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Engineering Characteristics of Concrete Made from Daz Shrub Fibers and Iranshahr Daman River Sediments in the Southeast of Iran in Strengthening Structures Against Earthquakes

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Abstract

The purpose of the present research is the engineering characteristics of concrete made from Daz shrub fibers and Iranshahr Daman river sediments in the southeast of Iran in strengthening structures against earthquakes. Therefore, in order to determine the textural characteristics and composition of sediments of the Daman River, 15 samples of the sediments of this river were collected in separate bags, and then to study, the composition, texture and constituents of these sediments were made into thin sections. The laboratory was transferred. Statistical graphs and parameters of sediments were drawn to determine the average size, frequency and cumulative graphs. Examining the process of texture changes along the river, after drawing the relevant graphs of texture changes and the composition of sediment samples taken from Daman River, shows textural changes. Also, a comparison between single-stranded, two-stranded and three-stranded leaves of Daz shrub was used to increase the strength of concrete, and the results showed that the effect of concrete strength is by changing the number of leaves from one strand. It varied in three fields. The resistance of two strands of Daz leaves was 10.1 MPa, a single strand was 9.5 MPa, and a sample of cylindrical concrete consisting of three strands of Daz leaves was the least resistant, i.e. 5.1 MPa. Therefore, the highest resistance is related to the concrete made of two strands of leaves.

Keywords: concrete engineering, sediments, Daz shrub fibers, earthquake, Iranshahr Daman river in the southeast of Iran

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Introduction

A look at the damage caused by past earthquakes shows that a high percentage of reinforced concrete buildings that have been built in the country so far are not resistant to earthquakes or do not have sufficient and acceptable resistance, hence the need to strengthen them. The structure of these buildings (concrete) is felt especially to deal with lateral forces and with reliable, easy, fast and economical retrofitting methods. Concrete strength as an important parameter can play an important role in the behavior and performance of the structure. Therefore, the use of high-strength concrete can improve the performance of the structure (Gudarzi & Vajdian, 2023: 33). One of the technical characteristics of concrete that has been the focus of researchers is its compressive and tensile strength. In order to achieve this goal, in recent years, the use of a lower water-cement ratio with the help of super-lubricants, as well as the use of natural or artificial pozzolans, as well as the use of fibers of different types and specifications. It has become common in the concrete mix.

The use of natural fibers not only saves construction materials, but also helps to solve the problem of disposing of this material. The most economical and ecological is to increase construction work facilities in the current economy (Bebitta & Shiela, 2020). The use of fiber concrete to improve the properties and mechanical behavior of concrete is expanding. The fibers in concrete reduce the brittleness of concrete and improve its plasticity. Fibers may be from plants, artificial and metal materials that improve the mechanical properties of concrete under compressive, tensile, bending and shear stress (Hadi et al, 2020). Pineapple is very important in the production of materials for structural and non-structural industrial products with other natural and synthetic fibers with different matrix (Santosh & Suresh, 2019). Polypropylene (PP) fibers with their lightness, corrosion resistance and relatively low cost are included in concrete production to enhance mechanical resistance, cracking patterns, durability and fire resistance (Mohammad et al, 2020). Fiber reinforced concrete (FRC) coatings are used to strengthen and repair pavements (Lampros et al, 2020). The elastic modulus and tensile strength of FRP rods are significantly controlled by fiber properties and fiber volume ratio (Usman & Majid Ali, 2018). In most lightweight concrete mixtures, a high content of cement materials is used to achieve mechanical properties (Kaiyue et al, 2018). Textiles used as reinforcement of composite materials usually include round fibers in two directions. The main advantages of fabric reinforced mortar (TRM) compared to FRP systems are the relatively low cost of the matrix, resistance to high temperature and fire (Amin et al, 2018). During the study of the contribution of plant fibers in the behavior of reinforced concrete, it can be concluded that the combination of wheat straw in concrete has improved the absorption of bending energy and resistance indices. Natural fibers are sustainable materials that are easily available in nature and have advantages such as low cost, light weight and renewable (Habibunnisa et al, 2020). Concretes containing pineapple leaf fibers can be used in normal (non-marine) conditions due to their better mechanical properties. Steel fibers in composite mixtures reduce the positive

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effect of polyolefin fibers on the corrosion performance of concrete (Pawel et al, 2020). Macropolyolefin fibers exhibit the highest breaking energy, which is probably due to high mechanical bonding and low fiber aspect ratio (Mahmoud et al, 2020). The use of fibers in SCC improves the mechanical properties and durability of hardened concrete, such as impact resistance, bending resistance and vulnerability to cracking (Habibunnisa et al, 2020).

