THE USING OF RECYCLED AGGREGATE CONCRETE

Graiti A.A.H.[1], Kolosova N.B.[2] (Russian Federation) Email: Graiti51@scientifictext.ru

[1]Graiti Ali Abbas Hussien – Undergraduate,
[2]Kolosova Natalya Borisovna – Associate Professor, Honorary Worker of Higher Professional Education of Russia, Senior Lecturer,
DEPARTMENT OF CONSTRUCTION OF UNIQUE BUILDINGS, CIVIL ENGINEERING FACULTY;
SAINT-PETERSBURG STATE POLYTECHNIC UNIVERSITY NAMED AFTER PETER THE GREAT,
ST. PETERSBURG

Abstract: *recycling of concrete debris can make a contribution to reduce the total environmental impact of the building sector. The use of demolished concrete debris as aggregates in concrete results in significant economical and environmental benefits. Reuse of Construction waste gives two aims, the first is to remove large quantities of pollution resulted from these waste, the second provides cheap resources for concrete aggregates. In present work, an attempt has been made to study the effect of recycled aggregate on behavior the properties of concrete. The experimental program includes using the Pozzolana and replacement of natural aggregates by recycled aggregates. Five aggregate replacement of 0%, 25%, 50%, 75% , 100% were accounted in experimental program. Experimental results show up to 23% reduction in compressive strength, 24% reduction in split tensile strength, 20% reduction in modulus of elasticity and when use Pozzolana due to increasing the properties of concrete.*
Keywords: *Recycled aggregate, construction material, concrete, recycled aggregate concrete (RAC). Pozzolana, compressive strength, modulus of elasticity*

ИСПОЛЬЗОВАНИЕ ПЕРЕРАБОТАННОГО АГРЕГАТНОГО БЕТОНА

Граити А.А.Х.[1], Колосова Н.Б.[2] (Российская Федерация)

[1]Граити Али Аббас Хуссейн – магистрант,
[2]Колосова Наталья Борисовна – доцент, почётный работник высшего профессионального образования РФ, старший преподаватель,
кафедра строительства уникальных зданий и сооружений, инженерно-строительный факультет;
Санкт-Петербургский государственный политехнический университет им. Петра Великого,
г. Санкт-Петербург

Аннотация: *утилизация бетонного мусора может внести вклад в снижение общего воздействия строительного сектора на окружающую среду. Использование снесенных бетонных обломков в качестве агрегатов в конкретных результатах имеет значительные экономические и экологические преимущества. Повторное использование строительных отходов имеет две цели: первая заключается в удалении большого количества загрязнений, вызванных этими отходами, вторая обеспечивает дешевые ресурсы для конкретных агрегатов. В настоящей работе была предпринята попытка изучить влияние переработанного агрегата на поведение свойств бетона. Экспериментальная программа включает в себя использование поззолана и замену натуральных агрегатов переработанными агрегатами. В экспериментальной программе было учтено пять агрегатных замен в 0%, 25%, 50%, 75%, 100%. Экспериментальные результаты показывают снижение прочности сжатия на 23%, уменьшение разрыва на растяжение на 24%, уменьшение модуля упругости на 20% и использование поззолана за счет увеличения свойств бетона.*
Ключевые слова: *переработанный агрегат, конструкционный материал, бетон, переработанный агрегатный бетон (RAC). Поззолана, прочность на сжатие, модуль упругости.*

Introduction:

Recycling as part of environmental considerations has become a common feature in the construction industry. Use of recycled aggregate with natural aggregate in concrete may be useful for environmental protection. Recycled aggregates are the materials for the future. By collecting the used concrete and breaking it up. In this study focuses on coarse RCA which is the coarse aggregate from the original concrete. The use of recycled aggregate has been started in a large number of construction projects of many European, American and Asian countries, these countries have gained many experiences on application of RAC in their construction industry [1, 2, 8]. Most of properties of recycled coarse aggregates are similar to the properties of natural coarse aggregates.

Advantages of recycling of construction materials:

● Cost saving: - There are no detrimental effects on concrete & it is expected that the increase in the cost of cement could be offset by the lower cost of Recycled Concrete Aggregate (RCA).

