Using Propylene–Ethylene Grid to Improve the Production of Precast Concret Slabs

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Received on: 29/2/2012 & Accepted on: 4/10/2012

ABSTRACT

The precast concrete roofing slab produced from the local factory were below the Iraqi standard requirement (NO 1107-1988).

This study has been made to improve the production of precast concrete slabs by using(propylene – ethylene copolymer grid)which is a waste material produced from the base of polymer boxes .

The depended mix of the precast concrete slab in the local factory did not use the correct proportion ,tested mixes were redesigned and prepared to achieve the limited requirements . Propylene – ethylene copolymer grid was used to have better results، less costs, with protection of the environment from pollution ,where there is difficulty to remove it even when it is fully exposed to severe weather conditions .the manufactured slabs had dimensions of (800×800×40)mm and testing program extended to 60 days of age and comprised ,breaking loads, water absorption ,and impact resistance of concrete. The total number of manufactured samples was (55 slabs).

The test results indicated that the weigh ted mix proportions ((1:1.5:2.45) cement :sand : gravel) with w/c=0.41 , superplasticizer(0.75 liter/100 kg of cement)and propylene –ethylene copolymer grid with a dimension (600×600)mm enhances the mechanical properties of concrete . It increased the breaking load by 81 % compared to ordinary production. while the impact resistance increased to 26 blows compared to 3 blows for the ordinary production. However, the polymer grid decreased the width and depth of cracks and maintained the integrity of the slabs after failure .

Key words: precast concrete , polymer grid , load at rupture , impact resistance, cracking behavior .

استخدام مشبكات البروبلين اثيلين في تطوير صناعة الألواح الخرسانية الجاهزة الصب (الشتايكر)

الخلاصة

عند اخذ عينات من الألواح الخرسانية الجاهزة الصب المنتجة في المعامل المحلية تبين بأنها لا تحقق النسب المطلوبة ضمن المواصفات القياسية العراقية (رقم 1107 لسنة 1988) وقد

تمت دراسة أمكانيه تحسين وتطوير صناعه قطع الصب الجاهز (الشتايكر) باستخدام مواد متوفرة محليا وهي عبارة عن مشبكات الأقفاص البلاستيكية المتكونة من مادة البروبلين اثيلين كوبوليمر .

إن الطريقة المتبعة من قبل المنتج المحلي لا تستخدم النسب الصحيحة للخلط وبذلك تم إعادة تصميم الخلطة الخرسانية للوصول إلى الحدود المطلوبة ضمن المواصفة القياسية العراقية ، كما تم إضافة مشبك بلاستيكي لتعزيز الحصول على نتائج أفضل وبكلفة قليلة مع الحفاظ على البيئة حيث إن المواد البوليميرية يصعب التخلص منها حتى في الظروف الجوية القاسية وقد تم أعداد قطع كونكريتية بإبعاد (800*800*40) ملم .وأمتد البرنامج العملي لغاية 60 يوم ، وتم دراسة خواص القطع المنتجة من خلال فحوصات قوة الكسر ، امتصاص الماء ومقاومة الصدم ، بلغ العدد الكلي للنماذج المصنعة (55 عينه).

وبعد إجراء محاولات عديدة تم التوصل إلى خلطة بنسب وزنيه (1 :1.5 :2.45) (الاسمنت : رمل : حصى) مع مضاف مقلل للماء بنسبة 0.75 لتر لكل 100 كيلو غرام من الاسمنت لتصبح نسبة الماء إلى الاسمنت بما يعادل 0.41 ، واستخدام مشبك بلاستيكي بأبعاد (600* 600) ملم قد أعطت لهذه الخلطة زيادة في قوة الكسر بما يعادل 81% عن قطع الخلطة المعتمدة في المعامل المحلية ، بينما ازداد عدد الضربات اللازمة لتحقيق الفشل إلى 26 ضربة بدلا من 3 ضربة بالنسبة للخلطة المحلية .

