AN EXPERIMENTAL STUDY ON MIX DESIGN AND STRENGTH OF PERVIOUS CONCRETE

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Abstract: This entire project is about Mix designing the pervious concrete as per the IS 10262-2009 and IS 456-2000 and achieve the strength near M20 concrete with different water cement ratio and different ratio of fine aggregates. Pervious concrete is a unique sort of concrete with high porosity utilized for solid flatwork applications that permits water from precipitation and different sources to go legitimately through, consequently decreasing the overflow from a site and permitting groundwater energize. In this project we added fine aggregate in different amount with different water cement ratio to increase the strength of the pervious concrete along with keeping the concrete permeable. The experiments was done using three water cement ratio i.e 0.42, 0.46, and 0.50 and three course aggregate and fine aggregate ratio, which are 6:1, 5.5:1.5 and 5:2. An ideal rate was being discovered which shows the solid is porous and having great compressive quality. It is hard to make pervious cement with high porosity and high quality. In this task we considered the mechanical properties of Pervious Concrete used to structure Road Pavements. Fundamental focal point of the task was to decide and improve compressive quality. By doing all the experiments we found out that mix of w/c ratio 0.46 with CA: FA= 5.5:1.5 was best to use as it had good permeability and good compressive strength with compressive strength 20.2 MPa in 28 days.

Keywords – Pervious concrete, PPC (Portland pozzolana Cement), Aggregate (Coarse & Fine), Water

1. Introduction

Pervious concrete is a mix of shake or stone, bond, water and alongside zero sand which influences an open cell to structure that empowers water and air to experience it. According to EPA (Environmental Protection Agency's) storm water flood can send as much as 90% of toxic substance, for instance, oil and other hydrocarbon. The main objective is to investigate the performance characteristics of the pervious concrete such as porosity, compressive strength, and infiltration rate etc. The previous solid black-top has a number of ideal conditions that help to boost the city's condition, as follows:

i. Since the black-top is air permeable and water vulnerable, the water will easily channel into the earth, allowing groundwater supplies to re-establish over time.
ii. The previous solid black-top can withstand vehicle commotion, resulting in a quiet and friendly setting.
iii. The previous solid black-top has no plash at first glance during stormy days and does not flash at night. Drivers would be more comfortable and prosperous as a result of this.
iv. The pervious solid black-top materials have warm-accumulating openings.
v. This type of black-top will change the temperature and dampness of the Earth's surface, as well as get rid of pollution of the wonders of a hot island in a city

Material Used:

I. Portland Pozzolana Cement (PPC)

Portland Pozzolana Cements are a mix of natural or industrial pozzolana and Portland cement. In addition to underwater use, the high alkalinity of pozzolana makes it especially resistant to common forms of corrosion from sulphates. Once fully hardened, the Portland Pozzolana Cement (PPC) will be stronger than Ordinary Portland Cement (OPC), due to its lower porosity, which also makes it more resistant to water absorption and spelling. It gains high compressive strength with age unlike rapid hardening cement. It is cheap and affordable. Following uses of PPC:

1. Concrete pavements.
2. Structures and foundations.
3. Mass concrete applications, such as dams.
4. Precast concrete, such as pipe and block.
5. Prestressed or post-tensioned concrete.
6. Concrete exposed to water and marine applications.
7. High-performance/high-strength concrete, used typically in high-rise building or bridges to give 100 year service life.

Fig.1. Cement

II. Aggregate

Aggregates are inert materials which are mixed with binding material such as cement or lime for manufacturing of mortar or concrete. Aggregates are used as filler in mortar and concrete and also to reduce their cost. Aggregate which account 60-70% of total volume of concrete are divided into two categories:

- Fine aggregates:-
    i. Aggregates whose particles pass through 4.75 mm IS sieves are termed as fine aggregates.
    ii. Most commonly used fine aggregates are sand (pit or quarry sand, river sand and sea sand) and crushed stone in powdered form, however some times sukhi and ash or cinder are also used.
- Coarse aggregate:-
    i. Aggregates whose particles do not pass through 4.75 mm IS sieves are termed as coarse aggregates.
    ii. Most commonly used coarse aggregates are crushed, stone gravel; broken pieces of burnt bricks, etc.

Fig.2 Aggregate

III. Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6. The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizers or super-plasticizers.

