Experimental Investigation on Pervious Concrete Paved Brick

M.Kathiresan [1], A. Vigneshwaran [2], K. Vijay [3], G. Jothimani [4], M. Karthick [5]
[1]Assistant Professor, Department of Civil Engineering, Sri Ramakrishna College of Engineering, Perambalur - 621113, Tamil Nadu, India.
[2, 3, 4, 5] UG scholar Department of Civil Engineering, Sri Ramakrishna College Of Engineering, Perambalur- 621113, Tamil Nadu, India.

Abstract – Pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. It is also called as porous concrete, permeable concrete, no fines concrete and porous pavement. Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. This type of concrete having a high void content of about 30%, is becoming popular nowadays due to its potential to reduce the runoff to the drainage systems which can provide a water flow rate around 0.34 cm/second. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality . Pervious concrete also find its effective application in low loading intensity parking pavements, footpaths, walkways and highways. The water-cement ratio was kept at different ratios 0.35, 0.40, 0.45. Different properties of pervious concrete e.g. workability, compressive strength test at 7, 14 & 28 days have been studied experimentally. The mix proportions with aggregates size (4.75 mm to 10 mm) gives higher strength when compared to mixes with aggregates size (10 mm to 20 mm),pumice and (4.75 mm to 20 mm) respectively.

Index Terms – Pervious concrete, Mix proportion, Permeability, porosity.

1. INTRODUCTION

1.1. General

Concrete is a construction material composed of cement, commonly Portland cement as well as other cementations materials such as fly ash and slag cement, coarse aggregate, fine aggregate, fine aggregate such as sand, water, and chemical admixtures. Both the fine and coarse aggregate bind together with the fluid cement that hardened over time most concrete used are limed based concrete such as Portland cement concrete or concretes made with other hydraulic cements.

1.2. Basic principle

In pervious concrete the most important and basic principal which turns out to be different from other types of concrete like PCC and RCC because, it has no fine aggregates in it. pervious concrete also has interconnected voids and because of that water will percolate and spread in all direction which is not possible if those joints are not interconnected.

1.3.Pervious concrete

The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groin. Pervious concrete is a special type of concrete with a high porosity used for concrete Flatwork applications that allows water from precipitation and other sources to pass through it, thereby reducing the runoff from a site and recharging ground water levels.

The void content can range from 18 to 35% with compressive strengths of 400 to 4000psi . The infiltration rate of pervious concrete with fall into the range of 2 to 18 gallons per minute per square foot(80 to 720 liters per minute per square meter).

1.4.Uses of pervious concrete

Pervious concrete is traditionally used in parking areas, areas with light traffic pedestrian walkways, and greenhouses. Pervious concrete is an important application for sustainable construction. Porous concrete is concrete is concrete which is designed to have many voids to trap water and allow it to penetrate through the concrete to the ground below. This concrete does not use fine aggregates in the mixture that why it has more voids than conventional concrete.

1.5.Advantages of pervious concrete

Porous concrete can help route storm runoff and rain directly into the soil where it can nourish gardens and flow down into the water table. It also can be made with recycled materials including recycled concrete rubble and recycling aggregates. It an ecologically friendly and aesthetically pleasing building material.

1.6.Disadvantages of pervious concrete

Its low compressive and flexural strength than conventional concrete, rough surfaces and honey combed surface. This may hinder its application in pavements for

use in heavy traffic like highways.The cost of maintenance is high. Its clogging effects may result a decreased water permeability hence affecting its durability.

2. LITERATUREREVIEW

1.Karthik H.Obla (2010) Investigated that Pervious concrete is a special high porosity concrete used for flatwork application that allows water from precipitation and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels. Its void content ranges from 18 to 35% with compressive strengths 28 to 281 kg/cm^2.The Pervious concrete will fall into the range 80 to 720 per minute per square meter. Typically, Pervious concrete has little or no fine aggregate and just enough cementations paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids.

