Effect of the aggregates size on some properties of modified pervious concrete

Israa Hasan Nayel **Mohammed Kareem Abed**
Alforat Alawsat technical University,Technical Institute of Babylon
Mohammed-k1965@yahoo.com

Abstract

Pervious concrete is concrete mixture made from cement, coarse aggregates, water, little or no fines aggregate and in some cases admixtures. It has been considered a best management practice because of its ability to reduce storm water runoff and to initiate the filling of pollutants. Because the hydrologic properties of pervious concrete has been the primary reason for its reappearance in roads. Pervious concrete strength and other properties mainly depend on aggregate size and proportion of the materials. This study focused on the effect of the aggregate size on the pervious concrete content of fiber and latex. The aim in this study of laboratory test was give rise progress the strength properties of pervious concrete during find out the maximum size of aggregate with incorporation fiber and latex. The test results indicate that strength and permeability of pervious concrete mixture was increase by the decreasing of maximum size aggregate.

Keywords: Pervious Concrete, Management, Aggregate Size, Fiber, Permeability.

الخلاصه

الخرسانة النفاذة هي عبارة عن خليط خرساني مصنوع من الإسمنت، الركام الخشن، الماء، الركام الناعم بكميات قليلـــة أو معدومة والمضافات في بعض الحالات. وقد اعتبرت أفضل طريقة وذلك بسبب قدرتها على تقليل مياه الأمطار والبـــدء فـــي مـــلء الملوثات. لأن الخصائص الهيدرولوجية للخرسانة النفاذة كانت السبب الرئيسي في ظهورها في اعمال الطرق. تعتمد قوة الخرســـانة النفاذة والخصائص الأخرى بشكل رئيسي على المقاس الاقصى للركام المستخدم بالإضافة لنسب المواد. ركزت هذه الدراسة علـــى تأثير حجم المقاس الاقصى للركام على الخرسانة النفاذة الحاوية على الالياف كذلك المضافات. الهدف من الفحوصات المختبرية في هذه الدراسة لتحسين خصائص قوة الخرسانة النفاذة الحاوية على الالياف والمضافات من خلال معرفة تأثير الحجم الأقصى للركام. نتائج الاختبار تشير إلى أن قوة ونفاذية خليط الخرسانة النفاذة يزداد كلما قل المقاس الاقصى للركام.

الكلمات المفتاحية: الخرسانة النفاذة، الخصائص الهيدرولوجية، المقاس الاقصى، الالياف، قوة الخرسانة.

1. Introduction.

Porous concrete or permeable concrete also referred to Portland cement pervious concrete (pcpc). It's a mixture of regular coarse aggregate, cement with or some times without a little amount of fine aggregate and water. to make a post that combine a thin coat around aggregate particles appropriate amounts of water and cementatious material are employed but let go free spaces between them. Also, pores are create in the permeability materials (Huang et.al.,2010; Montes, 2006). Pcpc contains small or fine aggregate, to cover and bind the aggregate particles with each other we using an suitable amount of cement paste to make a system of high porosity, and inter connected voids that can drain off water quickly. In addition, generally we shall know the void content of (pcpc) is between 15% and 25% , and the permeability of water is typically about 2-6 mm/s (Tennis *et.al.*,2004; Schaefer *et.al.*,2006). Pcpc has been used for over 30 years in many countries , for its deferent environmental interest like controlling storm water runoff , restoring supplies of ground water , and reducing water and soil infection (Kajio *et.al.*,1998;Tennis *et.al.*,2004). Strength and resistance abrasion of (pcpc) can be recover greatly by using appropriately – selected aggregate. Mixtures of fine aggregate and organic intensifiers (Yang and Jiang, 2003). From pervious studies we know that gradation and particle size of aggregate , mass ratio of aggregate to cement are the primary factors influence on porosity , permeability and compressive strength of pcpc whenever water cement ratio has a minor impact on properties of (pcpc) (Jiang *et.al.*,2005). The number of aggregate