2. Literature review

In this paper "Design of Eco Friendly Pervious Concrete" concentrated the mix design of pervious concrete according to ACI 522R-06 gave by American Concrete Institute for design of Pervious Concrete Road Pavements. He found that Aggregate Cement Ratio of 3:1 had most elevated strength quality. The 3days, 7days, 14days, 27days strength quality were observed to be 7.32, 17.16, 23.4, 24.57 and 25.73 individually [1]. In this paper "High Strength Permeable Pavement is utilizing no Fines Concrete" concentrated pervious concrete with various mixes of Cement, GGBS, water and Coarse aggregate. M20 grade concrete was accomplished with a w/c proportion of 0.36. Coarse aggregate of nominal size 20 mm passed and 10 mm held. Cement was halfway supplanted with 30% of GGBS and with a cement & Coarse aggregate proportion of 1:4. Its compressive strength was seen to be 20.4 kN/m^3. A perforated pipe can be given at focus of the pavement above sub-base with the purpose that it gathers the water put away in concrete and depletes it to the required treatment plant or a recharge pit [2]. In this paper "Utilization of Pervious Concrete in Construction of Pavement for Improving their Performance" solid and consider pervious cement blends for low-volume boulevards are developed. The effects of two types of fine totals i.e. Pulverized Stone and River Sand on various properties of pervious cement were considered. In comparison to normal pervious bond concrete blends, the fine total & coarse total extent of 1:5.720 appeared differently. Bond content was increased by 10 kg/m^3 from 300 kg/m3 to 340 kg/m3. In total, 10 different pervious cement blends were made with each and different level of bond content and fine totals. Steel fibre was used to increase the consistency parameter. The effects of such minor take-off from the properties of pervious cement blends were considered [3]. In this paper "Concrete mix proportioning as per IS 10262:2009 – Comparison with IS 10262:1982 and ACI 211.1-91" stated that when choosing the fundamental w/c extent, one should be cautious because it determines the figured bond content. For e.g., for an M20 solid blend, w/c may be 0.5 or 0.55 in any case, and the concrete material will adjust accordingly. The degree of this examination was to dissect BIS and ACI proposed blend configuration rules. The estimation frames in the two codes were consolidated by showing plan measures. These were used to build a standard M20 blend setup [4]. In this paper "Pollution Retention Capability and Maintenance of Permeable Pavements" permeable asphalts made of solid clearing stones are commonly used for storm water infiltration in Germany. Contaminations in the overflow such as overwhelming metals and hydrocarbons can endanger soil and groundwater if they are not properly evacuated by the asphalts (GOLWER 1991). Toxin maintenance capacities were investigated in four different frameworks: clearing stones, pavers with invasion joints, permeable solid pavers with channel sheet, permeable pavers, and pavers with greened penetration joints. Each of the four frameworks showed high contamination maintenance limits, but the greened frameworks and permeable pavers performed better than the penetration joint system. In another examination, the permeable solid pavers were explored with various roadbeds to their toxins evacuation. Contrasts in contamination maintenance limits between the sub-base materials exist. The most astounding poison maintenance limits were come to by pulverized stones with high substance of $CaCO_3$. To check the research facility comes about a field consider on current asphalt before a grocery store was done. The asphalt comprises of permeable solid pieces and was worked in 1985. One stopping box was uncovered and tests of the pavers, the joint filling, the sub-base and the basic soil were taken and explored for substantial metals and hydrocarbons. A slight increment of overwhelming metals was found in the upper 2 cm of the structure; be that as it may, the dirt was not influenced. Mineral oils were additionally found in the dirt, however focuses were low and don't achieve as far as possible for contaminants in soils. From the consequences of the field think about no imperilling of soil and groundwater could be recognized following 15 years of task. Stopping up and the diminishing of the invasion limit regularly happen in penetrable asphalts. Another cleaning device was developed to recover the penetration cap, ensuring the researched asphalts' lifetime operation. When the cleaning strategy with the recently developed cleaning vehicle emerges, he guarantees that the invasion cap can be recouped from 1l/(s.ha) to more than 1500 l/(s.ha) (s.ha). The German control for porous asphalts is pleased with this respect. The asphalts must be cleaned on a regular basis. [5]. In this paper "Permeable Pavements for Roadway Shoulders" traditional shoulders are intended to provide a safety zone for emergency pull offs, provide an operation path during reconstruction and upkeep