كما تبين إن استخدم المشبك البلاستيكي يقلل من عرض ومن عمق الشقوق المتكونة في القطع الكونكريتية ويقلل من تشظي وتكسر الخرسانة ويساعد على بقاء القطعة ككتلة واحدة .

INTRODUCTION

Inexpensive and versatile concrete is simply the best building material for many applications .it performs admirably under compression , but tends to be brittle and some what weak in tension .

Tensional stress as well as plastic shrinkage during cure leads to cracks, which invite moisture ingress [1].Traditionally , steel reinforcement controls this cracking in many types of concrete construction .To control cracking best, the reinforcement should be placed as close as possible to the concrete surface . Steel typically can not be placed less than 1 or 2 inches from the surface , however ,because it might corrode and spun the surface concrete .

Polymers grids are an alternative to steel mesh used for crack control. because they don't corrode , the grids can be placed closer to the surface where they'll do the most good. [2]

The test results on the samples made using the ordinary concrete mix were below the Iraqi standard specification (No 1107 -1988). This is due to the non attention in the mix design for the slabs. By watching the manufactory of these slabs , a high water content was used more than the required in the mix design to increase the fluidity of fresh concrete , this is cause to bad produce, economy missing, and easy deterioration in the storage and transfer process.

The uses of chemical admixtures such as (superplasticizer) need good experience and care by the workers because there was side effects when it doesn't use in correct ratio and may be cause opposite results .

Al-mashhadany , et al [3] had shown that the inclusion of steel grid to the precast concrete slab was more resistance to breaking loads by 21% .

Despite their low modulus of elasticity ,fibrillated polypropylene fibers have been used in the manufacture of concrete piles to increase their impact resistance . Also , the increase in impact resistance of concrete stair treads has been demonstrated by the inclusion of polypropylene and steel fibers . The geometry of the steel fibers has a significant effect on the breaking load and impact resistance of the composite .However , steel fibers are relatively expensive and susceptible to corrosion [4].

Trevor [2] showed that the polymer grids spread stresses and dissipated strains over a larger area , reducing crack width, and help concrete absorb energy from impact forces without shattering .

Jenkins,et al [5] stated that the reinforced slab with three dimensional polymer grid contributed significantly to rut resistance in asphalt layers and improved performance in fatigue results compared to the non reinforced reference mix .

The shape of the grid opening and the number of layers applied varied the results of strength and the ultimate strain [6]

In this study to improve precast concrete slab , it was used readily available material , inexpensive , highly resistant to chemical attack , and easy in use to ensure achieve the requirement although there was careless or weak quality control by the supervisor. Slabs of (800×800×40) mm in dimension were prepared with inclusion of (600×600) mm polymer grid in a mid of height of the slab . the behavior of the slabs was studied with the required test in the Iraqi standard specification .

EXPERIMENTAL WORK

The program of this work was designed to investigate the effect of using polymer grid on development of precast concrete slab. The materials used for making concrete mixes were :

1-Ordinary Portland cement manufactured by Kufa cement factory (IQS 5-1984) [7].

2- Natural siliceous sand brought from al-Echether region with 2.7 fineness modulus as fine aggregate (IQS 45-1984, zone2) [8] , specific gravity =2.63

3- Crushed gravel brought from al- Nebaee quarry with maximum size of (10mm) as coarse aggregate (IQS 45-1984) [8] ,specific gravity was 2.61 ,SO3=0.03%,dry ridded unit weight=1695 kg/m^3

4-An additional material commercially marketed superplasticizer was used ,chemically it is polycarboxylic ether polymers with long chains (type A and G according to ASTM C494-1992)[9] .It is commercially known as hyperplast pc 260 .Table (1) shows the technical description of the superplasticizer used

5- Polymer grid manufactured from propylene-ethylene copolymer. it produced by cutting the basis of vegetable box which dimension (300×600) mm , all two basis were linking by metal wire to make grid with dimension 600 × 600 mm . The size of openings was (17×17)mm . Table (2) shows the characteristics of the grid used . Figures (1) and (2) show the shape of grid used to reinforce concrete slabs , and their positions in the slabs .