2.Baoshan huang(2009) studied the balance between permeability and strength properties of polymer – modified pervious concrete(PMPC). In addition to latex, natural sand and fiber were included to enhance the strength properties of pervious concrete. The test results indicate that it was possible to produce pervious concrete mixture with acceptable permeability and strength through the combination of latex and sand, pervious concrete has been increasingly used to reduce the amount of runoff water and improve the water quality near pavements and parking lots.

However, due to the significantly reduced strength associated with the high porosity, pervious concrete mixtures currently cannot be used in highway pavement structures. A laboratory experiment was conducted in this study to improve the strength properties of pervious concrete through the incorporation of latex polymer.`

3.Ming-Ju Lee,Ming-Gin LeeYishuo Huang,and Chia-Liang Chiang in "Purification Study of Pervious Concrete Pavement studied by capturing storm water and allowing it to seep into the ground, pervious concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S . Environmental Protection Agency storm water regulations. In this research, water quality and pollutants leached from pervious concrete pavement was investigated.

This project mainly aims to study the pervious concrete pavement by pollutants such as acid rain, sea water or waste lubricating oil. The results show that pollutant and water purification of pervious concrete pavement both significantly improved in the acid rain, sea water or waste motor oil test.

A diluted sulphuric acid solution(PH value 2) after the pervious concrete pavement system could significantly enhance its PH value to 6.5 above. This study demonstrates that implementing pervious concrete pavement is valuable for road design and hydrologic consideration.

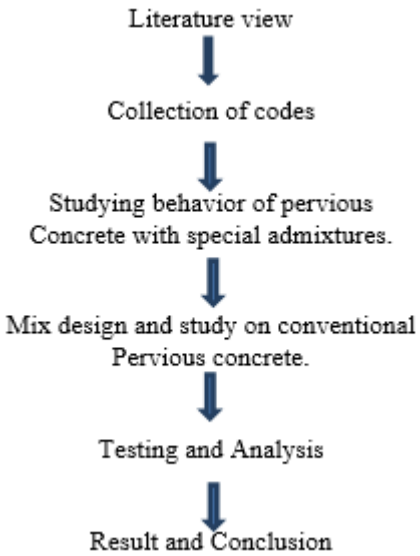
3. METHODOLOGY

3.1. Objective

The main objective of the project is to investigate the experimental investigation of pervious concrete with special admixtures. In this project, a brief literature review has been carried out on previous concrete, GGBS and Polyvinyl alcohol.

3.2. Work to be done

Detailed Literature Survey was carried out on pervious concrete and their behavior with admixtures. Experimental investigation of concrete by various concentrations of admixtures.



3.3.Collection of materials

In this chapter various materials which were used in project are explained along with its properties and method of conducting the test was discussed in detail.

3.4.Materials used

- Aggregates
- Coarse aggregate(20mm).
- Ordinary Portland cement
- GGBS(Ground –granulate blast slag)
- Poly(Vinyl Alcohol)
- 10mm Aggregate
- Pumice

3.4.1.Aggregates

The aggregates are the main components of the concrete which greatly varies the strength, density and other properties of

concrete

3.4.2.Coarse Aggregate(20mm)

Coarse aggregates are widely used in construction applications. They are generally categorized as rock larger than a standard No. 4 sieve (3/16 inches) and less than 2 inches. Usually available coarse aggregates having the maximum size of 20mm were used in this project.

3.4.3.Ordinary Portland Cement

OPC is the general purpose cement used in concrete constructions. OPC is a compound of lime (CaO), silica (SiO_2), alumina (AL_2O_3), iron (Fe_2O_3) and sulfur trioxide (SO_3). Magnesium (MgO) is present in small quantities as an impurity associated with limestone.

3.4.4.GGBS

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

GGBS is use to make durable concrete structures in combination with ordinary Portland cement an /or other pozzolanic materials.

3.4.5.Poly(Vinyl Alcohol)

Poly(vinyl alcohol) (PVOH, PVA, or PVAl) is a water-soluble synthetic polymer. It has the idealized formula $[CH_2CH(OH)]_n$. It is used in papermaking, textiles, and a variety of coatings. It is white (colorless) and odorless. It is sometimes supplied as beads or as solutions in water.

