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Sustainability of Construction Aggregates in Kuwait

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Abstract

Kuwait is facing a current construction boom with projects worth of more than USD188bn. The huge infrastructure spending plan of Kuwait is reflected with a growing demand of concrete as concrete is the most commonly used building material in the local construction. At the present, the quarrying of coarse aggregate which is a main concrete constituent material is banned in Kuwait since 1997 and construction industry depends on the imported coarse aggregates from neighbouring sources such as United Arab Emirates and Iran. Kuwait is also interested in challenging the growing concern of an effective environmental management of water, land and atmosphere to achieve a sustainable civilization. The increasingly environmental pressures coupled with the limited available economical resources are causing the decision making authorities to consider the practice of recycling and waste utilization. This paper presents Kuwait Institute for Scientific Research (KISR) efforts to investigate sustainable sources of coarse aggregate for construction industry from waste. The first sustainable source investigated is the production of synthetic lightweight aggregates utilizing combinations of argillaceous indigenous and waste materials, and the second is recycled aggregates from construction and demolition wastes. The potential of the two sustainable sources of construction aggregates are presented and the needed steps for real industrial application are addressed.

Keywords

Coarse; Recycle; Waste; Synthetic; Demolition.

1. Introduction

The construction industry within the Arabian Gulf states is continuously blooming. According to BNC Project Intelligence Database, the Gulf cooperation countries (GCC) are undergoing approximately 18,885 construction projects with an estimated total cost value of USD 2.3 trillion. The estimated value of construction projects in Kuwait makes up around 10% of all construction project values in the GCC (Kuwait construction market report, 20161). Table 1 detailed the construction industry within the Arabian Gulf states.

Table 1. Details of current Construction Projects in the GCC

Country	Number of Projects	Total Cost (million USD $)
United Arab Emirates	9125	836
Saudi Arabia	3424	722

Continued on next page

Table 1 continued

Qatar	2514	238
Oman	2237	183
Bahrain	876	93
Kuwait	709	230
Total	18885	2302

Source: BNC Project Intelligence Database

The growth of Kuwait construction market is reflected with the increased demand of building materials and products. Concrete is the most commonly used building material in the local and regional construction. In 2015, the demand for concrete was estimated to reach $49bn across the GCC according to an industry forecast and this will keep escalating according to the construction boom within the GCC countries (construction week online, 2013) Kuwait is a dessert country and is facing the challenge of the limited availability of resources and a distinct shortage of raw materials. At the present, coarse aggregate quarrying is banned in Kuwait since 1997 (Beatona Magazine, EPA) and construction industry depends on the imported coarse aggregates from neighbouring sources such as United Arab Emirates and Iran. The total amount of aggregate that moves within the Arabian Gulf is 50 million tons per annum valued at approximately US$ 2.8 billion. The recent developments in the gulf and the related construction projects are reflected on the requirement of aggregates, which is showing a steep increase with Bahrain, Kuwait and Iraq demands requiring an additional 50 million tons a year. (Navjot-singh, 2015). Kuwait is also interested in challenging the growing concern of an effective environmental management of water, land and atmosphere to achieve a sustainable civilization. The increasingly environmental pressures coupled with the limited available economical resources are causing the decision-making authorities to consider the practice of recycling and waste utilization. The need for sustainable construction is becoming a priority within the asphalt and concrete applications. This trend is necessitated by the high diminishing rate of construction materials, pressing demand on existing landfill sites, rising dumping fees, and reduced emissions into the environment. KISR is an independent national institute of scientific excellence. Set up in 1967 with the mission to develop, deploy, and exploit the best science, technology, knowledge, and innovation for the benefit of Kuwait. Sustainability of building materials is addressed through construction and Building Material research program under the energy and building research center. This paper presents KISR efforts to investigate sustainable sources of coarse aggregate for construction industry from waste. The first sustainable source investigated is the production of synthetic lightweight aggregates utilizing combinations of argillaceous indigenous and waste materials, and the second is recycled aggregates from construction and demolition wastes. The potential of the two sustainable sources of construction aggregates are presented and the needed steps for real industrial application are addressed.