● Save environment: - There is no excavation of natural resources & less transportation. Also, less land is required.

● Save time: - There is no waiting for material availability.

Disadvantages of recycling of construction material

● Less quality (e.g. compressive strength reduces by 10-30%).

● Very high-water absorption (up to 6%).

● Land, special equipment machineries are required (more cost) [3].

Objectives of the study: -

● To find out the % use feasible for construction.

● To carry out different tests on recycled aggregates & natural aggregates & compare their results.

Experimental Program:

The main object of this study is to compare the properties of concrete with different amount of recycled aggregate. Two concrete groups were tested within the research program. Every group had five types of concrete as given in Table-1.

Table.1. Percentage of aggregate used in each mix

Group	**Type of aggregate**	**Mix**				
		Mix 1	**Mix2**	**Mix3**	**Mix4**	**Mix5**
Group 1 without Pozzolana	NA	100%	75%	50%	25%	0%
	RCA	0	25%	50%	75%	100%
Group 2 with 15% Pozzolana	NA	100%	75%	50%	25%	0%
	RCA	0	25%	50%	75%	100%

1. Materials Used

1.1- Cement: In this research ordinary Portland cement (OPC) (Type I) manufactured by Kufa Factory. The chemical composition and physical properties are given in Tables (2) and (3), respectively. Test results indicate that the adopted cement conforms to Iraqi specifications (IQS No.5/ 1984*)* [4].

Table 2. Physical properties of cement

Physical properties	**Test results**	**Limit required by Iraqi standard no.5-1984**
Fineness, m^2/kg : (Blaine)	260	Min. 230
Time of setting, min : (Vicat) Initial set Final set	 80 170	 Min.45 Max.600
Compressive strength, MPa 3 days 7 days	 18.4 26.9	 Min.15 Min.23

Table 3. Chemical properties of cement

Chemical properties	**Present by weight**	**Limit required by Iraqi standard no.5-1984**
Silicon dioxide (SiO_2)	21.267	-
Calcium oxide (CaO)	65.894	-
Aluminum oxide (Al_2O_3)	3.684	-
Ferric oxide (Fe_2O_3)	4.771	-
Magnesium oxide (MgO)	1.638	Max. 5.0
Sulfur trioxide (SO_3)	2.237	Max. 2.8
Loss on ignition	3.88	Max. 4.0
Insoluble residue	0.9	Max.1.5

1.2- Fine aggregate: Use river sand, and the natural fine aggregate from Al- Al-Akhdar region was used throughout this work. The chemical composition and physical properties are given in Table (4), respectively. Test results indicate that the adopted cement conforms to Iraqi specifications (IQS No. 5/ 1984*)* and (ASTM C 127) [5].

Table 4. The properties of fine course aggregates

Properties	**Sieve size (mm)**	**Percent passing**	**Limit of Iraqi specification No.45/1984**	
			Minimum limit	**Maximum limit**
grading	10	100	100	100
	4.75	97	90	100
	2.36	78	75	100
	1.18	63	55	90
	0.6	52	35	59
	0.3	23	8	30
	0.15	7	0	10
Specific gravity	Bulk (oven dry basis)		2.7	accordance with ASTM C127
	Bulk SSD basis		2.73	
	Apparent		2.79	
Water absorption %			1.28	

1.3- water: Use the normal tap water in the concrete work.

1.4- Coarse aggregate:

Natural aggregate:

River crushed gravel was used as aggregate in natural concrete mixes. The particle shape of the crushed gravel is angular and the surface texture is generally rough. The chemical composition and physical properties are given in Table (5), respectively. Test results indicate that the adopted aggregate conforms to Iraqi specifications (IQS No.45/ 1984*)* and (ASTM C 127).