particles per unit volume of concrete , the specific surface of aggregate , and the binding area can increase , which eventually results in an improvement in strength of pervious concrete by using smaller size aggregate(Wang,1997).To replace approximate 7% (by weight) of coarse aggregate used river sand to improve the concrete strength . The results indicated that the 7-day compressive strength increases from (9.6 – 14.5 MPa) to (22.2 – 22.7 MPa).In spite of the void content is reduced of the fine sand in the mixtures , all values of the void content are still with an acceptable rang (715%) for pcpc applications (Wang, 1997). The high porosity in pcpc is usually associated with relatively low strength. Its application of conventional pervious concrete is limits because of the low strength like heavy traffic highway but also effected on the stability of the structures, in spite of like susceptibility to frost damage and low resistance to chemicals. So pcpc with low strength can only be use in some application like as sidewalls , parking lots and sub bases for pavement (Nader 1995; Fukute,1998; Wang, 1997). Also kevern refer that the fiber of polymer (SBR) has a significantly improves workability , strength , permeability and freeze – thaw resistance , which makes porous concrete obtain higher strength at relatively lower cement contents and results in relative higher porosity (Kevern, 2008).

2- Proposed method of this research.

The aim of this study is to show the effect of the size of aggregate in polymer modification pervious concrete (pmpc) at the properties(mechanical and physical) of pmpc. In this study were used three different maximum size aggregates (14 mm , 10 mm and 4.75mm) with one type of fiber and latex (SBR) that was used to create the mixture of pervious concrete .

By test of air void, compressive strength test and test of splitting tensile, the properties of pervious concrete were reform.

3. Materials

The materials of the proposed method require the following.

3.1. Cement

The ordinary Portland cement corresponding to the Iraqi specification No.(5)/(1984) was used and it has been stored as well to keep it from humidity .

The following Table (1) shows the chemical analysis of the proportion of cement components and the user specification limits of Iraqi No (5)/(1984).

Table (1) Chemical analysis of cement

Compound Composition	Abbreviation	Percentage By Weight	Limits of Iraqi Specification No.5/1984
Silica (%)	SiO2	22.04	-
Lime (%)	CaO	61.67	-
Alumina (%)	AL2O3	4.10	-
Iron Oxide (%)	Fe2O3	5.08	-
Sulfate (%)	SO3	1.77	≤ 2.8%
Magnesia (%)	MgO	2.14	≤ 5%
Loss On Ignition (%)	L.O.I	1.99	≤ 4%
Lime Saturation Factor	L.S.F	0.86	0.66 – 1.02
Insoluble Residue (%)	I.R	0.60	≤ 1.5

In addition, Table (2) shows the analysis physicist of the proportion of Portland cement was used in this study.

Table (2) Physical analysis of cement

Physical Property	Test result	Limits Of specification No 5/1984
Specific surface area (gm/cm^2)	3400	2500
Setting time Initial hrs : minutes Final hrs : minutes	 3:15 4:30	 0:45 (Min.) 10:0 (Max.)
Compressive strength (MPa) 3 days 7 days	 25.5 32.2	 15 (Min.) 23 (Min.)

3.2. Fine aggregate

The use of sand AL-ukhaydir that corresponding to Iraqi specification No.(45)/(1984) and the absorption and specific gravely are equal to (0.08 , 2.64) respectively .

Table (3) Grading of fine aggregate.

Sieve size (mm)	% passing	Iraqi specification No.(45)/(1984) Zone No.2
4.75	99	90 – 100
2.36	87	75 – 100
1.18	76	55 – 90
0.60	47	35 – 59
0.30	18	8 – 30
0.15	6.4	0 – 10
Fineness modulus 2.664		

3.3. Coarse aggregate.

The use of rivers from Al- Nibai area has been taking of three samples in maximum size according to Iraqi standard specifications. The absorption and specific gravely are equal to (0.03 , 2.68) respectively. Table (4) shows that the Grading of coarse aggregate.

Table (4) : The Grading of coarse aggregate.

Sieve size (mm)	% passing	Iraqi specification No.(45)/(1984)
14	100	90-100
10	75	50 – 85
4.75	8	0 – 10
2.36	-	-

3.4. Water

The drinking water was used during mixing and curing processes for all concrete mixtures.

4- Latex polymer and fiber.

SBR is type of additives is chosen and added to the mixture to improve the strength of the pervious concrete, where it has susceptibility for bonding between the components of the mixtures successful. Where it is a thick white fluid in appearance and has a rood viscosity with water content about 52.7%. It has several engineering applications that shall be used to supply or replace the cement like a bond material and to improve strength for compressive, tensile and splitting tensile for concrete. In addition of SBR it used fiber in mixture to evaluated the effected of maximum size aggregate on the mechanical property of pmpc. Fiber of Polymer has a difficult properties like control on the form of cracks in concrete.