2. The production of synthetic lightweight aggregates utilizing combinations of argillaceous indigenous and waste materials

Lightweight aggregates (LWA) are defined by ASTM C125 (2016) as aggregates having bulk density less than 1120 kg/m3 and this includes pumice, scoria, volcanic cinders, tuff, and diatomite; expanded or sintered clay, or slag; and end products of coal or coke combustion. LWA are used in wide applications of concrete products including insulating screeds to reinforced and prestressed concrete. The most common use of LWA is in the manufacture of precast concrete masonry units. The production of synthetic aggregate from clay is based on Rileys study which instructed heating raw material with a proper ratio of fluxing oxides (CaO, MgO, FeO, Fe2O3, Na2O and K2O) to silica (SiO2) and alumina (Al2O3), to sufficiently high temperature to melt to a viscous, pyroplastic mass. The entrapped gases in the viscous mass cause the expansion (bloating) of the mass and subsequently a porous structure with low density is obtained on cooling (Riley,1951). Kuwait Institute for Scientific Research started investigation of LWA by a preliminary study conducted in 1981(Parks, 1981). Lab production of LWA using marine siltey clay from Sulaibikhat bay indicated that LWA aggregates with a bulk density of 700 - 800 kg/m3 can be produced by firing to 1100 oC – 1150 ^{o}C. That was a major study, which proven uneconomical at that time. Further studies were conducted to characterize the clayey material from Bahra (North-East of Kuwait) by Al-Bahar S. and V.T.L. Bogahawatta, (2000, 2008). The study developed a promising composition amenable for bloating by incorporating additives such as sawdust and waste oil. In 2012 , The production of synthetic lightweight aggregates (LWA) was investigated by Al-Bahar S. and etc to explore the suitable indigenous raw materials for the production of LWA, and to ensure that their quality and properties are suitable for use as building in kuwait (Al-Bahar S and etc,2012). The study also included investigation of sand wash which is a by-product material of sand quarrying in kuwait as another raw material and as a subject of an environmental issue. The following, detailed the raw materials used, the firing, bloatability assesment and the engineering assesment of the produced sythenic light weight aggregates (LWA).

2.1. Raw materials Preparation and assesment

Different locally available raw and waste materials were used in the study; details are presented in Table 2. Raw materials in combination with other additives were used to formulate mixtures into pellets for a set of physical minorological, and chemical tests to investigate the bloating behaviors. Plasticity index according to ASTM D 4318 were checked to determine the clay content and plasticity of the mixture to shape uniform strands. Aggregate wash, red clay, and mixture of them have high degree of plasticity which indicates their silt clayey material nature, and suitability of pelletizing.

In addition, chemical analysis of representative samples of raw materials and subsequent raw mixtures is carried out by the X-Ray Fluorescence (XRF) method and results are presented in Table 3. The resulting calculated major and fluxing oxides (SiO2, Al2O3 and CaO, Fe2O3, MgO, Na2O, K2O respectively) were plotted on Riley's diagram as illustarted in figure 1, to locate their position with respect to the tertiary area of successful bloating. This implies the ability of fired materials to change phase into a mass viscous enough to ensure good bloatability. Accordingly AW, RC, GC, and 50AW/50RC, all fell in the tertiary area of successful bloating. The minolorlogical testing of RC, GC, and AW showed the presence of fairly good amounts of bloatable clay minerals like, muscovite, albite, and kaolinite. Results of XRF and XRD analyze have shown the similarities between the chemical and the mineralogical compositions of the RC and AW.

Table 2. Raw materials investigated for the production of LWA.

Raw Material	Source
Red Clay	Natural clay dug and collected from Bahra area
Grey Clay	Natural clay dug and collected from Bahra area
Normal Sand	Normal sand collected from local quarries located in Sulaibiah area in Kuwait
Aggregate Wash	Very fine natural material resulting from the washing process of sand. This slurry is basically a mixture of clay and friable materials.
Fly Ash	An imported pozzolanic material with mineral composition similar to Portland cement. It is a by-product of the coal industry.
Sewage Sludge	An industrial waste material resulting from sewage treatment plant located in Al-Regga area
Oil Based Mud cutting Cuttings	An industrial waste material resulting from the oil well drilling operations and collected from Kuwait Oil Company
Gatch	A consolidated material which is a mixture of calcium carbonate and calcium sulphates. It is quarried in several locations in Kuwait.
Lime Powder	indigenous raw materials quarried from Ahmadi and Mina Abdullah area
Dolomite	indigenous raw materials quarried from Ahmadi and Mina Abdullah area

Table 3. XRF Analysis of Raw Materials and Raw Materials Mixtures

Sample Designation	SiO2	Al2O3	CaO	Na2O	MgO	Fe2O3	K2O	TiO2	P2O5	MnO
AW	63.1	18.20	3.42	1.09	3.85	3.83	1.52	0.26	0.05	0.03
RC	59.2	20.80	0.50	3.94	5.43	6.895	2.91	0.54	0.28	0.12
GC	65.3	18.70	1.20	2.07	3.30	5.05	2.98	0.47	0.27	0.04
50%AW-50%RC	60.4	20.00	1.69	2.07	4.94	5.75	2.10	0.42	0.21	0.08
SS	8.93	4.34	0.00	1.39	3.68	N-D	0.00	0.00	2.15	0.00