projects, provide sidelong support to the mainline asphalt, and provide a movement path to various modes of transportation. These features, as well as storm water management, will be provided by a porous asphalt bear system. Prior to constructing penetrable shoulders, road bear applications have a novel set of plan considerations that should be evaluated and properly designed. The design of permeable asphalt shoulders must strike a balance between providing fundamentally adequate asphalt that can withstand activity stacking while still meeting the storm water management/15 hydrologic design objectives. The success and longevity of the penetrable asphalt shoulders are dependent on development strategies and proper maintenance of the porous shoulders. Scratch configuration highlights incorporate a cautious evaluation of the porous asphalt site and its encompassing area use to guarantee that the asphalt surface does not end up sullied with sand/clean or vegetative issue. A hydrological configuration considering precipitation water arriving on the asphalt and water shed from the encompassing territory can be suited into the porous asphalt and after that legitimately treated for water quality enhancements and allowed to leave the asphalt either through penetration into the subgrade or controlled through under drains. The protection of the asphalt from pollutants during construction should be considered, as should the asphalt's ability to accommodate both vehicle stacking and water penetration and exfiltration according to the asphalt plan. Finally, maintenance procedures should include vacuuming to extend the life of the penetrable surface, as well as repairs to correct any minor flaws, such as settlement and ravelling. [6]. In these paper "Concrete in Severe exposures" sources incorporate tempest water spill over from parking areas, water that typically would fly out through tempest sewers to neighbourhood waterways and streams without treatment. Stage I of the NPDES programme, which was distributed in 1990, refers to districts with a population of 100,000 or more residents, as well as construction locales larger than 2.0 ha (5 sections of land). Stage II, which was released in 1999, refers to areas with a population of 10,000 people or more, as well as construction locales larger than 0.4 ha (1 section of land), greatly increasing the number of impacted areas. Permeable asphalt, particularly Portland bond pervious cement (PCPC), helps control contamination release by enabling water to quickly penetrate into an open graded total sub-base and after that into the ground. Hydrocarbons (such as engine oil and fuel) become entangled in the PCPC's vast surface zone or the total sub-base, where they are depleted by general deterioration, either by disappearing or natural degradation. During routine maintenance, 1, 2 PCPC often mechanically sift through larger bits of metal or organic material for later collection. As a result, the pervious solid structure expels the majority of first-flush toxins. Toxins are prevented from accessing storm water authorities and being passed on to surface waters in the neighbourhood as a result of this. By permitting storm water to normally permeate into the dirt, PCPC can likewise decrease or dispense with the requirement for storm water maintenance zones and the framework required passing on the water. Following the Phase II use of NPDES, the United States Green Building Council identified pervious asphalt as a potentially useful framework in its Leadership in Energy and Environmental Design (LEED) program4. Noting the subsequent increased demand for this innovation in all parts of the United States, including cool climate districts, Iowa State University (ISU) began a PCPC research programme in 2004. The following is a summary of the portion of our research that focused on the solidity of PCPC after being subjected to solidifying and defrosting (FT) cycles. For more details, see References 5 and 6. [7]. In this paper "Virtual pervious concrete: microstructure, permeation, and porousness" the effective improvement of a virtual pervious cement in light of a relationship channel 3D remaking calculation has been illustrated. The virtual pervious cement contains a 3D void structure that displays permeation qualities and processed transport properties in great concurrence with those of genuine pervious cements, in view of accessible writing information. The required 2D relation capacities were obtained in this study from the half and half HCSS display, but they could later be obtained directly from 2D pictures of real pervious cements. When complete 3D tomography informative collections from real pervious concretes1 are available, the displayed permeation and transport property measurement codes can be used to register permeation, conductivity, and porousness of the real materials. Finally, possible expansions of the virtual pervious cement have been proposed for investigating strength issues such as solidifying and defrosting safety, as well as stopping up. [8]