Peng et al. (2023), in a research, investigated the tensile mechanical properties of dynamic cracks and analyzed the microscopic mechanism of reinforced concrete with steel fibers. The results showed that the static and dynamic crack tensile strength of concrete reinforced with steel fibers increased with the increase in the content of steel fibers. The dynamic splitting tensile strength and peak deformation of steel fiber reinforced concrete increased significantly with increasing strain rate, and the dynamic splitting tensile strength of steel fiber reinforced concrete increased in the range of 1.1 to 3.3 compared to the static splitting tensile strength. The increase in the tensile strength of the dynamic gap with the increase in the strain rate in different fiber contents showed a significant trend and then flattening. In addition, the crack dynamic tensile strength and strain rate sensitivity of non-steel fiber concrete is higher than that of steel fiber reinforced concrete. Zhang et al. (2023), in a research, have investigated the tensile strength and fracture toughness of reinforced concrete with Polyoxy methylene fibers. In this study, Polyoxy methylene (POM) fibers were added to concrete to increase crack resistance. First, three-point bending tests and split tensile tests were performed on notched beams and cube samples of plain concrete and reinforced concrete with POM fibers. Then, taking into account the heterogeneity of concrete, the tensile and crack test results were analyzed to reveal the fracture behaviors of plain concrete and reinforced concrete materials with POM fibers. It was found that the addition of POM fibers is beneficial for improving the fracture resistance of concrete. The boundary effect model (BEM) was used to estimate the tensile strength and fracture toughness of plain concrete and POM fiber-reinforced concrete materials from tensile test results, which correlated well with the results obtained from splitting tensile tests and the conventional method. In addition, the effect of POM fiber length and volume fraction on fracture resistance was evaluated. The findings showed that increasing the fiber length and volume fraction effectively increases the tensile strength and fracture toughness of concrete materials. Chen et al. (2023), in a research titled "Recent Advances in Natural Fiber Concrete: A Review of Properties, Stability, Applications, Barriers, and Opportunities," systematically reviewed 196 articles using a literature review method to understand new properties, properties Mechanical, durability, thermal conductivity, sound absorption properties, stability, applications, barriers and opportunities of natural fiber concrete were analyzed. The results showed that natural fibers reduce the cracking rate of concrete and increase the tensile strength. Although fibers increase the stress distribution in concrete and increase its stability, they decrease the compressive strength. In addition, 85.7% of natural fiber concretes show significant environmental benefits. However, 28.6 and 43% of the reviewed

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studies indicate effective economic and social sustainability, respectively. Liu et al. (2022), in a research, evaluated the concrete engineering properties of recycled biomass aggregates made from coconut shell. The results showed that the mechanical strength of concrete with artificial biomass recycled aggregates achieved at least 90 and 80% of the strength of natural aggregate concrete in 3 days and 28 days, respectively. In addition, compared to natural aggregate concrete (NAC), coconut shell composite concrete (CCSAC) and synthetic biomass recycled aggregate concrete (SBRAC) show significant improvements in thermal conductivity, which shows the energy saving potential of buildings. . Eswari (2015), investigated the flexural performance of concrete reinforced with composite fibers in a laboratory and evaluated the effect of different amounts of polymer and metal fibers on the strength and flexural performance of fiber concrete samples and reported that the addition of fibers, the evaluated parameters compared to normal concrete.

In this research, concrete samples were made by adding the leaves of the Daz shrub. These leaves are found from shrubs in the southeastern part of Iran and its effect on the tensile strength of concrete was investigated.

Location of the study area

Daman River is located 25 km north of Iranshahr and on the side of Chabahar-Zahedan transit road. The only way to access this river is the main Iranshahr-Khash road. Iranshahr is located 335 kilometers south of Zahedan, the capital of Sistan and Baluchistan province.