Table 5. The properties of natural course aggregates

Properties	**Sieve size (mm)**	**Percent passing**	**Limit of Iraqi specification No.45/1984**	
			Minimum limit	**Maximum limit**
grading	37.5	100	100	100
	20.0	98	95	100
	10.0	40	30	60
	5.0	4	0	10
Specific gravity	Bulk (oven dry basis)		2.61	accordance with ASTM C127
	Bulk SSD basis		2.67	
	Apparent		2.77	
Water absorption %			2.2	
Unit weight (kg/m^3)			1335	

Recycled aggregate:

Recycled aggregate was prepared by crushing the cubes and cylinders made from natural concrete manually. Crushing products were screened. In order to produce the recycled coarse aggregate, the various size fraction was recombined to give a grading similar to that of the natural crushed grave the chemical composition and physical properties are given in Table (6), respectively. Test results indicate that the adopted aggregate conforms to Iraqi specifications (IQS No.5/ 1984*)* and (ASTM C 127).

Table 6. The properties of natural course aggregates

Properties	**Sieve size (mm)**	**Percent passing**	**Limit of Iraqi specification No.45/1984**	
			Minimum limit	**Maximum limit**
grading	37.5	100	100	100
	20.0	96	95	100
	10.0	45	30	60
	5.0	6	0	10
Specific gravity	Bulk (oven dry basis)		2.39	accordance with ASTM C127
	Bulk SSD basis		2.51	

	Apparent	2.76	
Water absorption %		4.5	
Unit weight (kg/m^3)		1280	

2. Concrete Mix:

Two sets of mixtures were prepared:

- The first group used ordinary Portland cement and four different ratios of RCA (0%, 25%, 50%, 75%, 100%).
- The second group was used for normal Portland cement with the use of natural limestone as addition to the mixture by 15% of the weight of the cement used by four different ratios of RCA.

3. Laboratory Tests:

Test on hardened concrete:

1. Compressive strength:

Compressive strength is defined as the maximum resistance of a concrete cube to axial loading. For each group six concrete cube with dimensions (15*15*15CM) were prepared, then manually pound on layers and then processed by placing them in water until the test date according to ASTM C39 [6]. Three cubes (7 days) were examined, and three cubes (28 days) were examined and each was average.

2. Split Tensile strength test:

Split tensile test was conducted on specimens of size 150mm diameter and 300mm height. Six concrete specimens were prepared, then manually pound on layers and then processed by placing them in water until the test date according to ASTM C496. Specimen (28 days) were examined and each was average

3. Modulus of Elasticity:

Modulus of elasticity test was conducted on specimens of size 100mm diameter and 300mm height. Six concrete specimens were prepared, then manually pound on layers and then processed by placing them in water until the test date according to ASTM C463. [7] Specimen (28 days) were examined and each was average.

Table 7. The properties of natural course aggregates

Group	**Mix**	**Compressive strength (Mpa)**		**Split tensile (Mpa)**	**Modulus of elasticity (GPa)**
		7 days	**28 days**	**28 days**	**28 days**
Group 1	Mix 1 (0% RCA)	27	36	2.8	30.9
	Mix 2 (25% RCA)	26.2	35	2.6	28
	Mix 3 (50% RCA)	25.3	34	2.4	26.1
	Mix 4 (75% RCA)	23.6	32.8	2.3	24.3
	Mix 5 (100% RCA)	22.5	31	2.1	23.1
Group 2	Mix 1 (0% RCA)	31	43	3.1	33
	Mix 2 (25% RCA)	30	41	2.9	30
	Mix 3 (50% RCA)	27	36	2.6	28
	Mix 4 (75% RCA)	25	35	2.4	26
	Mix 5 (100% RCA)	23	32	2.33	25

Results and discussion:

Compressive strength:

Compressive strength is the major parameter which influences other properties of concrete. Compressive strength of different concrete specimen with different recycled coarse aggregates (0%, 25%, 50%, 75%, 100%) was found to be respectively for first group 27 Mpa, 26.2 Mpa, 25.3 Mpa, 23.6 Mpa and 22. and for second group 31 Mpa, 30 Mpa, 27 Mpa,25 Mpa and 23 Mpa. From the test results, it is mean that when natural coarse aggregate is replaced with RCA, the compressive strength is found to be reducing. The same was observed by many the earlier researchers. This may be due to the fact that the reducing of normal strength concrete is caused by mortar failure. The bond between mortar and recycled concrete aggregate is weaker than that of natural concrete aggregate. But many researchers said on (High strength concrete), the concrete failure is due to aggregate crushing. In group two when used Pozzolana (15% of the weight of cement) the compressive strength is found to be increasing than in group one (fig. 1).