CONCRETE MIXING

A dram mixer was used to prepare the concrete mixes (M1,M2,M3), as displays in Table (3).

The mix design used in a local factory was done on volumetric basis ,it transfer to weighting basis equal (1:1.55:2.6) , the w/c was 0.60 , this mix named M1 .

In this study the mix design was made according to the British method [10] . The proportioning was done on weighting basis to produce a concrete with 30 MPa compressive strength at 28 days . the cement content was 450 kg/m^3 , the water to cement ratio (w/c)was 0.45 and the mix proportions by weight was (1 : 1.5 : 2.45)(cement :sand :gravel) this mix named M2. Another mix was made to improve the strength of (mix2) by adding superplasticizer with a dosage of (0.75 liter /100 kg of cement) . the water to cement ratio after using the superplasticizer became 0.41 and the mix proportions was (1 :1.5 :2.45) (cement : sand : gravel), this mix named M3. the above mixes (M2,M3) were achieved after many trials .

The superplasticizer added to the concrete mix (M3) with the mixing water to achieve optimum performance .The optimum dosage of superplasticizer after the trials was 0.75 liter/100 kg of cement material.

For the polymer grid reinforced slabs , 75% of concrete mix was placed at the mould . After the vibrating process ,the layer of polymer grid with dimension (600 × 600)mm immersed by hand to ensure full impregnation of the matrix ,then added the 25% of remain concrete mix to form a slab of the required thickness .

Steel moulds (800 ×800×40) mm was used for making the specimens , the surfaces of the molds were leveled and covered with nylon sheets until remolding 24 hours later. The manufactured slabs of mixes (M2,M3) were placed in a water tank until they were tested at the age of (28) day for the load at rupture and water absorption test ,the testing program for the impact test was extended to 60 days age .The slabs produced by the ordinary mix (M1) cured as known in the local factories.

CONDUCTED TESTS

1- Load at rupture

It was carried out according to the Iraqi standard specification No.1107-1988[11].

2- Water absorption test

The water absorption test was carried out according to the Iraqi standard specification No 1107 -1988 [11] . the absorption was recorded after interval time of 30 minute and 24 hours.

The water absorption is calculated by the equation :

$$A=[(W\ wet-W\ dry)/W\ dry]*100 \quad \text{----------} \ (1)$$

Where : A=absorption value (%),

W wet=wet weight of the specimen (kg),
W dry= dry weight of the specimen (kg)

According to the IQS No1107-1988 ,the increase in specimen weight should not exceed 4% for 1/2 hour absorption and 10% for 24 hour absorption test.

IMPACT TEST

The apparatus used in this study consists mainly of three parts ,1- the main supported frame (a steel frame ,strong enough to be held rigidly during impact loading ,2- drop mass guide system (A tube of circular section is held vertically above the center of the slab) ,and 3- striker falling steel ball with a mass of 3.36 kg and a diameter of 9.54 cm , it was repeatedly dropped on the slab until failure is occurred . the impact test was developed by ACI committee 544 [12]. The steel drop ball was lifted up to the control height of(0.5 and 1.2)m and then released ,the number of impact to cause scabbing and perforation were noted and recorded.

Much researches have been directed towards developing materials which exhibit better impact resistance than dose non reinforced concrete , polymer grid reinforced concrete has emerged as available structural material for the use in such instances [2,13] .

RESULTS AND DISCUSSION

load at rupture results

The results of the load at rupture are shown in Table (4) . Precast slabs with and without polymer grid reinforced concrete ,and superplasticizer were used to asses the load at rupture test .