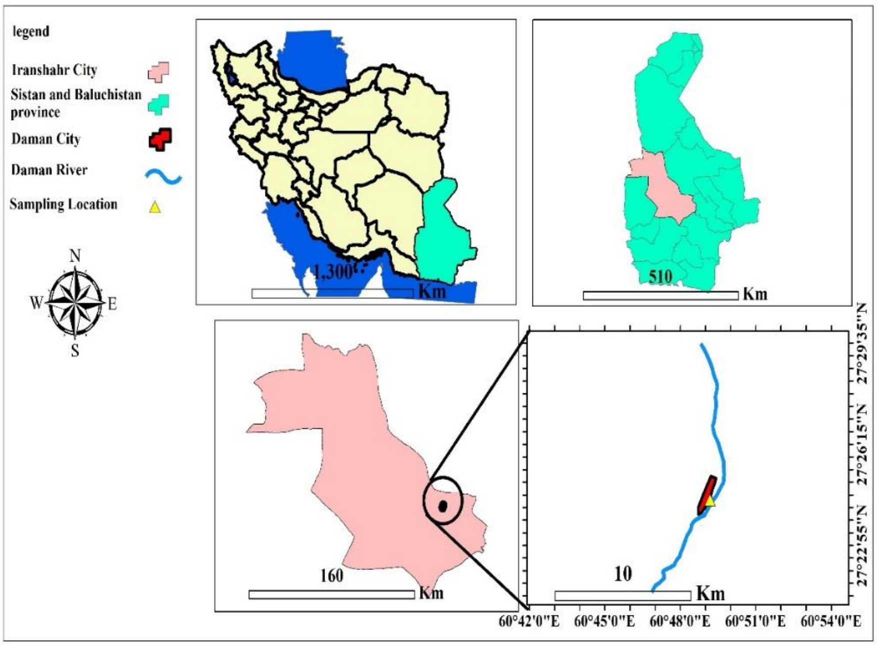

Fig 1: Geographical location of the study area

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Methodology

The sampled points of Daman river area

In order to determine the textural characteristics and composition of sediments of the Daman river, 15 samples of the sediments of this river were collected in separate bags and then transferred to the laboratory to study and make thin sections of the composition, texture and constituents.

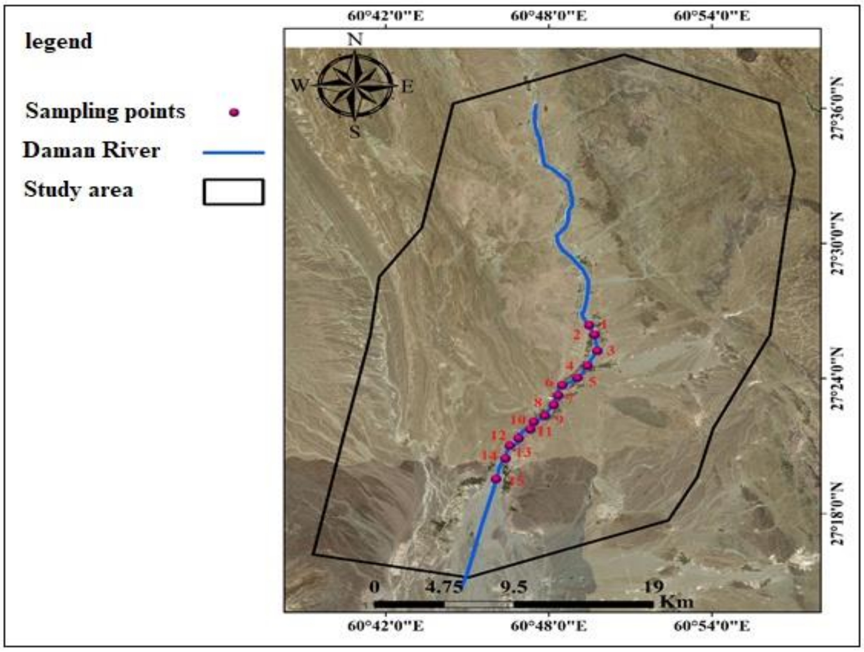

Fig 2: Sampling locations along Daman River

Interpretation of grain measurement data

Changing the characteristics of sediments along the river and downstream is one of the elements of the transportation process, which is a direct geomorphological function. Due to the fact that several factors, especially the slope and discharge of the current, are subjected to systematic in the downstream direction, it is expected that both the size and the frequency distribution (sorting) of the sediment particles of the same bed load will change. In changing the size and frequency distribution of particles, there are two main processes, Abrasion and Sorting.

Various statistical parameters such as mean diameter of particles, median, sorting and skewness have been calculated using drawing method and with the help of Folk (1980) formulas (Fig 3).

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$$\text{Mean} = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

$$\text{Median} = \phi_{50}$$

$$\text{Sorting} = \frac{\phi_{16} + \phi_{84}}{4} + \frac{\phi_{95} - \phi_{5}}{6.6}$$

$$\text{Skewness} = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_{5} + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi_{5})}$$

Fig 3: Foulk's (1980) formulas for calculating median, mean, sorting and skewness

Table (2): Statistical parameters related to the texture of the sediments

Sample number	Mean (ø)	Median (ø)	Sorting(ø)	Skeweness
1	0.9	0.5	1.57	0.26
2	0.9	1.4	94/1	0.88
3	1.3	0.9	05/2	0.15
4	0.3	0.1	27/1	0.57
5	0.9	0.6	1.67	0.31
6	0.3	0.1	1.35	0.24
7	0.9	1	1.1	0.076
8	1.16	1.6	1.67	0.22
9	0.8	0.8	1.63	0.096
10	0.6	0.5	1.45	0.71
11	0.5	0.4	1.69	0.70
12	1.1	1.4	2.1	0.17
13	0.2	0.2	1.53	0.46
14	0.9	0.8	1.83	0.16
15	1.4	1.9	2.43	0.063

