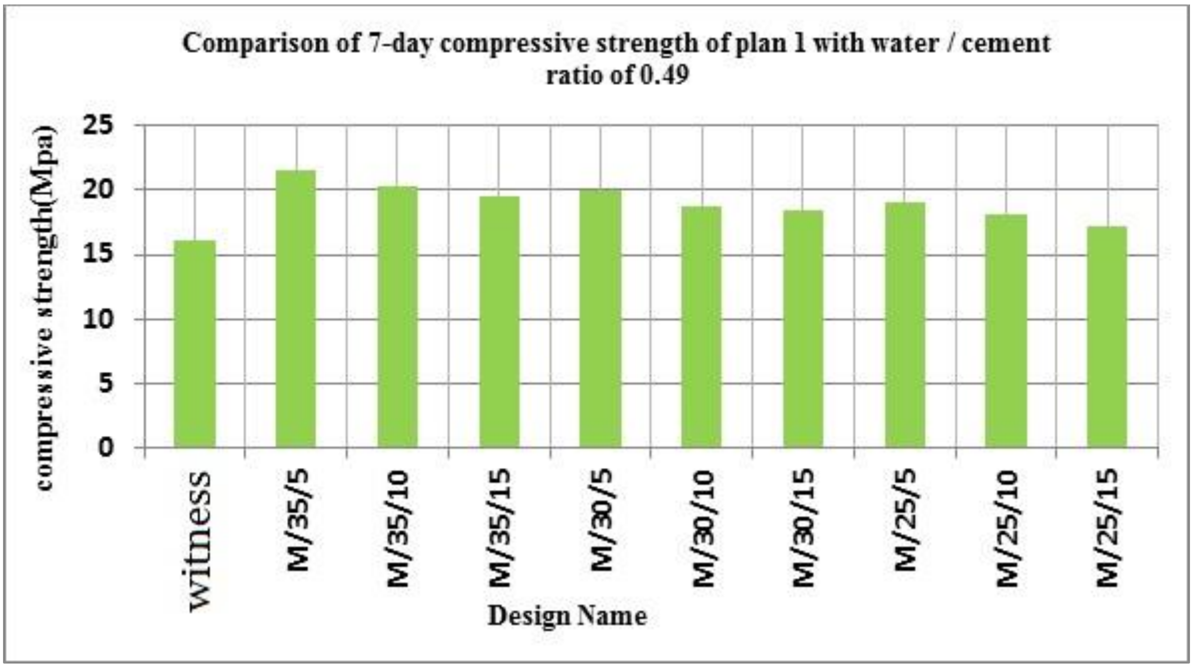

Figure 1. Comparison chart of 7 day compressive strength of Scheme 1 with water to cement ratio of 0.49