Figure (3) shows that after a water curing period of 28 days the maximum increase in load at rupture was achieved when using propylene – ethylene grid with superplasticizer(S 5) . the increase in load at rupture compared to non reinforced slab (S2) was 32 %. This is due to the improvement in all mechanical properties and bond strength for admixture concrete mixes

The load at rupture results increased for polymer grid concrete slab (S3) by 9% compared to non reinforced concrete slab (S2).

For superplasticizer concrete slab (S4) , the increase in load at rupture was 19 % compared to non reinforced concrete slab (S2) , these results improved as the strength of the mix increased (when using superplasticizer)in M3 compared to M2.

The load at rupture for the non reinforced concrete slab which prepared from the ordinary mix (M1) was 4.04kN, this value failed to achieve the minimum limit in the Iraqi standard specification No 1107 – 1988. With limited as 5.4 kN for slab (800×800×40)mm.

After rupture the propylene – ethylene concrete slabs remain together in one piece , while non reinforced concrete slabs exhibit total disintegration . This is due to the effect of presence of propylene – ethylene grid that tries to entire concrete slabs together.

water absorption results

Details of the water absorption slabs are presented in Table (4) and plotted in Figure (4). From the results presented in the Table, it is indicated that the water absorption of propylene – ethylene copolymer grid reinforced concrete slabs(S 5) decreased as compared to other concrete slabs . the percentage of decrease for 1/2 hour water absorption was 27%, and it was 21 % for 24 hour water absorption compared to ordinary slabs (S1).

The superplasticizer concrete slabs (S4) gives a reduction in water absorption in 1/2 hour water absorption was 3.5 % , and 6 % in 24 hour water absorption compared to ordinary slabs (S1) . This is due to densities the concrete matrix and reduces the water absorption when addition the superplasticizer .

For polymer concrete slabs (S3) the reduction in 1/2 hour water absorption was 19% compared to ordinary slabs (S1) . while it was 10% in 24 hour water absorption.

From the previous results , it is clear that using propylene –ethylene grid minimizes the ability of concrete to absorb water . that is due to the control cracks distribution by binding the aggregate together and it minimizes the cracking on remolding and subsequent handling .

Impact load results

The results of the impact slabs are presented in Table (5). Impact load to cause failure refers to the number of blows required to cause scabbing and spalling of concrete slab.

The non reinforced concrete slabs (S1) made using the ordinary mix (M1)and slabs type (S2)made of mix2 required (2,3) blows to cause failure at age 28,60 days respectively .

When using superplasticizer as water reducing admixture to increase the concrete strength , it can be seen that impact strength increased lightly .For example slabs type (S4) required (3,4) blows at age (28,60) days respectively to cause failure .This is due to the brittleness nature of concrete mixes with or without superplasticizer .

The slabs reinforced with polymer grid type(S3) was 18 blows for slabs tested at (28)days , and 35 blows at age (60) days .These can denoted to good damping properties for the polymer grid leading to increase the energy absorption capacity of the produced slabs.

The number of blows required to cause failure for polymer grid reinforced concrete with superplasticizer (S 5) was higher than the other concrete mixes as shown in Figure (5). This is due to the improvement in all mechanical properties and bond strength for superplasticizer concrete mixes in addition to the inclusion of polymer grid in concrete which improves the ductility of concrete leading to increase the number of blows required to cause failure . This identical with the conclusions of Mickael [14]. In general , the test results showed that the impact strength of concrete increased with its compressive strength and increased with time .

Cracking behavior

Normal concrete slab (S1) subjected to impact loading showed three large crack near the mid span ,this cracks penetrated the full depth of the specimen which resulted in separation . The crack in the slabs reinforced with propylene –ethylene grid (S3,S5) decreased, and these slabs exhibited extensive cracking with no separation indicating considerable ductility .

The total length of cracks increased for both impact and rupture loads, unlike the cracking pattern under rupture loading where most cracks were parallel , impact loading produced both parallel and diagonal cracks passing through the mid span.