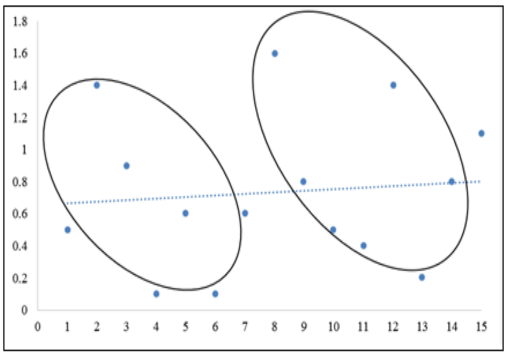

Fig 4: The mean size of Daman river sediment particles, two accumulations

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In this figure (4), it can be seen that the mean size of the particles is between 0.5 and 1.

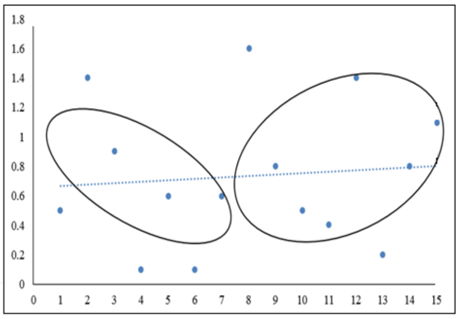

Fig 5: The mean size of sediment particles

In this figure (5), the mean size of the sediment particles is mainly particles with a size between 5 and 10, which indicates that the particles are small.

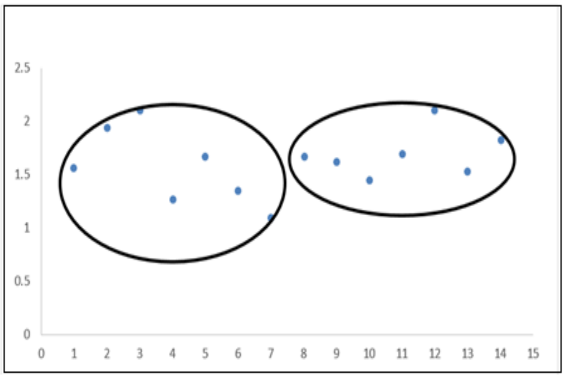

Fig 6: Sorting of sedimentary particles

In this figure (6), the accumulation of particles is among the numbers 1 to 2, which indicates poor particle sorting. In the Daman river, due to the entry of sub-branches with a high bed slope, as well as the occurrence of lateral erosion that leads to the entry of sediments into the main channel, confusion occurs in the sediment grading system. After that, discontinuities are created in sorting, median and mean particle size. Analysis of thin section of Daman river sediments and composition of sediment constituent particles to make thin sections, first some of the sieved sediments in 2 x 2 dimensions are placed in a special can-like mold and the mold is filled with epoxy glue, sample 24 hours It is suspended inside the glue, then the mold is opened from top to bottom and the sample is separated from the mold along with the glue and its surface is cut so that the sediments can be touched, after that it is polished with special powder and This work is done several times, and after each step, the cross-section is controlled with a microscope until the radiation and reflection light works in such a way that the minerals can be identified well.

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Composition of sedimentary particles

According to the study of thin sections prepared from sediments by polarizing microscope, the constituent particles of sediments include polycrystalline quartz, monocrystalline quartz, lithic fragments (carbonate, shale and siltstone) and calcite (Fig 7 - 10).