3.4.6.10mm Aggregate

10mm crushed river aggregate to concrete production specification. Blue grey to brown in colour this aggregate can meet many job application. A Hard an durable rock, washed and screened, with consistent cubic particle shape, Australian standard complaint Technical information and NATA certificates available on request.

4. TESTING OF MATERIALS

4.1.Test on aggregates

Aggregate plays an important role in pavement construction. Aggregates influence, to a great extent, the load transfer capability of pavements. Hence it is essential that they should be thoroughly tested before using for construction.

i. Water absorption

ii. Specific Gravity Test

4.1.1.Water Absorption Test

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000g should be used.

RESULTS

Water absorption = [(A – B)/B] x 100%

=1.21%

4.1.2.Specific gravity test

Specific gravity test on aggregate

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity test was carried out by using Pycnometer.

Calculation

TABLE 1: Specific garavity calculation

S. No	Description	20mm agg	10mm agg	pumice
1.	Weight of empty pycnometer(W_1)	0.60	0.60	0.60
2.	Weight of pycnometer+coarse aggregate(W_2)	1.25	1.25	1.30
3.	Weight of pycnometer +coarse aggregate+ water(W_3)	1.80	1.80	1.80
4.	Weight of pycnometer +water(W_4)	1.40	1.40	1.40
5.	Specific gravity (G)	2.72	2.60	2.33

4.2.Test on cement

Quality tests on cements at construction site (also called field tests on cement) are carried to know the quality of cements supplied at site. It gives some idea about cement quality based on color, touch and feel and other tests.

i) Consistency Test

ii) Initial and Final setting time test

iii) Specific gravity

4.2.1. Specific gravity test of cement

This test was carried out to determine the quantity of water required to produce a cement paste of standard consistency. Consistency test was determined by using Vicat apparatus.

Calculation

Found standard consistency of cement =29.5%

Empty weight of crucible (w1) = 29.90g

Weight of crucible +cement (w2) = 47.77g

Weight of crucible + cement+ kerosene (w3)= 80.49g

Weight of crucible + kerosene (w4) = 67.36g

Specific gravity of kerosene ranges from 0.79 to 0.84.

Take specific gravity of kerosin as 0.82.

Specific gravity = 3.15

4.2.2.Setting time test of cement

Initial setting time is that time period between the time water is added to cement and time at which 1 mm square section needle fails to penetrate the cement paste, placed in the Vicat's mould 5 mm to 7 mm from the bottom of the mould.

Initial setting time = 4.2mins

Final setting time = 4.95mins

5. MIX DESIGN

A-1 Stimulations for proportioning:

Grade designation:M40

Type of cement : OPC43 grade

Maximum nominal aggregate size : 20mm

Minimum cement content : 320 kg/m3

Maximum water cement ratio : 0.34

Workability : 100mm (Slump)

Exposure condition : Severe

Type of aggregate : Crushed angular aggregate

Maximum cement content (OPC) : 400 kg/m3

Chemical admixture type : Super plasticizer confirming to IS-9103

TABLE 2: MIX DESIGN FOR NORMAL AND MIXED PERVIOUS CONCRETE

MATERIAL	CEMENT	COARSE AGGREGATE	SP	WATER
QUANTITY(kg/m³)	466.66	1140	7	140
PROPORTIONS	1	2.44	0.015	0.30

6. TEST ON FRESH CONCRETE

6.1.1.Slump cone (workability test)

Slumptestisused to determine the work ability of fresh concrete. Slumptest as per IS:1199-1959 is followed.

TABLE 3: Slump value of pervious concrete

SL.NO	CONCRETE MIX	SLUMP VALUE(mm)
1	Conventional pervious concrete	80
2	Mixed pervious concrete	60

6.1.2.Compaction Factor Test

Compaction factor of fresh concrete is done to determine the workability of fresh concrete by compaction factor test as per IS: 1199-1959.

TABLE 4: Compaction factor

SL.NO	CONCRETE MIX	COMPACTION FACTOR (%)
1	Conventional pervious concrete	86
2	Mixed pervious concrete	88

7. HARDENED CONCRETE TESTING

7.1.General

The hardened concrete testing is used to determine the strength of the concrete.