5. Mix Design

In this study we take a control mixture which contain cement , water , fine aggregate and a different three size of coarse aggregate was used in every mixture to improve the total behavior of Portland modified pervious concrete pmpc latex and fiber were added to the mixture. When latex adding to the mix. The portion of solid for latex was used to replace %15 from sand and cement that replace %8 from coarse aggregate as weight ratio.

The properties for pmpc are compared with the control mixture for the three different size of coarse aggregate for pervious concrete. From Table 5, it can be noted that the A means control mix, B is the modified by latex, C is the adding fiber, and D means adding the fiber and latex. A mechanical mixer was use where they were mixing the following materials (cement, sand, gravel, and fiber). Then added water to the blender then continued for (5 minutes) until it became homogeneous concrete .Then it was monitoring templates after it is lubricated with oil where it was put concrete in the form of layers, the author used a vibrator for (10-25) sec. To get rid of air bubbles were then modified surface models and left it in the lab for nearly 24 hours .then weight the models and flooded with water up to the age of the test , models test by age was (7,14,28) day.

Table (5) shows the proposed method based on different three size of coarse aggregate.

Table (5): Proposed method based on different three size of coarse aggregate.

Agg.size	Mix type	Cement	Latex binder	Coarse agg.	River sand	Water	Fiber
14 mm	A	301.6	29.8	1352.6	94.8	105.2	
	B	285.1		1331.0	92.1	87.9	0.8
	C	302.8	29.8	1352.6	94.8	105.2	0.8
	D	296.8		1331.0	92.1	87.9	
10 mm	A	312.9	31.4	1403.6	98.2	109.2	
	B	307.8		1381.2	95.7	91.3	0.8
	C	310.8	31.4	1403.6	98.2	109.2	0.8
	D	307.1		1381.2	95.7	91.3	
4.75 mm	A	330.8	31.5	1483.9	103.8	114.4	
	B	325.1		1460.3	101.1	96.8	0.8
	C	328.9	31.5	1483.9	103.8	114.4	0.8
	D	325.4		1460.3	101.1	96.8	
Note : A – control ; B- latex modified ; C – fiber added ; D – latex and fiber .							

6. Test method

6.1 Compressive strength

The metal molds with dimensions (100×100×100)mm were used according to the Bs 1881 part 116-83.The fat templates for each group before casting process at a rate of three specimens for each form to different age (7,14,28) day .

6.2 Splitting tensile strength.

Cylindrical molds were used with dimension (100×200)mm. The vertical load and splitting tensile were recorded and found in the test.

6.3 Air voids test

It is necessary to know the bulk volume properties of the compacted concrete to obtain the airs content of void. It's inappropriate to use the submaerged weight measurement to get the bulks volume because the pervious concrete has high interconected voids air .

So in this study a vacuum package sealing device was used to measure the specifics gravity for asphalt mixtures to get the effective air voids to pervious concrete specimens.

7. Results and discussion.

The compressive strength is considering one of the important properties of the concrete to get strength to carry the different loads .The Fig. (1) show the effect of the maximum aggregate size on the compressive strength with latex and fiber. So as it is expected the size of the smaller particles is met the high compresive strength. and it's clear when adding latex and fiber for different size of aggregate both of them were increasing the compressive strength of the mixture because it will increasing the amount of the cement past and this will increasing the connected area between the neighbors aggregate particles. It is noteworthy that rehydration products of cement and the latex will working together as over lapping material that will improving the strength .