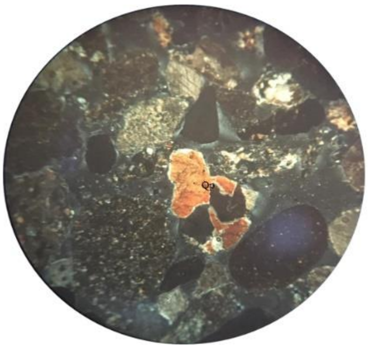

Fig 7: Composition of sediment particles, sample number 1

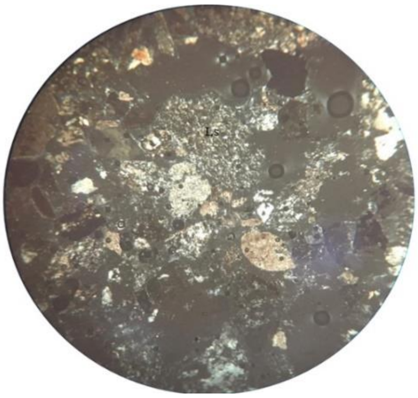

Fig 8: Composition of sediment particles, sample number 2

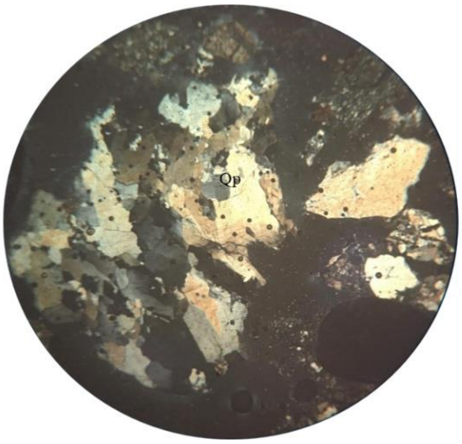

Fig 9: Composition of sediment particles, sample number 3

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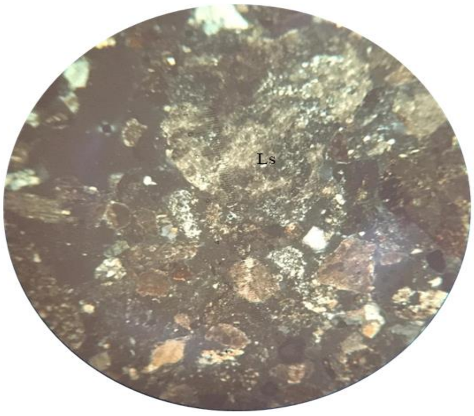

Fig 10: Composition of sediment particles, sample number 4

Findings

Specification of Consumables

- Water

The water used in the production and processing of concrete is from the drinking water of Zahedan city, which is not a problem due to its potable consumption for making concrete.

- Aggregates

Although aggregates are considered as inert materials in concrete, they constitute between 60 and 85% of the volume of concrete. The characteristics of stone materials have important effects in determining the mixing ratio of components and the finished price of concrete. In general, the materials should consist of clean and hard grains. The aggregates of river sediments of Daman region are of rounded corner type, which after sieving, were divided into different sizes in order to prepare the mixing plan in separate trays. (Fig11).

Fig 11: sieved materials in order of size to prepare the mixing plan

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The shape of the aggregates

The shape and surface construction of stone materials has an effect on the properties of fresh and hardened concrete, but its effect is greater on fresh concrete. The lower the ratio of water to cement, the stronger the concrete will be. The shape of the aggregates of the river sediments is alluvial skirt and the type of rubble and rounded corners, which is due to the long course of the river and the Abrasion of broken and angular stones and their transformation into rubble. In this research, the effect of shape and size of Sistan and Baluchestan Province Daman River sediments on the engineering properties of concrete prepared from these sediments was investigated.

A) Oval coarse grain

According to ASTM regulations, the maximum allowable size of sand used is 20 mm. The coarse grains used are of round corner type. For granulation of used sand using standard sieves, the weight percent remaining on each sieve was calculated and by calculating the cumulative percentage passed, the granulation of used sand was obtained. In this research, the maximum nominal size of the sand used is 19 mm. The passing percentage of used sand granulation is specified in figure (12). The range of passing percentage of used sand is (19-2.36 mm). Therefore, according to the considered limits for the maximum size of coarse grains, it is suitable for making self-compacting concrete. The actual specific gravity (in saturated state with dry surface) and the apparent specific gravity of the gravel used are 2.63 grams per cubic centimeter and 2.66 grams per cubic centimeter, respectively, and the water absorption percentage of the aforementioned materials is 1.9 percent.

Considering that all types of fine grains are allowed to be used in fiber concrete, in this research sand with nominal sizes (9.5-1 mm) was used. The percentage of passing sand is used. The range of passing percentage of sand used corresponds to the range of passing percentage of ASTMC330 standard.

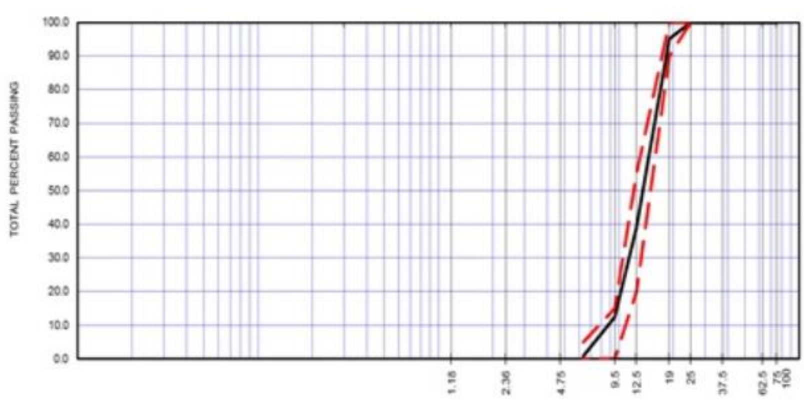

Fig 12: Course granulation curve, oval and upper and lower limits according to ASTM C330 standard

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The red lines indicate the standard size limit of relatively coarse grains of Daman river materials. In this curve, it can be seen that the size of the coarse grains of the material is within the standard range.