7.2.Compression strength test

The specimen is tested by compression test machine after 7 days, 14 days and 28 days curing. Load should be applied gradually at the rate of 140kg/cm per minute till specimens fails

calculation:
compressive strength:
Rectangular area = 225*105mm²
Load = 250KN
Strength = Load/Area
= 420*10³/23625
= 17.79N/mm²

TABLE :5 Compressive strength of concrete

RECTANGLAR SECTION			
Material used	28 Days		Compared Strength (N/mm^2)
	Load (K.N)	Stress (N/mm^2)	
Pumice	420	17.79	21.61
10mm Agg	340	14.40	
20mm Agg	510	21.61	

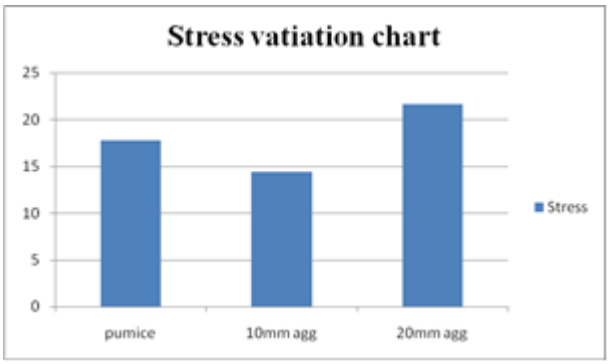


Chart:1-28-Days

TABLE :6 Compressive strength of concrete

CIRCULAR SECTION			
Material used	28 Days		Compared more Strength (N/mm^2)
	Load (K.N)	Stress (N/mm^2)	
Pumice	510	12.75	30.25
10mm Agg	630	15.75	
20mm Agg	1210	30.25	

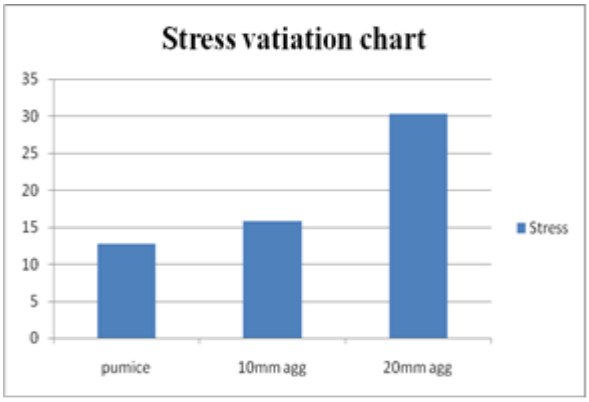


Chart:2-28-Days

TABLE :7 Compressive strength of concrete

SQUARE SECTION			
Material used	28 Days		Compared more Strength (N/mm^2)
	Load (K.N)	Stress (N/mm^2)	
Pumice	320	14.22	26.22
10mm Agg	530	23.55	
20mm Agg	590	26.22	

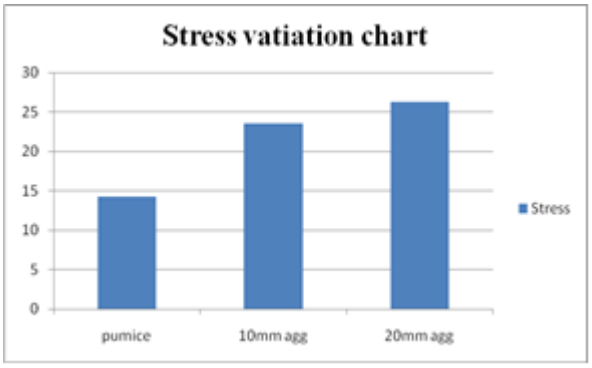


CHART:3-28-DAYS

TABLE :8 Compressive strength of concrete

I - SECTION			
Material used	28 Days		Compared Strength (N/mm^2)
	Load (K.N)	Stress (N/mm^2)	
Pumice	860	3.45	6.22
10mm Agg	980	3.93	
20mm Agg	1550	6.22	