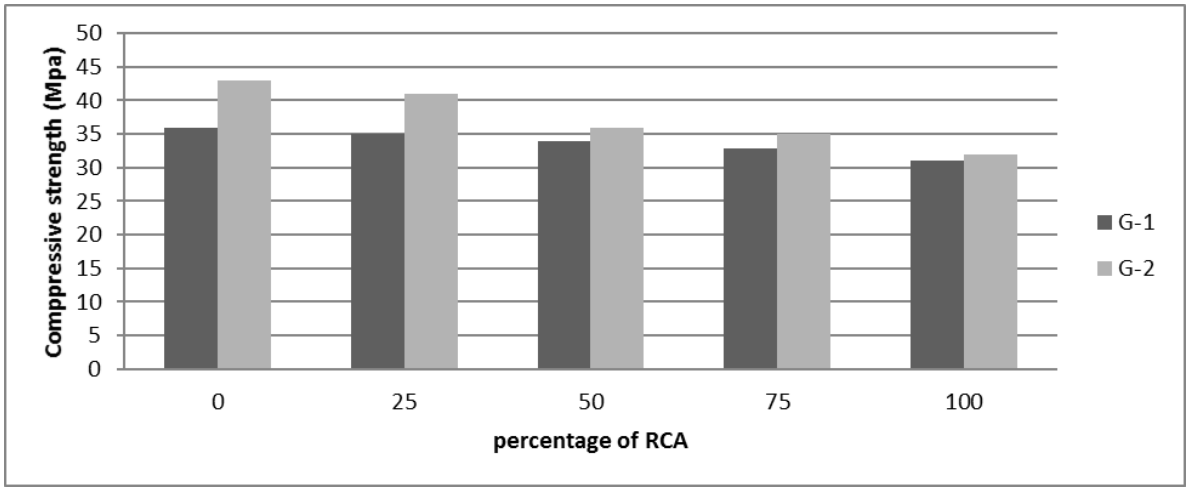

Fig. 1. Variation of Compressive strength with % of RCA

Split Tensile strength:

Split Tensile strength of different concrete specimen with different recycled coarse aggregates (0%, 25%, 50%, 75%,100%) was found to be respectively 2.8 Mpa, 2.6 Mpa, 2.4 Mpa, 2.3 Mpa and 2.1 Mpa for first group and 3.1 Mpa, 2.9 Mpa, 2.6 Mpa, 2.4 Mpa and 2.33 Mpa second group. Also, from the results, when natural coarse aggregate is replaced with recycled concrete aggregate, the Split tensile strength is found to be decreasing. form the results of the second group was found the use Pozzolana led to improve the value of split tensile strength (fig. 2).