B) Pisiform coarse grain

According to the ASTM regulations, the maximum allowed size of sand used is 20 mm. The coarse grains used are of round corner type. For the granulation of used sand using standard sieves, the weight percentage remaining on each sieve was calculated and by calculating the cumulative percentage passed, the granulation of used sand was obtained. In this research, the maximum nominal size of the sand used is 19 mm. The passing percentage of used sand granulation is specified in figure (13). The range of passing percentage of the used sand is (19-2-36 mm). Therefore, according to the considered limits for the maximum size of coarse grains, it is suitable for making self-compacting concrete. The actual specific gravity (in saturated state with dry surface) and the apparent specific gravity of the gravel used are 2.63 grams per cubic centimeter and 2.66 grams per cubic centimeter, respectively, and the water absorption percentage of the mentioned materials is 1.9 percent.

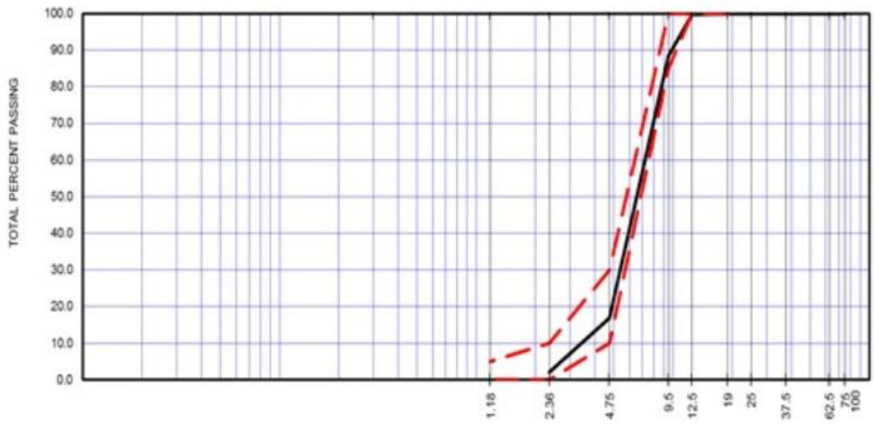

Fig 13: Pisiform coarse Granulation curve and upper and lower limits according to ASTM C330 standard

The red lines indicate the standard limit of the particle size, which indicates the size of the fine grains of the material in the standard range.

C) Sand

Considering that all types of fine grains are allowed to be used in self-compacting concrete, in this research sand with nominal sizes (9.5-1 mm) was used. The amount of passing percentage of the sand used is specified in figure (14). The range of passing percentage of sand used corresponds to the range of passing percentage of ASTM C330 standard. The red lines show

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the standard range and the suitable size of the sand grains of the material, which indicates that the size of the sand particles is within the range.

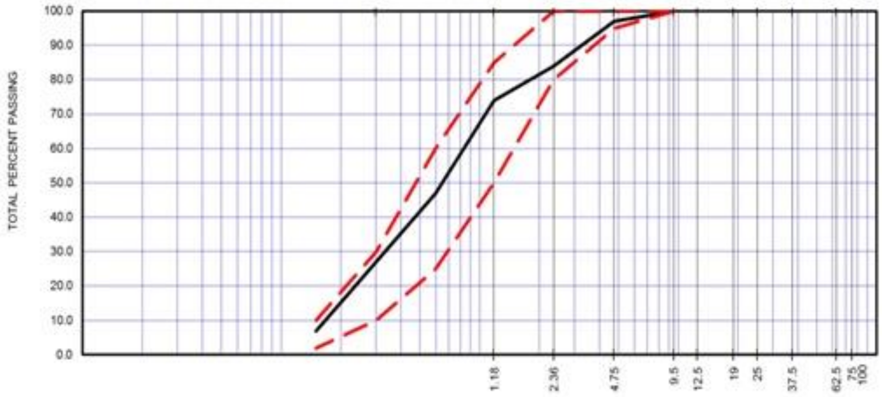

Fig 14: Granulation curve of sand and upper and lower limits according to ASTM C330 standard

Granulation of sediments

Sediment grading was done using standard sieves. The maximum size of the sediment grains is 19 mm. The actual specific gravity and apparent specific gravity of sand materials are 2.63 grams per cubic centimeter and 2.66 grams per cubic centimeter, respectively, and the water absorption percentage of the said materials is 1.9 percent.

- Daz shrub leaves

The leaves of the Daz shrub used in this research were used to strengthen and strengthen concrete (Fig 15), according to this fact, the optimal amount of leaves should be determined to achieve the characteristics of fresh and hardened concrete. In this research, Daz shrub leaves have been used. The characteristics of the leaves are given in table (3).