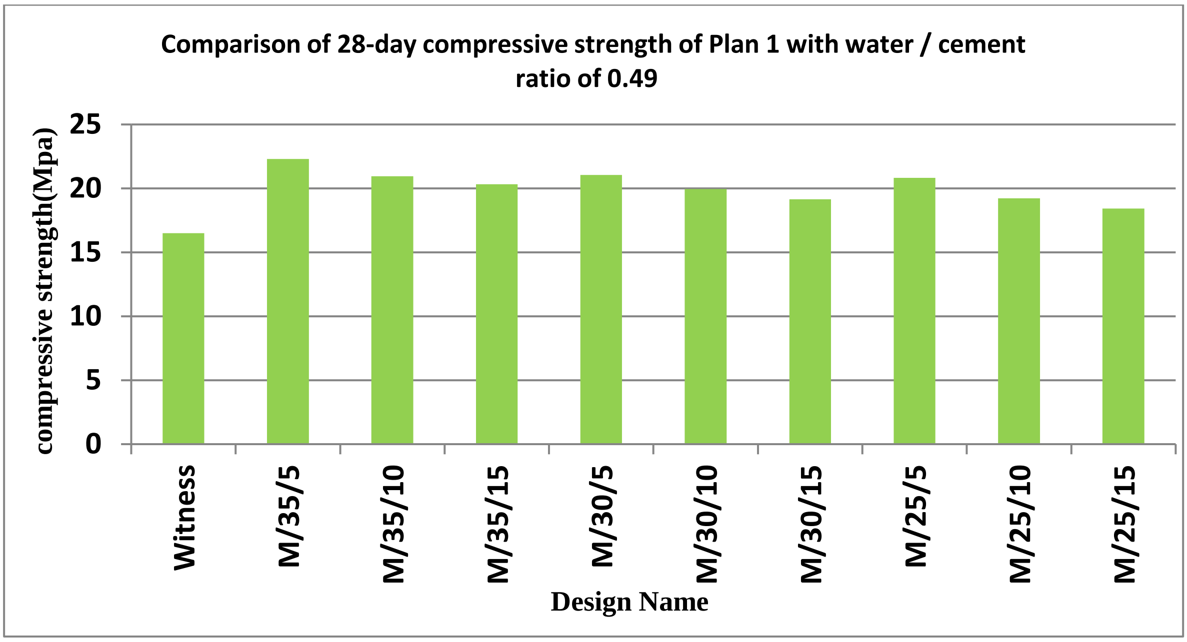

Figure 2. Comparison chart of 28-day compressive strength of Scheme 1 with water to cement ratio of 0.49.

Table 4. Results of secondary mixing design experiments with water to cement ratio of 0.55

28day compressive strength of cubic specimen(Mpa)	7day compressive strength of cubic specimen(Mpa)	Design Name	Number #
15/02	14/05	Witness	1
19/61	19/52	M/35/5	2
22/01	20/78	M/35/10	3
20/26	19/80	M/35/15	4
18/52	17/83	M/30/5	5
20/63	19/65	M/30/10	6
19/43	18/72	M/30/15	7
17/16	16/68	M/25/5	8
20/25	18/93	M/25/10	9
19/18	17/34	M/25/15	10

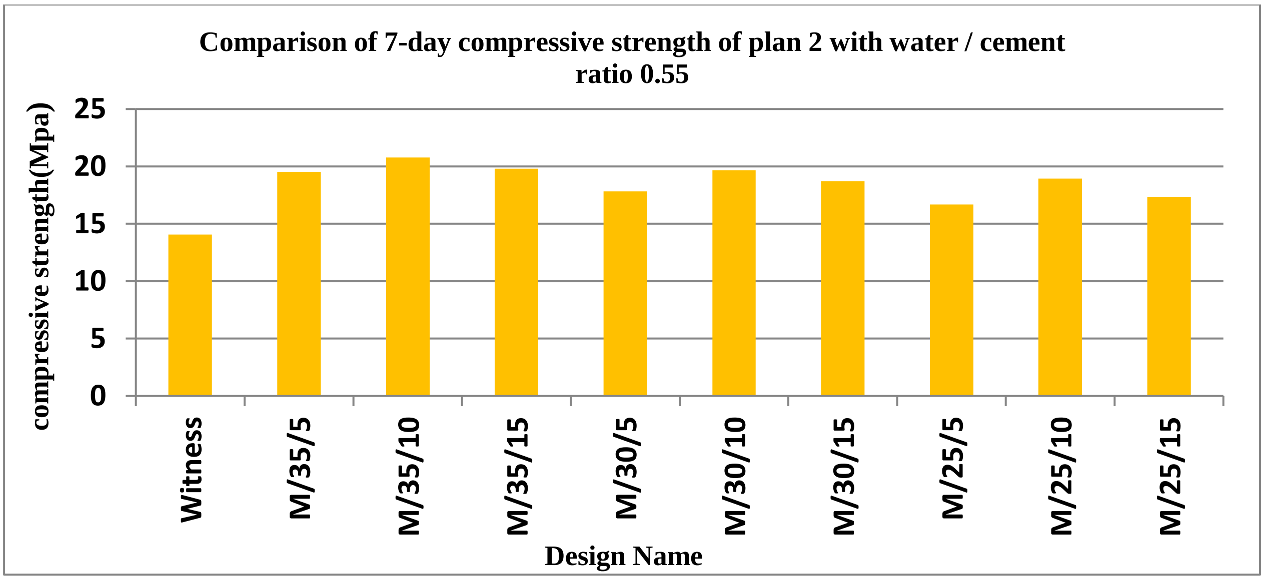

Figure 3. Comparison chart of the 7-day compressive strength of the two designs with water to cement ratio of 0.55