The inclusion of propylene – ethylene copolymer grid delayed the appearance of the visual cracks .

CONCLUSIONS

1-The manufactured precast concrete slab in a local factory failed to achieve the requirement of the Iraqi standard specification. This is due to the careless in choosing raw materials , mix design ,and curing .

2-The increasing in the load at rupture for polymer superplasticizer concrete slab (S5) was 11% than superplasicizer concrete slab(S4), 28% than polymer concrete slab (S3), and 32% than of non reinforced concrete slab (S2).

3-The use of polymer grid in reinforcing concrete minimizes the ability of concrete to absorb water , this is due to its ability to control cracks distribution .

4-The number of blows required to cause failure in the polymer superplasticizer concrete slab (S 5) is more than the non reinforce concrete slabs (S1,S2) ,and superplasticizer concrete slabs (S4) , this is due to the improvement of all mechanical properties and bond strength for superplasticizer concrete mixes and improve the ductility of concrete by inclusion of polymer grid in concrete .

5-Observations of the cracking behavior suggested that the propylene – ethylene grid concrete slab was superior because of finer cracks with no separation.

6-The overall performance of the polymer grid reinforced composites and suggested a potential low – cost application for resisting impact loads in steel corrosive environments .

REFERENCES

[1]. Black ,S., "Composites and concrete .",Technical editor composites technology , Internet ,http:www.compostesworld.com , April 2005 ,11pp.

[2].Tervor, G. E. ,"Reinforcing concrete with polymer grids.", Internet, http://www.concrete construction .net ,London ,England, August 1988 .

1- المشـهداني ،شـاكر، العطـار، طـارق والخطيـب وعـلاء، " تطـوير أنتـاج البلاطـات الخرسـانية (الشتايكر)"، مجلة الهندسة، المجلد 12 ، العدد 2، حزيران 2006 ، الصفحة 7-21.

[4].Fattuhi , N. I. ,"Toughness of thin slabs under flexural or impact loading .", The International journal of cement composites and lightweight concrete ,Vol.5, No.2,May1983,pp121-126.

[5].Jinkins,K.J. ,Denison, P., Ebels,L.J., and Mullins,L.S.,"3-D polymer grid reinforcement of asphalt for rut resistance . ",Internet , university of Stelenbosch ,2004, 9 pp.

[6].Shahawy, M., Mirmmiran, A., and Beitelman,T., "Tests and modeling of carbon – warped concrete columns.", Composites part B:Engeneering , 2000, Vol31, No 607, pp471-480.

[7]. Iraqi standard "Portland cement -IQS 5".Central organization for standardization and quality control ,Ministry of planning, 1984.

[8].Iraqi standard "Aggregate from natural sources for concrete –IQS 45".Central organization for standardization and quality control ,Ministry of planning, 1984.

[9]. ASTM standard C 494 ,"standard specification for chemical admixtures for concrete ". Annual book of ASTM standard , American society for testing and materials , Philadelphia ,1992, pp 310- 320.

[10]. Neville,A .M., "Properties of concrete ."Longman Group LTD.4th edition ,1995, pp. 762-768 .

[11]. Iraqi standard "precast concrete tiles land cement -IQS 1107".Central organization for standardization and quality control ,Ministry of planning, 1988.

[12]. ACI Committee 544, "Measurement of properties of fiber reinforced concrete ", Journal of American concrete institute . Vol.75, No.7,July 1978, pp.283-290.

[13].Suaris, W. and Shah, S.P. ,"Test methods for impact resistances of reinforced concrete .", International symposium on fiber reinforced concrete ,sp-81, 1984, PP.247-265.

[14]. Michael ,A. P., "Using carbon fiber reinforced polymer grids as confinement concrete .", Internet, university of Florida , 2006, 2pp.

Table (1) Technical properties of superplasticizer @ 25 c.