Table (3): Specifications of the leaves of the Daz shrub

length (cm)	26
Diameter(mm)	20
Specific gravity (gr/cm3)	7.64 – 1.82

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Fig 15: Daz shrubs in text and riverside

- Cement

Cement is a mixture of selected raw materials that are well ground, mixed with a certain ratio and baked in a furnace at a melting temperature of approximately 1500 degrees Celsius to obtain the desired chemical composition. Then the lumps resulting from this baking are completely powdered to obtain cement. As a result of combining cement with water, a chemical reaction takes place and the cement hardens into a stone-like object. The cement used in this research is Portland Type II produced in Qain Cement Factory, which has a specific density of 3150 kg/m and a specific surface area of 3000 cm/gr. The concrete used in this research is 400 grade concrete. The physical and chemical properties of cement used are given in table (4 and 5).

Table (4): Physical and chemical characteristics of cement used

Physical properties of type cement 2						
Autoclave expansion	Blain	Reception time		Pushing resistance		
		Primitive	Final	3 Days	7 Days	28 Days
≤ 0.8	≥ 2800	≥ 0.45	≤ 360	≥ 100	≥ 175	≥ 315

Table (5): Physical and chemical characteristics of cement used

Chemical properties of type cement 2								
Specification name	Sio2	Al2o3	Fezo3	Mgo	So3	Lol	Ir	C3a
Value in standard 389	≥ 20	≤ 6	≤ 6	≤ 5	≤ 3	≤ 3	≤ 0.75	≤ 8

The prepared concrete was added in a cylindrical mold of 30 x 15 cm. First, the leaf samples were arranged in one row, then in two rows. After filling the molds with concrete, the samples

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were dried during the day. After 24 hours passed and drying, the molds were opened and placed in the water pool for 28 days.

Tensile strength of concrete

Tensile strength of concrete is one of the most important characteristics that has a great impact on the creation and opening of concrete cracks. Tensile strength of concrete is often obtained by using splitting test of cylindrical sample or Brazilian test. (Fig16).

Fig 16: steps of making concrete sample and Brazilian test

Results and discussion

According to the ASTM C-90-496 standard, a standard cylindrical sample with a height of 30 cm and a diameter of 15 cm was placed horizontally along its axis in the concrete breaker jack. A continuous load was applied at a constant speed in the tensile stress range of concrete between 7 and 14 kg/cm2 (1.4 and 0.7 MPa) until the sample broke. The compressive stress caused a uniform tension in the direction perpendicular to the sample (Fig 17).

Fig 17: Compressive stress causes uniform tension

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The double tensile strength is obtained from equation (1).
Equation (1)
$T = 2P / \pi LD$
In the above relationship, (T) is the tensile stress (N/mm2), (P) is the breaking load, (L) is the length of the sample, and (D) is the diameter of the sample.

The samples were tested at 28 days in humid conditions. Tensile strength for all five samples in storage conditions at 28 days is given in Table (6). After the destruction and halving of the sample, the broken aggregates and broken leaves can be seen, which can be seen under the pressure of the concrete breaker jack (Fig 18). The results show that the presence of leaves increases the tensile strength, so that this increase is more significant in sample number (6), which can be due to the higher tensile strength compared to other cases. When the concrete is subjected to tensile stress, after the tensile strength of the concrete has reached the maximum and a crack is formed, the leaves of each zone are responsible for transferring the load. This means that the pressure is evenly distributed to the leaves, and the leaves act as a bridge. We found that the strength of concrete depends on several factors, including: the adhesion of the leaf to the concrete and the dimensions of the leaf. The mode of fracture in concrete leaf samples is different from plain concrete samples and has changed from brittle (sudden) to soft and gradual. When the tensile strength increases with the use of leaves, it can be explained as follows, when the leaves are divided between the split parts of the matrix, by transferring the stress from the matrix to the leaves, under They are stretched more, as a result, they cause an increase in tension, then an increase in tensile strength is observed.

Table (6): specifications and number of leaves used

Properties / Attributes	Tensile strength	Force applied (MPa)	Specific gravity	Length(cm)	Diameter(mm)	Number
Two strand of leaf	32.87	10.1	2.39	30	15	1
Without strand of leaf	29.11	9	2.39	30	15	2
Three strand of leaf	17.4	5.1	2.39	30	15	3
Single strand of leaf	29.82	9.5	2.39	30	15	4

The control sample was made without leaves, it was destroyed by a pressure of 9 MPa, the sample made with one string of leaves was broken at a pressure of 9.5 MPa, and the sample with two strings of leaves was broken at a pressure of 10.1 MPa, and at the end, the lowest strength related to the concrete was made It was a three-layered leaf that was destroyed by a maximum pressure of 5.1 MPa. At first, the increasing trend of tensile strength is seen, then the tensile strength decreases. In other words, increasing the number of leaves by three layers

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has significantly reduced the tensile strength of concrete. The highest tensile strength corresponds to sample 3, which consists of two layers of leaves.