3. Methodology

1. Collection of PPC Cement.
2. Collection of Coarse Aggregate and Fine Aggregate.
3. Preparation of molds for casting of concrete cubes.
4. Making test mixes with change level of Coarse Aggregate and Fine Aggregate –
   - Coarse Aggregate and Fine Aggregate will be gathered from industrially accessible sources, and acceptable prices for both totals will be determined.
5. Discovering Optimum Cement Content –
   - The concrete substance will be changed from 350kg/m3 to 420kg/m3 to create the blends.
6. Casting of Cubes and Curing –

- Set of 3 blocks will be cast, for each, with different proportion blend extent. The cubes will be deformed and water relieved for a few days after they have been cast for 24 hours.

7. Testing of molds –
   - Each concrete cube structure will be tested for mechanical properties over the course of 7, 14, and 28 days.
8. Laboratory testing –
   - With the help of compression testing machine capacity – 3000 KN, the compressive strength of the concrete cubes will be tested at certain period of time.

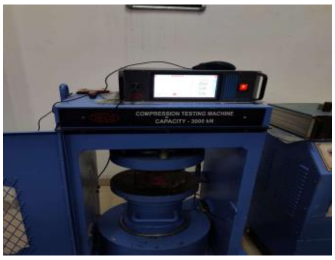


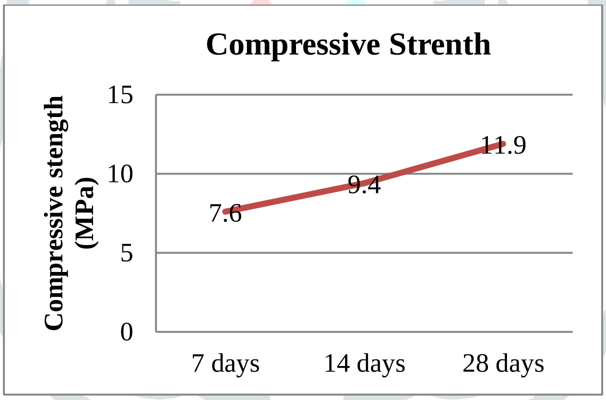
Fig.3 Compression Testing Machine


Fig.4 Concrete cubes

4. Result

Table 1.1 Average value of compressive strength (w/c=0.42, CA: FA=6:1)

Days	Compressive Strength (MPa)
7	7.6
14	9.4
28	11.9

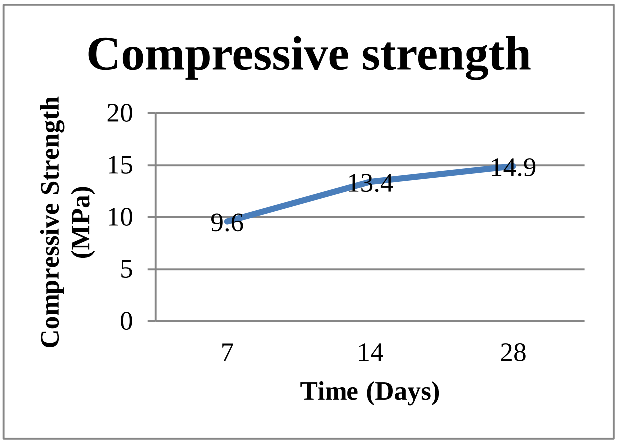


Graph 1.1 Compressive strength graph (w/c=0.42, CA: FA=6:1)

This graph shows testing of compressive strength at 7, 14, 28 days that use of fine totals, compressive consistency is extremely low.

Table 1.2 Average value of compressive strength (w/c=0.42, CA: FA=5.5:1.5)

Days	Compressive strength (MPa)
7	9.6
14	13.4
28	14.9

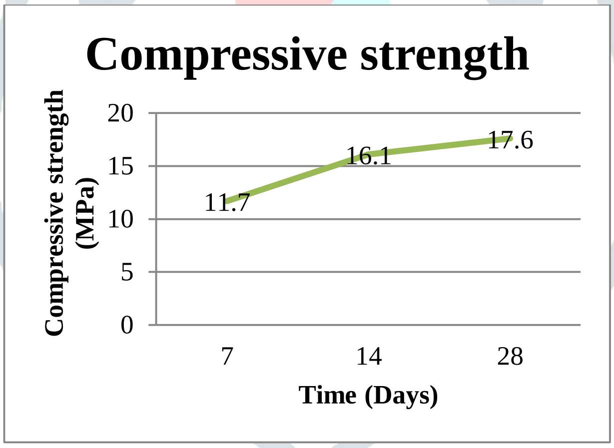


Graph 1.2 Compressive strength graph (w/c=0.42, CA: FA=5.5:1.5)

However in compare to previous one, use of more fine totals resulting bit higher compressive quality.