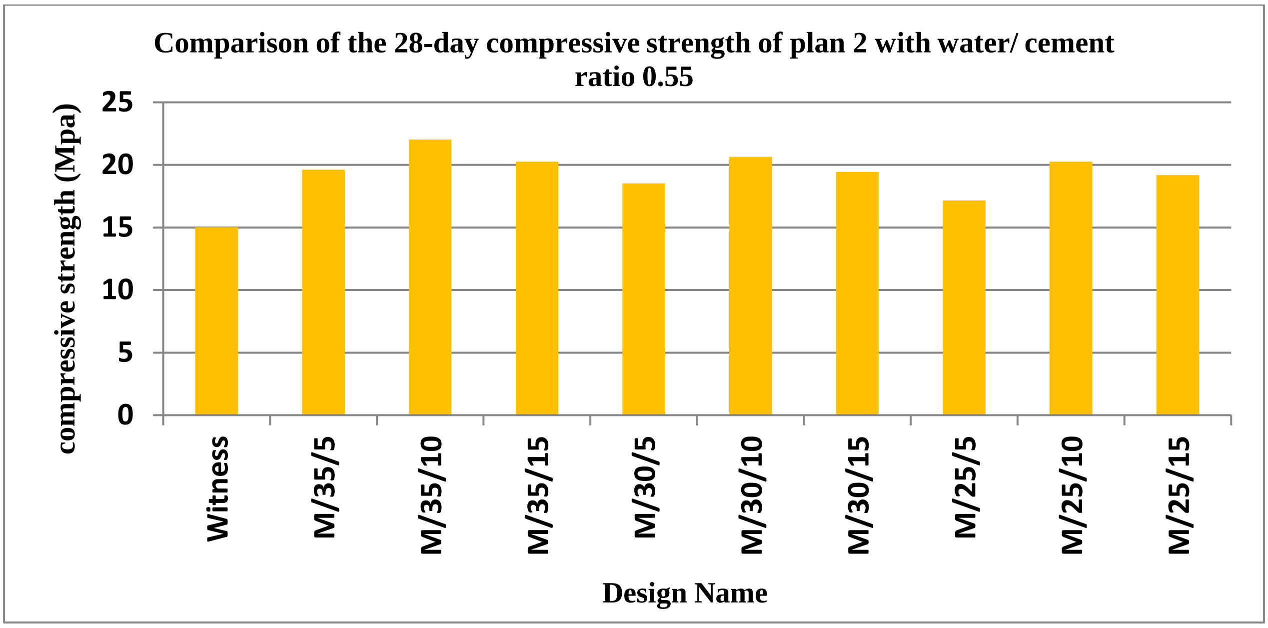

Figure 4. Comparison of 28 day compressive strength of Scheme II with water to cement ratio of 0.55