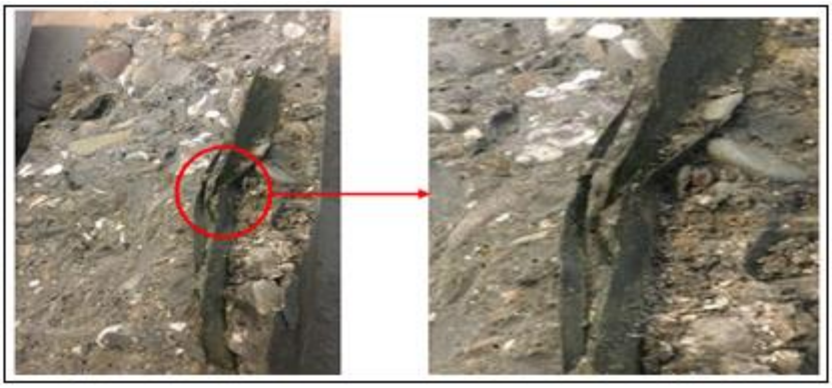

Fig 18: Cylindrical concrete sample after applying pressure and breaking the leaves in the concrete

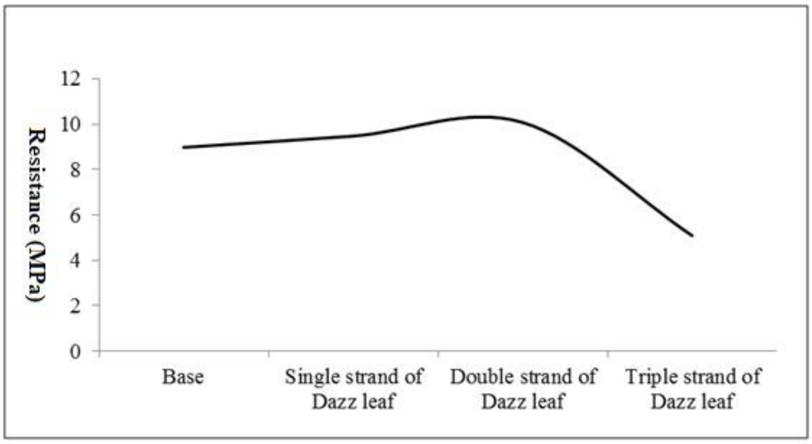

Fig 19: Diagram of the influence of the number of leaves used in concrete on its strength

Conclusion

The way of particle size distribution is related to sedimentary environments and the type of sedimentary processes effective in their formation. The analysis of the size of sedimentary particles as one of the main characteristics of the texture helps in determining and interpreting the sedimentary environment of ancient deposits and provides comprehensive criteria in determining the type of environment. After grain measurement, according to the study of thin sections by polarizing microscope, the material of Daman River sediments is siliceous containing monocrystalline and polycrystalline quartz as well as lithic fragments. The presence of quartz in river sediments has increased the resistance of sediment grains to transport from the upstream points of the river and over a long distance to the downstream points of the river.

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In this research, in order to investigate the effect of using the leaves of the Daz shrub on the engineering properties of concrete, after determining the optimal amount of leaves to strengthen concrete, the necessary tests were performed on fresh and hardened concrete. The construction of concrete reinforced by leaves shows that the filling properties of concrete are reduced by adding leaves, and adding leaves to concrete has increased the strength of concrete samples. By comparing the results of this test in ordinary concrete and concrete reinforced with Daz shrub leaves, it showed that this increase in strength at the age of 28 days was only used in single-stranded and double-stranded cylindrical samples of leaves. Showed an increase. While in the cylindrical sample with three strands of leaves, a significant decrease in the compressive strength of concrete was seen. The advantage of using leaves in concreting can be considered as providing very good adhesion between concrete, reducing the weight of concrete. It is also a good insulator against heat and sound transmission. Adding fibers in the industry, considering the increase of concrete structures and the many weaknesses they have, it is necessary and important to create and use solutions to fix and improve these defects.

Suggested

- It is suggested that due to the presence of quartz in the materials and the high resistance of Daman river sediments, these materials can be used as concrete for bridges in the region, which will reduce the cost of transporting borrowed materials from other places. It goes to this area. Also, in order to increase the strength of bridge columns, bridge decks and dams in the region, Daz elastic fibers, which are related to Iranshahr region, were used.
- The advantage of using Daz shrub leaves, in addition to increasing the strength of concrete, can be seen as providing very good adhesion between concrete and reducing the weight of concrete. It is also a good insulator against heat and sound transmission. Addition of fibers in the industry considering the increase of concrete structures and their many weaknesses, it is necessary and important to create and use solutions to fix and improve these defects.

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