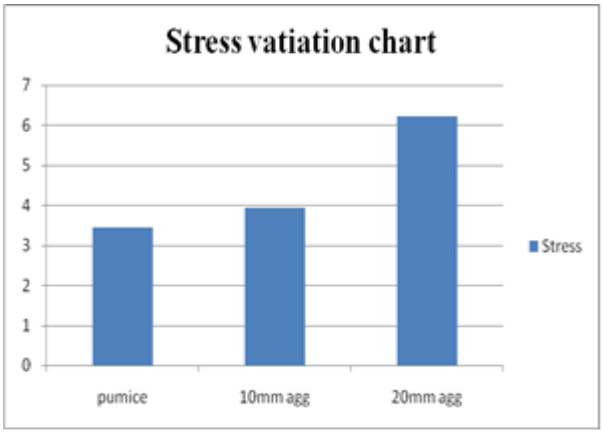


Chart:4-28-Days

8. RESULTS AND CONCLUSION

8.1.General

The pervious concrete which when tested by adding the admixtures gives desirable values in certain parameters which is discussed below. Based on the values and after testing in

various aspects, The values are compared normal e normal pervious concrete and the admixtures mixed pervious concrete.

The Pervious concrete in current scenario is the urgent need for maintaining the storm water management and to keep the surrounding waste stagnated water free environment. The GGBS and PVA is the two major admixtures which shows results in different variations when mixed with the normal pervious concrete as it differs the percentage in large amount and its is also cheap in range.

Pervious concrete acts a physical barrier to various action of any problems in the road surface. The flexural strength increases the durability and crack formation on the surface of the cracks is totally stopped by this pervious concrete enriched with PVA as the polymer enhances the flexural stability for the road. Also, the Compressive strength and crushing load helps in giving the more stability to the road.

The Durability of the Pervious concrete majorly such as Chemical attack, Carbonation is made here, The test shows the pervious concrete is completely from the chemical reaction induced in it and it also gives less carbonation as the cement which is major cause of CO2 is replaced by GGBS. Hence, The two parameters shows the durability of the pavement made from Pervious concrete efficiently up to thirty years with less traffic and manageable road acquisition.

TABLE 9: Final results of admixture used and normal pervious and percentage increase

S. No	Description	Normal Pervious Concrete 28 days strength (N/mm^2)	Admixture mixed pervious Concrete 28 days strength (N/mm^2)	Percentage Increased
1.	Rectangular Section	12.24	21.6	56.66%
2.	Circular Section	20.9	30.25	69.09%
3.	Square section	15.2	26.22	57.97%
4.	I-Section	1.23	6.22	19.77%

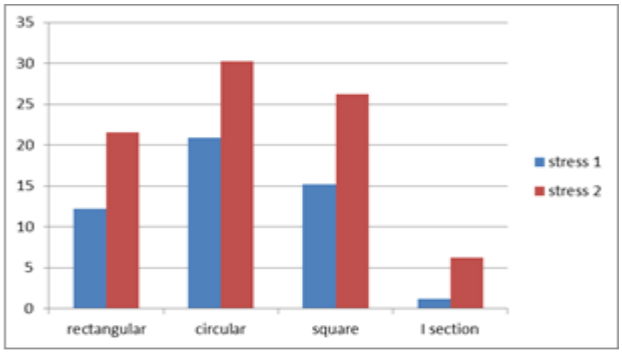


Chart-5-28 days final result

8.2 Permeability

The flow rate through pervious concrete depends on the materials and placing operations. Typical flow rates for water through pervious concrete are 3gal/ft²/min (288 in./hr, 120 L/m²/min, or 0.2 cm/s) to 8 gal/ft²/min (770 in./hr, 320 L/m²/min, or 0.54 cm/s), with rates of up to 17 gal/ft²/min (1650 in./hr, 700 L/m²/min, 1.2 cm/s). Even higher rates have been measured in the laboratory