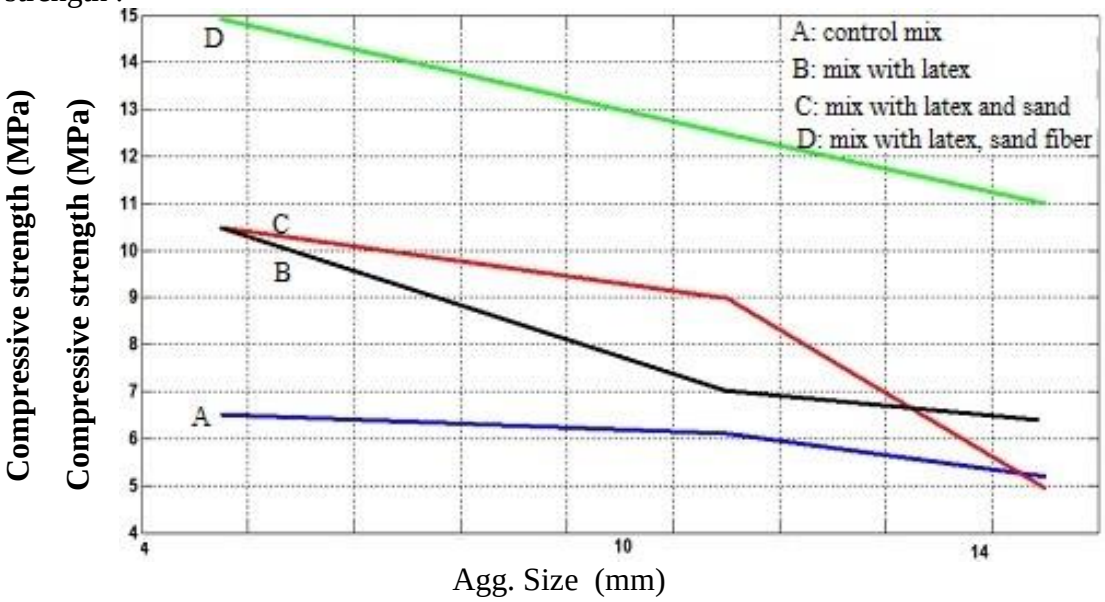

Fig.1 : Effect of maximum aggregate size on compressive strength

The all results of porosity for every different size of aggregate for pervious concrete mixture ,The effect of latex or fiber on porosity were show in Fig. (2).

However, most of the mixtures were have porosity around 20% to 30% and it was accepted. In contrast, the effect of the maximum size of the aggregate is trivial and not clear influence on the porosity. Furtherer more, it could be seen from the figure that adding the latex and sand to the different size of aggregate decreasing the porosity. However the combined between the latex and fiber is not effect on the decreasing the value of porosity. So that it was clear the mixture made from the latex and sand with fiber in higher size of aggregate have the higher porosity and accepted permeability as it expected.

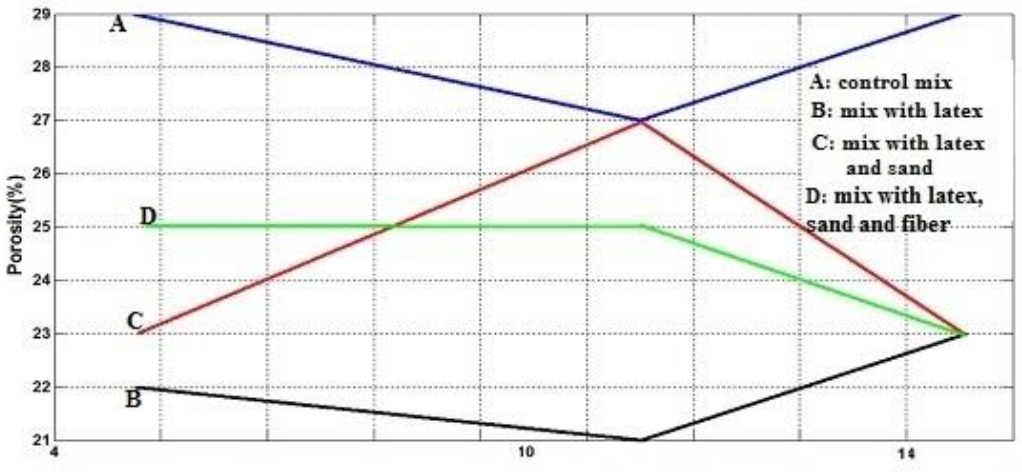

Fig. 2: Effect of the maximum aggregate size on porosity.

The latex and fiber influence for different size of aggregate at the strength of splitting tensile was compared in the Fig. (3).

As it similar to compressive strength for concrete mixture that was have a small particles aggregate it will have higher strength of splitting tensile . all over , the latex impact stay have a clear indicator that strength of splitting tensile are become better for each aggregate size in pervious concrete that come during the formation between the out puts of hydration of cement and latex . According to Fig. (3), it can be seen the effect of the fiber at the resistance of splitting tensile like to the compressive strength. Where adding fiber leads to indicator on the increasing in splitting tensile strength with control mixture.