Table 1.3 Average value of compressive strength (w/c=0.42, CA: FA=5:2)

Days	Compressive strength (MPa)
7	11.7
14	16.1
28	17.6

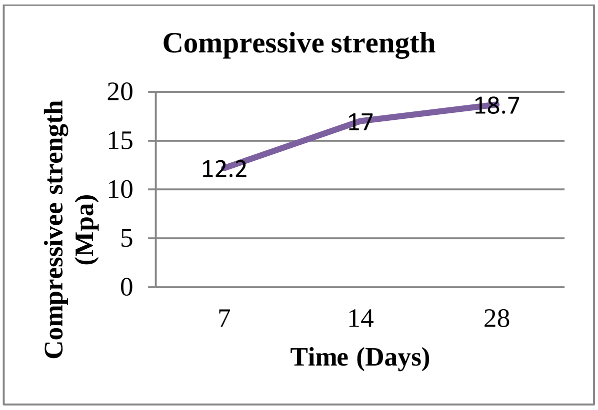


Graph 1.3 Compressive strength graph (w/c=0.42, CA: FA=5:2)

However in compare with previous two examples, makes use of much fine totals resulting higher compressive quality.

Table 1.4 Average value of compressive strength (w/c=0.46, CA: FA=6:1)

Days	Compressive strength (MPa)
7	12.2
14	17.0
28	18.7

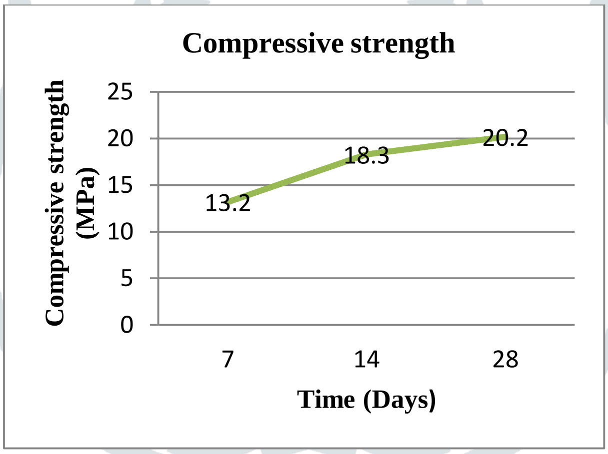


Graph 1.4 Compressive strength graph (w/c=0.46, CA: FA=6:1)

However, because of the higher w/c proportion in this case, much less fine totals are used, and compressive consistency is low and higher than in the previous tests of graph 1.1, 1.2. 1.3.

Table 1.5 Average value of compressive strength (w/c=0.46, CA: FA=5.5:1.5)

Days	Compressive strength (MPa)
7	13.2
14	18.3
28	20.2

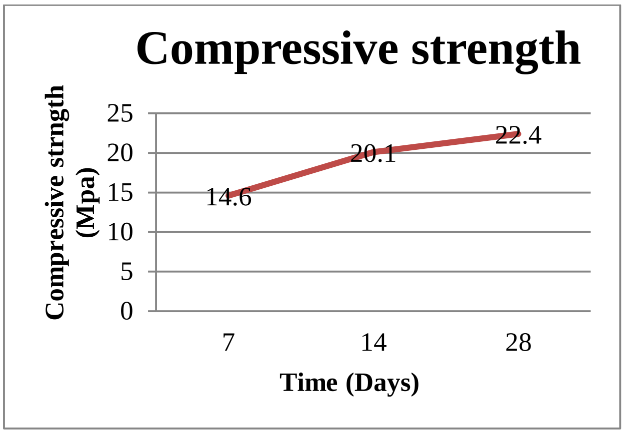


Graph 1.5 Compressive strength graph (w/c=0.46, CA: FA=5.5:1.5)

However, in comparison to the test of Graph 1.4, for this example more fine totals are used, so compressive consistency is higher than in the test of Graph 1.4 and higher than the tests of Graph 1.2 and Graph 1.3 with Consider same the w/c proportion.

Table 1.6 Average value of compressive strength (w/c=0.46, CA: FA=5.2)

Days	Compressive strength (MPa)
7	14.6
14	20.1
28	22.4

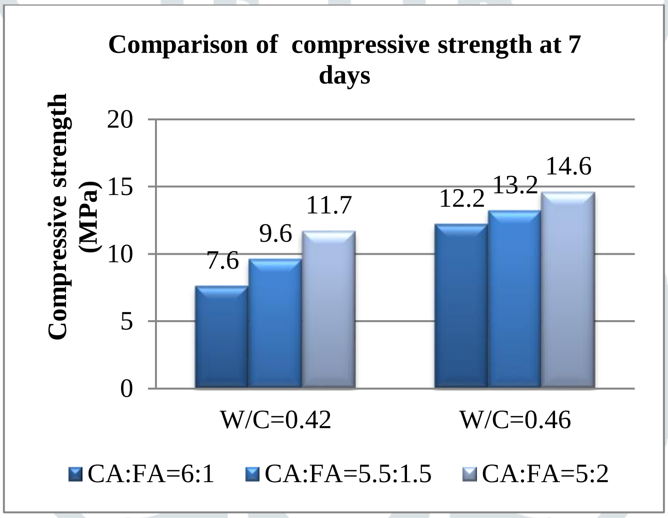


Graph 1.6 Compressive strength graph (w/c=0.46, CA: FA=5.2)