8.3 Durability

8.3.1Freeze-Thaw Resistance

Freeze-thaw resistance of pervious concrete in the field appears to depend on the saturation level of the voids in the concrete at the time of freezing. In the field, it appears that the rapid draining characteristics of pervious concrete prevent saturation from occurring. Anecdotal evidence also suggests that snow-covered pervious concrete clears quicker, possibly because its voids allow the snow to thaw more quickly than it would on conventional pavements. In fact, several pervious concrete placements in North Carolina and Tennessee have been in service for over 10 years.Note that the porosity of pervious concrete from the large voids is distinctly different from the microscopic air voids that provide protection to the paste in conventional concrete in a freeze-thaw environment. When the large open voids are saturated, complete freezing can cause severe damage in only a few cycles. Standardized testing by ASTM C 666 may not represent field conditions fairly, as the large open voids are kept saturated in the test, and because the rate of freezing and thawing is rapid. It has been shown that even after 80 cycles of slow freezing and thawing (one cycle/day), pervious concrete mixtures maintain more than 95% of their relative dynamic modulus, while the same mixtures showed less than 50% when tested at a more rapid rate (five to six cycles/day). It was noted that better performance also could be expected in the field because of the rapid draining characteristics of pervious concrete.Research indicates that entrained air in the paste dramatically improves freeze-thaw protection for pervious concrete. In addition to the use of air-entraining agents in the cement paste, placing the pervious concrete on a minimum of 6 inches (150 mm), and often up to 12 (300 mm) or even 18 inches (450 mm) of a drainable rock base, such as 1-inch (25-mm) crushed stone, is normally recommended in freeze-thaw environments where any substantial moisture will be encountered during freezing conditions.

8.3.2 Sulfate Resistance

Aggressive chemicals in soils or water, such as acids and sulfates, are a concern to conventional concrete and pervious concrete alike, and the mechanisms for attack are similar. However, the open structure of pervious concrete may make it more susceptible to attack over a larger area. Pervious concretes can be used in areas of high-sulfate soils and

groundwaters if isolated from them. Placing the pervious concrete over a 6-inch (150-mm) layer of 1-inch (25-mm) maximum top size aggregate provides a pavement base, stormwater storage, and isolation for the pervious concrete. Unless these precautions are taken in aggressive environments, recommendations from ACI 201 on water-to-cement ratio and material types/proportions should be followed strictly.

8.3.2 Abrasion Resistance

Because of the rougher surface texture and open structure of pervious concrete, abrasion and raveling of aggregate particles can be a problem, particularly where snowplows are used to clear pavements. This is one reason why applications such as highways are generally not suitable for pervious concretes. However, anecdotal evidence indicates that pervious concrete pavements allow snow to melt faster, requiring less plowing.Most pervious concrete pavements will have a few loose aggregates on the surface in the early weeks after opening to traffic. These rocks were loosely bound to the surface initially, and popped out because of traffic loading. After the first few weeks, the rate of surface raveling is reduced considerably and the pavement surface becomes much more stable. Proper compaction techniques reduce the occurrence of surface raveling.

9. CONCLUSION

The Compressive strength, had increased by adding admixtures such as GGBS(25%) and POLYVINYL ALCOHOL (2%). By using these admixtures the above strengths are increased when compared to Normal Pervious Concrete. The Compressive strength has increased by 55%, Flexural strength has increased by 61%, Split Tensile strength has increased by 40%.

Achieved greater flexural strength comparing to the normal pervious concrete.It also reduces the emission of CO2 which is produced from the cement because of partial replacement by the GGBS .Itis the mineral admixtures which increases the compressive strength in certain aspect and PVA which is the chemical admixture increases the flexural strength in pervious concrete by small amounts.These can also be used as sound absorbing walls in classrooms, auditorium etc. This can also be used at railway platforms. This will help in reducing water accumulation on railway tracks, parking lots etc .

The strength characteristics of previous concrete can be further studies by taking into account the following parameters :

1. By varying the water cement ratio.
2. By varying the amount of silica fume and addition of super plasticizers.By using some little amount of fine aggregates.
3. By using recycled coarse aggregates in the concrete mix as replacement of coarse aggregates.
4. Using the super plasticizers in the mixes only by removing silica fume.
5. Using different aggregates size and mix ratio

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