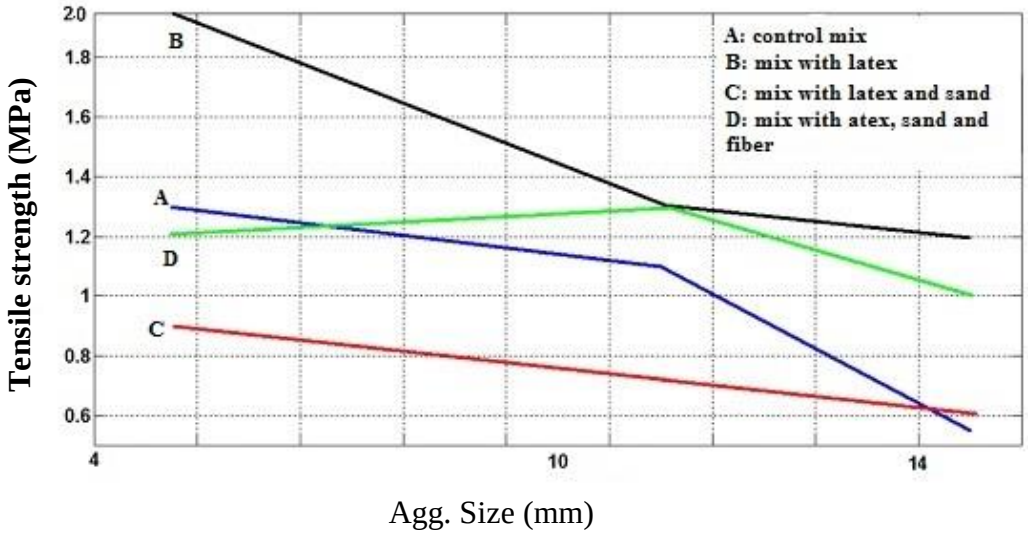

Fig 3: Effect of maximum aggregate size of tensile strength

8- Conclusion

By using (matlab) computer software program to compare for the three different size of coarse aggregate present similar porosity. Thus, aggregates gradation did not have a considerable action in property of the (pmpc). However, it definite that the most of the mixtures had porosity in the limited from 20% to 30% which is adequate. The collecting between the latex and river sand with fiber to all gradation can produce pervious concrete with enough for both discharge and strength.

It's clear that decreasing the size of aggregate confront increasing in compressive strength and we notice that fiber don't have marked effect in this study As for latex and sand they minimize the porosity for pervious concrete and increasing the splitting tensile strength.

9- References.

Cackler ET., 2006. " *Evaluation of US and European Concrete Pavement Noise Reduction Methods* " National concrete pavement technology center. Concrete pavement surface characteristics project report. Lowa State University.

Fukute T., 1998, " *Reduction of Environmental Load by Water Penetration*" Concr JJpn, Vol 3. No. 36. P. 8-16.

Huang *et.al.*, 2010,"*Construction and Building Materials* " 24, 818-823.

Jiang Z., Sun Z., Wang P., 2005," *Effect of Some Factors on Properties of Pervious Concrete"* J Build Mater, vol. 8. p. 9-13.

Kajio S., Tanaka S., Tomita R., Noda E., Hashimoto S., 1998. "*properties of porous concrete with high strength*" In proceeding 8th international symposium on concrete roads. P. 7-171.

Kevern JT., 2008, " *Advancement of Pervious Concrete Durability* " Ph.D Dissertation,Low State University, Amen (1A).

Montes F., 2006"*Pervious Concrete :Characterization of Fundamental Properties and Simulation of Microstructure* " Ph.D. Dissertation, University of South Carolina..

Nader G., Shivaji D., 1995, *" Development for no- Fines Concrete Pavement Applications"* ASCE Transport Eng.

Schaefer VR.,Wang K., Suleiman MT., Kevern JT., " *Mix Design Development for Pervious Concrete in Cold Weather Climates*" final report national concrete pavement technology center, Lowa State University. Ames, IA, 2006.

Tennis PD., Leming ML., Akers DJ., 2004 " *Pervious concrete pavements " EB302 Portland cement association Skokie Illinois and national ready mixed concrete association Maryland.. Silver spring* ".

Wang W., 1997, " *Study of Pervious Strength"* Sci Technol Build Mater. China, Vol.6 , No.3 p. 8-25.

Yang J., Jiang G., " *Experimental Study on Properties of Pervious Concrete Pavement Materials,* " Cem Concr Res. Rol. 33, P. 6-381. 2003.

Youngs A.,2005," *Pervious Concrete it's for Real Presentation at Pervious Concrete and Parking Area Design Workshop* " Omaha..