According to Figures 1 and 2, it was found that with increasing the super-lubricant percentage and decreasing the percentage of micro-silica powder, the compressive strength increased, indicating that the higher super-lubricant percentage (0.35%) resulted in better concrete density and percentage. Less silica (5%) due to its water absorption properties improves the concrete density; Figures 3 and 4 also show that with a higher water-cement ratio (0.55), 10% of the silica powder and 0.35% of the super-lubricant increased the compressive strength. This indicates that the higher the percentage of water to the cement, the higher the amount of silica powder will increase the density and ultimately, the compressive strength, and the higher the percentage of silica powder (15%). And according to a study by Katokhoda et al., On the effect of silica fume on high strength of 5% different light silica concrete (5%, 10%, 15%, 20%, 25%) and 5 different water/cement ratios (0.26%). , 0.32, 0.34, 0.38, 0.42) have been used which results show that at lower water / cement ratios and 15% micro-silica, higher resistance is observed than other percentages [27]. In another study by Mohammadi et al. On the effect of silica soot on the properties of three percent lightweight compacted concrete (5%, 10%, 15%) and 2% plasticizer and water/cement ratio 5/5 at ages 3, 7, 28, 90-day applied results show for SCLC mixtures significant results were obtained from 15% silica vapor. The minimum compressive strength was 3 days and the maximum compressive strength was 90 days [28]. In another study by Mortazavi and Majlesi on the effect of silica smoke on the compressive strength of lightweight structural concrete containing Lika as lightweight material, 120 cubic 10 * 10 * 10 specimens were made and mixtures with water to cement ratio of 0.37 and 0, 5, 10, 15, 20, 25% of the soot constitute the replacement cement silica, for each mixed design 20 samples for 7, 14, 28, 42 days in standard water at 20 ° C and Also, 20 specimens were prepared with identical composition from 0% silica vapor as natural weight concrete and were compared for results. The results showed that increasing the silica soot caused a significant increase in compressive strength. Silica soot also gives concrete a higher initial compressive strength at a given time compared to ordinary weight concrete [29]. In another study, Transportation and Mechanical Properties of Lightweight Silica-Concrete Lightweight Concrete investigated the performance of lightweight structural lightweight concrete for up to 28 days in terms of concrete permeability and compressive strength. The concrete mixture containing 10% silica fume is replaced by the weight of the cementitious material. The results show that density and compressive strength increased by 30% and 27%, respectively. The strength of the Scoria light-grain concrete against chloride ion penetration is increased by the use of silica fume in the mixture. According to the evaluation parameters, the concrete containing silica soot shows a much lower corrosion rate than conventional concrete [30]. All samples were resistant to the control sample without any additives due to the presence of additives in the mixing design. In the design of a compressive strength, we will have a higher compressive strength than in Scheme II because in a scheme, a water-cement ratio is lower and since the water available for hydration is very low, almost all of it is used during the reaction, so the water will evaporate. It does not stay and hence the resistance due to cavity formation will be much lower when the w / c ratio is low.

4. CONCLUSION

• The highest compressive strength of the 7-day mixing design with water/cement ratio of 0.49 is M / 35 /5 with 21/48 Mpa, which has a higher lubricant percentage (0.35%) and lower powder content. Silica (5%) is due to better compression of concrete.

• The highest 28-day compressive strength of his mixing plan with the water-to-cement ratio of 0.49 L is related to sample M / 35/5 with a resistance of 22/3 Mpa, which has a higher percentage of super-lubricant (0.35%) and a lower percentage. More (5%) of the silica powder is due to better compression of the concrete.

• The highest 7-day compressive strength of the second mixing scheme with water/cement ratio of 0.55 is related to the sample of M/35/10 with a resistance of 20.78 MPa which has a higher percentage of super-lubricant (0.35%) and has 10 The% silica powder is due to better compression of the concrete.

• The highest 28-day compressive strength of the second mixing scheme is M / 35/10 with 22 /01 Mpa sample having a higher percentage of super-lubricant (0.35%) and 10% powdery microcrystalline due to better compression of the concrete.

• The highest impact of silica powder in the first mixing scheme was 5%, with a lower water-to-cement ratio (0.49) with a lower percentage of powdered silica (5%).

• The maximum impact of micro-silica powder on the second mixing scheme was 10%, with the water/cement ratio (0.55) having the highest (10%) micro-silica.

• In all designs, the compressive strength of concrete increases with increasing age of concrete from 7 days to 28 days.

• The highest compressive strength of concrete at the age of 7 days was related to the first mixing design with a lower water / cement ratio of (0.49). Low ratio of water to cement

• The highest compressive strength of concrete at 28 days of age is related to the first mixing design with lower water / cement ratio (0.49).

• The maximum compressive strength growth of 7-day samples of first mixing design M / 35/5 with 33% growth compared to control had highest 7-day growth in first mixing design.

• The maximum increase in compressive strength of 28-day samples of first mixing design M / 35/5 with 35% growth compared to control had the highest 28-day growth in first mixing design.

• The maximum compressive strength growth of 7-day samples of the second mixing design M / 35/10 with 48% growth compared to control had the highest 7-day growth in the second mixing design.

• Maximum increase in compressive strength of 28-day samples of the second mixing design M / 35/10 with 47% growth compared to control had the highest 28-day growth in the second mixing design.

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CONFLICT OF INTEREST
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