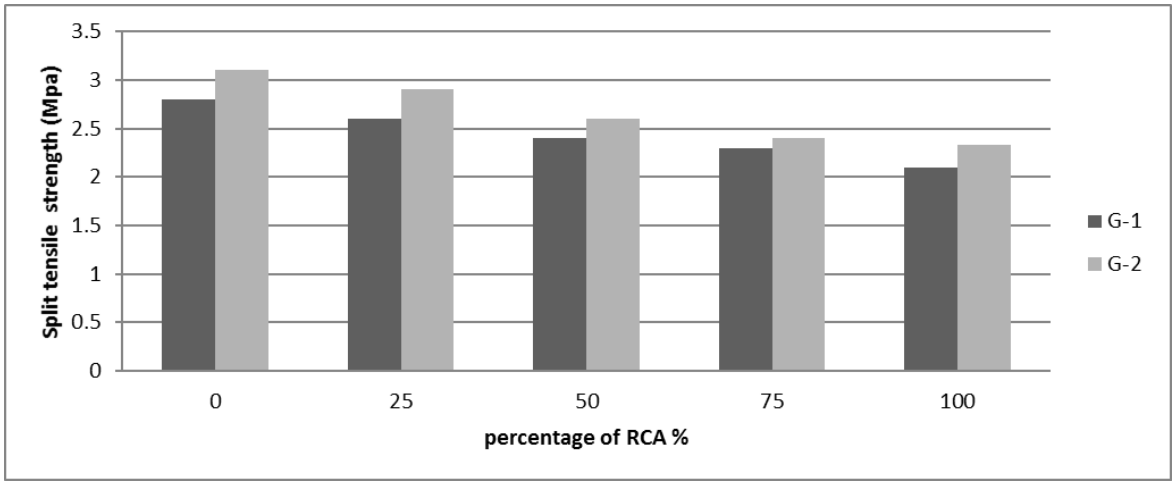

Fig. 2. Variation of split tensile strength with % of RCA

Modulus of Elasticity:

Modulus of elasticity of concrete specimens with different recycled coarse aggregates (0%, 25%, 50%,75%,100%) was found to be respectively 30.9 GPa, 28 GPa, 26.1 GPa,24.3 GPa and 23.1 GPa for first group and 33 GPa, 30 GPa, 28 GPa, 26 GPa and 25 GPa for second group. from the test results as same as a reduction of modulus of elasticity. when natural coarse aggregate is replaced with RCA that time modulus of elasticity is found to be reducing. But when use Pozzolana with RCA that time modulus of elasticity is found increasing (fig. 3).

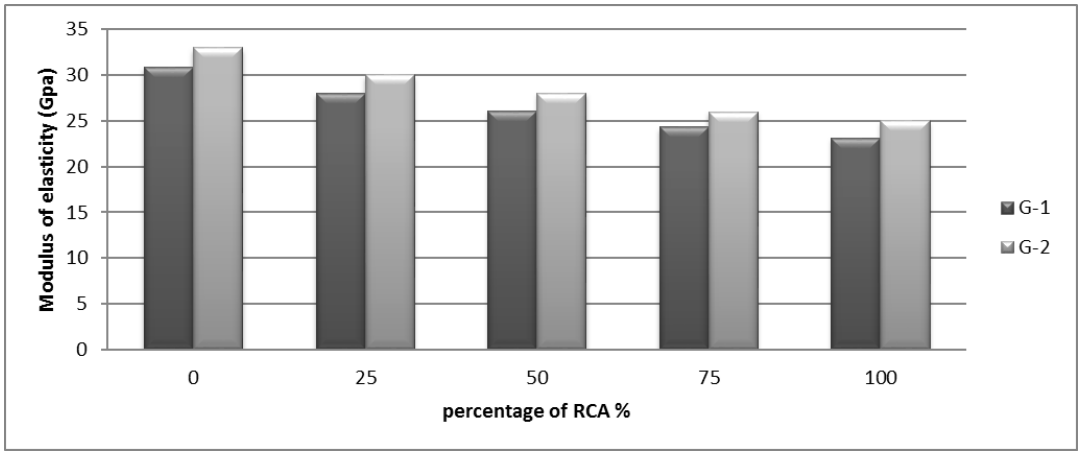

Fig. 3. Variation of Modulus of Elasticity with % of RCA

CONCLUSIONS:

From this we can conclude the following:

1- Use of recycled aggregate up to 30% does not affect the functional requirements of the structure as per the findings of the test results.

1- Recycled aggregate without additions is not suitable for structural uses because of low mechanical properties and is therefore more suitable for non-structural uses such as road works, block construction, non-carrying walls, and mass dams.

References / Список литературы

1. *Graiti A., Kolosova N*. Research about recycling concrete. International scientific review. Chicago. USA, 2017. № 5 (36). P. 26-30.
2. *Karlsson M.* Reactivety in Recycled Concrete Aggregate, 1998. 125 p.
3. *Mr. Tushar R. Sonawane, Prof. Dr. Sunil S. Pimplikar* "Use of Recycled Aggregate Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). ISSN: 2278-1684. Pp: 52-59ю
4. Iraqi Standard Specification (Portland Cement), 1984. № 5.78 p.
5. ASTM Standard Specification, ASTM C127, 2001.
6. ASTM Standard Specification, ASTM C39, 2001.
7. ASTM Standard Specification, ASTM C496, 2001
8. *Neville A.M.* Properties of Concrete, John york, 1996. № 4. 34 p.