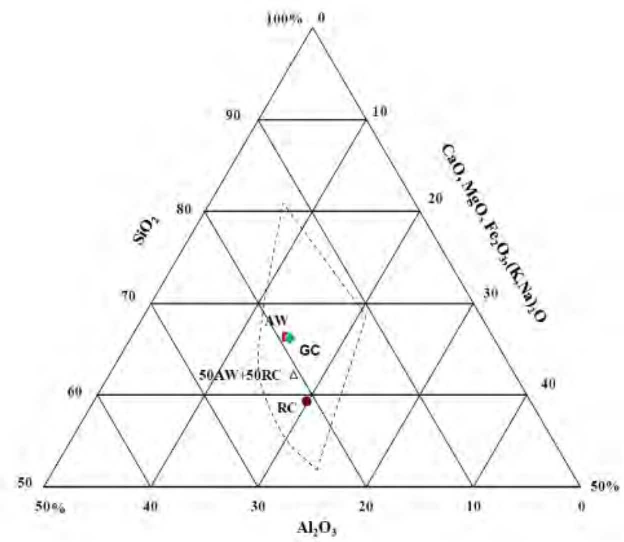
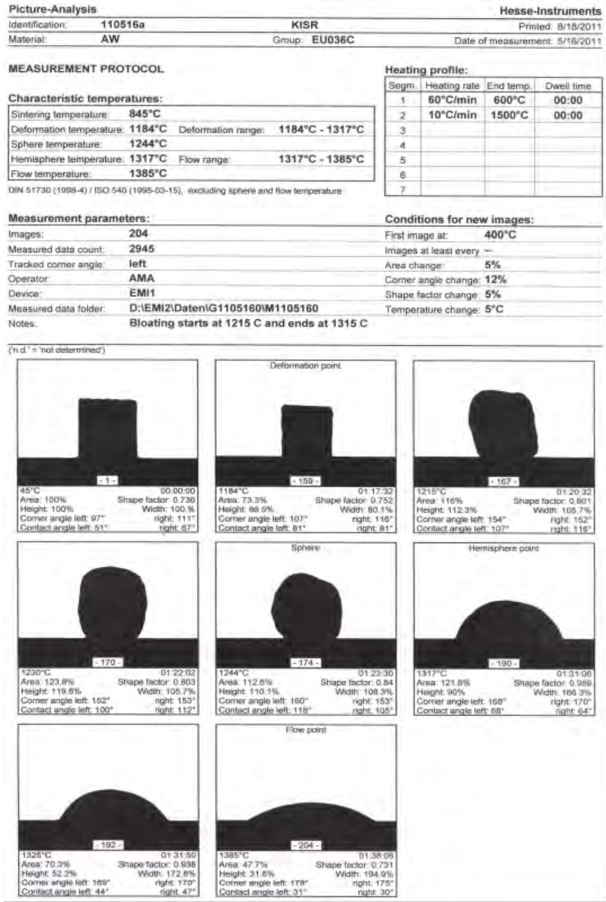


Figure 1. Raw materials and mixtures positioning in Riley's composition diagram of major oxides

Furthermore, by the use of the "Heating Electron Microscope", HEM, technique, the bloating of raw materials and mixtures were examined. The HEM is simulating the kiln heating environment with heating temperature ranging from 25 to 1600^{o}C. The melting of materials was monitored by a camera, which captures different images of melting of raw materials at different temperatures to its computer. The computer software analyzed the images and identified the different temperature peaks related to the sample. HEM can identify different temperatures as explained in table 4. The precise identification of the indicated temperatures will detect the start and end of gas liberation period. HEM results showed that RC and the AW samples, have both exhibited maximum bloating at 1260^{o}C. Figure 2 illustrates the picture analysis of HEM of Aggregate wash.

Table 4. Temperature peaks identified by HEM

Temperature peak	Definition
Sintering Temperature	The temperature at which the specimen starts to shrink
Deformation Temperature	The temperature at which the specimen starts to soften as indication of the start of gas liberation
Sphere Temperature	The temperature at which gas liberation is maximum
Hemisphere Temperature	The temperature at which the specimen attains the hemisphere shape as indication of the end of gas liberation
Flow Point Temperature	the temperature when sign of the mass collapse occur and gas escaping from the melted structure starts.