Color	Light yellow liquid
Freezing point	-7 C
Specific gravity	1.1±0.02
Storage life	12 months if stored at temperatures between 2C and 50 C
Air entrainment	Typically less than 2% additional air is entrained above control mix at normal dosages

Table (2) Characteristics of polymer grid used in this research.

Size of grid opening (mm)	Specific gravity	Tensile strength N/mm^2	Elongation %	Hardness (shore A)
17×17×2.5	0.95	20.3	6.7	70

***Tests on poly grid was made by the Iraqi central organization of standard and quality control(ICOSQC).**

Table (3) details of manufactured slabs.

Symbol of slab	Type of mix	Type of addition
S1	M1	Non
S2	M2	Non
S3	M2	Polymer grid
S4	M3	Superplasticizer
S5	M3	Superplasticizer+ polymer grid

Table (4) Concrete slabs results.

Symbol type of slabs	Load at Rupture (kN)			Absorption %			
	Test results		Limit of specification	Test result (Average)		Limit of specification	
	28 day	Average		30 min	24 hr	30 min	24 hr
S1	4.11 4.00 4.02	4.04	5.4	2.64	6.82	4 mix limit	10 mix limit
S2	5.5 5.4 5.7	5.53	5.4	2.41	6.57	=	=
S3	6.09 5.89 6.18	6.05	5.4	2.13	6.42	=	=
S4	6.05 6.87 6.84	6.58	5.4	2.55	6.39	=	=
S5	7.25 7.35 7.34	7.31	5.4	1.92	5.37	=	=

Table (5)Impact resistance test results for precast concrete slabs.

Type of slabs	Impact resistance	
	No of blows to cause failure at 28 days	No of blows to cause failure at 60 days