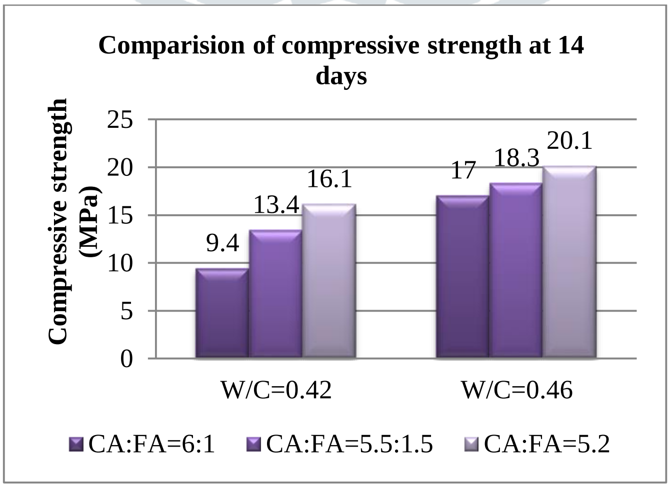
However, in comparison to the tests of Graph 1.4 and Graph 1.5, more fine totals are used in this example, so compressive efficiency is higher than the test of Graph 1.3 due to the considering higher w/c proportion.

Due to very low porosity, compressive strength of samples of following ratios was not tested:

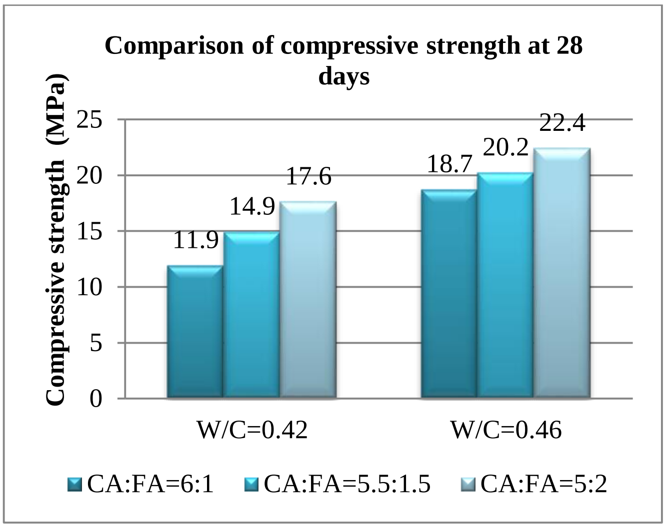
- ✓ W/C=0.50, CA: FA=6:1
- ✓ W/C=0.50, CA: FA=5.5:1.5
- ✓ W/C=0.50, CA: FA=5:2



Graph 1.7 Comparison of compressive strength on 7 days



Graph 1.8 Comparison of compressive strength on 14 days



Graph 1.9 Comparison of compressive strength on 28 days

5. Conclusion

1. We found out that the compressive strength of pervious concrete is increases with increase amount of fine aggregate & mixing the amount of water added with aggregates and cement. However, increase fine aggregate with increases amount of water added in the mixture then it decreases the compressive strength of the pervious concrete.
2. We also find out that increase in water cement ratio is increases the compressive strength of pervious concrete to some limit but decreases the porosity of the concrete.
3. As the water cement ratio is raised, the cement and fine aggregate fill the pores. Because of the high volume of water, compressive strength testing for w/c ratio 0.50 was not performed.
4. We found out that cube with w/c ratio 0.42 with CA: FA=6:1, CA: FA=5.5:15 and CA: FA=5:2 had greater permeability but very less compressive strength.
5. We found out that cube with w/c ratio 0.5 was very less porous or impermeable.
6. We found out that cube with w/c ratio 0.46 had good permeability but when increase CA: FA ratio decreases the permeability.
7. Finally, it was determined that a combination with a w/c ratio of 0.46 and a CA: FA ratio of 5.5:1.5 was the best to use because it had strong permeability and compressive power.

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