S1	**2**	**3**
S2	**2**	**3**
S3	**18**	**25**
S4	**3**	**4**
S5	**22**	**26**

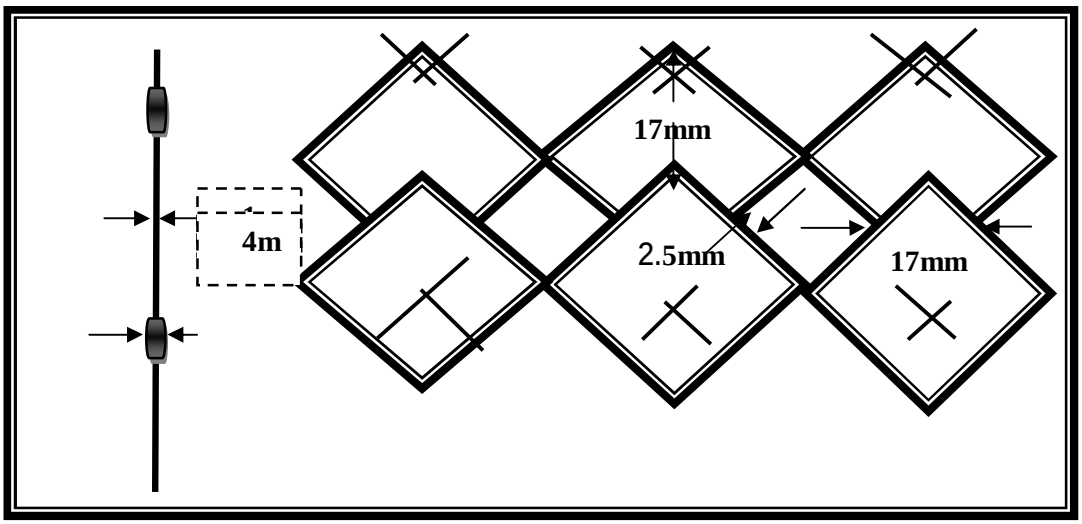

Figure (1) typical dimensions of polymer grid

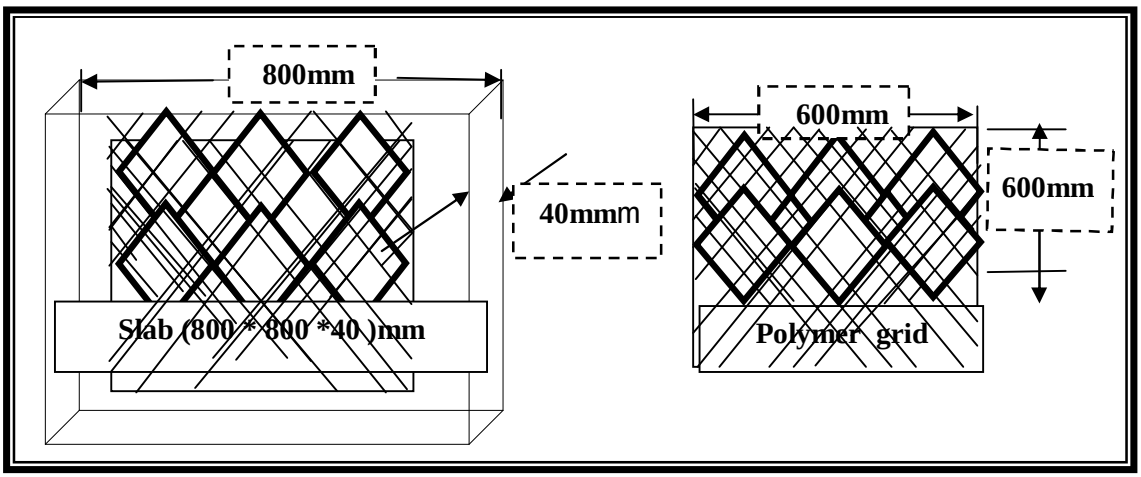

Figure (2) shape and position of polymer grid used to reinforce concrete slabs.

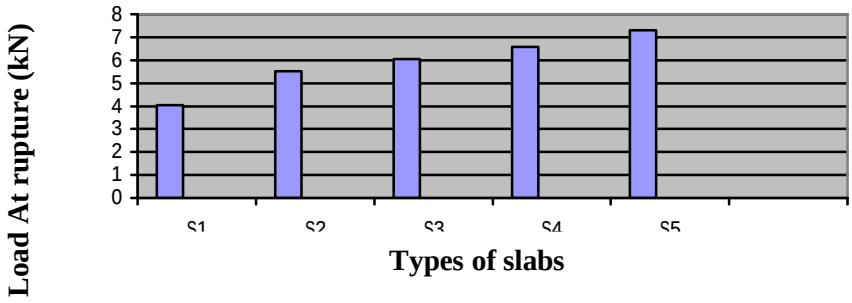

Figure (3) load at rupture results.

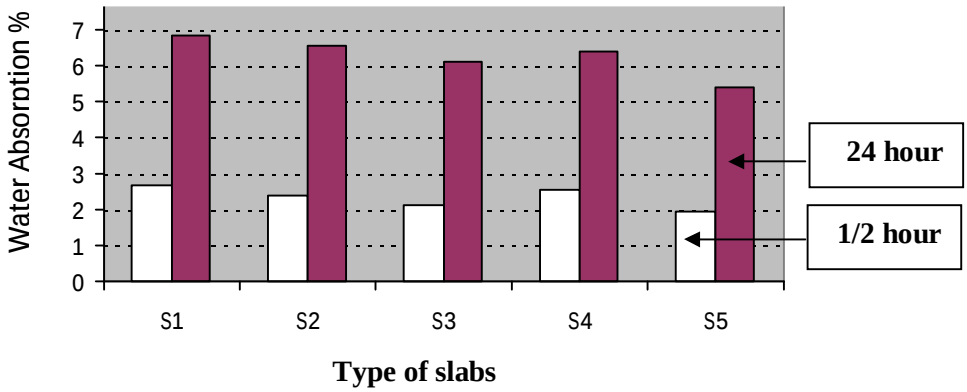

Figure (4) water absorption results.

Figure (5) impact load results.