Picture-Analysis Hesse-Instruments
Identification: 110516a KISR Printed: 8/18/2011
Material: AW Group: EU036C Date of measurement: 5/16/2011

MEASUREMENT PROTOCOL

Characteristic temperatures:

Sintering temperature:	845°C		
Deformation temperature:	1184°C	Deformation range:	1184°C - 1317°C
Sphere temperature:	1244°C		
Hemisphere temperature:	1317°C	Flow range:	1317°C - 1385°C
Flow temperature:	1385°C		

DIN 51730 (1998-4) / ISO 540 (1995-03-15), excluding sphere and flow temperature

Heating profile:

Segm.	Heating rate	End temp.	Dwell time
1	60°C/min	600°C	00:00
2	10°C/min	1500°C	00:00
3			
4			
5			
6			
7			

Measurement parameters:
Images: 204
Measured data count: 2945
Tracked corner angle: left
Operator: AMA
Device: EMI1
Measured data folder: D:\EMI2\Daten\G1105160\M1105160
Notes: Bloating starts at 1215 C and ends at 1315 C

Conditions for new images:
First image at: 400°C
Images at least every –
Area change: 5%
Corner angle change: 12%
Shape factor change: 5%
Temperature change: 5°C

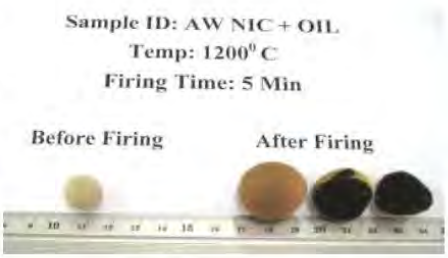
('n.d.' = 'not determined')

Figure 2. Heating microscope melting graphs of the wash.aggregate

2.2. Firing and Bloatability assessment

Actual firing trials were conducted on 800 prepared green pellets in a laboratory muffle furnace setting. The bloatability assessment was conducted based on the quality of the finished product. The quality of the finished product was assessed in terms of its bloating ratio, surface texture, specific gravity, and bulk density. The surface texture of the fired specimens was evaluated mainly on the basis of the presence of glass melts on the specimen surface. The presence of excessive glass on the surface is undesirable in industrial production as it causes ring formation within the rotary kiln at high temperatures. The firing assessment indicated that desert clay and clay from natural sources AW are promising raw materials for synthetic aggregate preparation. The effect is more prominent in clay samples containing oil and sewage sludge as bloating additives. Nevertheless, due to the difficulty in accessing the clay reserves in the desert, relying on these clays alone would be impractical. Therefore, AW waste materials were found to be most suitable, and reliable for production of synthetic aggregate, in different combinations with the natural clays and other additives, such as lube oil and sewage sludge. Bloatability and texture assessment of AW is presented in Table 5.

Table 5. Texture and Bloatability Assessment of Fired Pellets

Sample	Bloating Temperature (^{0}C)	Assessment at 5 min firing time					
		Density after bloating (g/cm^3)	Bloating ratio	Quality of bloating	Surface Texture	Remarks	Photo
AW	1200	1.18	1.15	Fair	Fairly good	Grey to brown in color with a fair quality of bloating and a fairly good surface texture	
AW+OIL	1200	0.44	1.55	Very Good	Fairly good	Grey to brown in color with a very good quality of bloating and a fairly good surface texture. This sample has the best bloating ratio of all the fired pellets	

2.3. Pilot plant production of synthetic aggregate and engineering assessment of LWA

For pilot plant production of LWA, green pellets were produced f every selected mixture combination, as optimized in the previous stage. Raw materials were stockpiled, dried, crushed, and powdered. Then powdered materials were liquefied, screened, press filtered reducing the moisture, extruded into strands, and then pelletized into green pellets. The green pellets then dried and conditioned. Two rotary kilns were used for firing the clay pellets, the laboratory rotary kiln and the pilot rotary kiln. Firing in both kilns was performed using natural LPG gas cylinders to simulate industrial production environment. Firing process was done in two stages, The first, was the calcination stage where the green pellets to be fired at 650 ^{o}C for duration of 3 to 6 minutes. The second, was the bloating stage where the calcined pellets to be subjected to a temperature of about 1200 ^{o}C for 10 to 20 minutes. So as materials pass through a kiln, the heating stages may be designated in approximate order of temperature rise from mechanical moisture or drying period, to hygroscopic or colloidal water dehydration period, then to chemical or molecular water dehydration period, to oxidation period, to dissociation-reduction period, to vitrification period, which means first glass and melting formation period, then followed by what is called pyroplastic condition, a period of bloating for clays, while all the gases present in the material are completely liberated, sealed and entrapped within the bloated pellet. 10 pilot plant firing trials were attempted with high degree of success after adjusting heat conditions, modification to gas supply set up and fine tuning with better regulation to calcination temperature and holding time and the bloating temperature. KISR pilot plant were able to produce and approve five batches of LWA using 5 different combinations of raw materials and firing trials. The produced LWA was characterized according to ASTM test methods which include the identification of bulk density, voids, relative density (specific gravity), absorption and percentage of clay lumps and friable particles. The study also evaluated concrete specimens containing LWA intended for use as concrete masonry units. The evaluation included the test for popouts materials and shrinkage of concrete test. The evaluation tests were done according to Standard specification for Lightweight Aggregates for Concrete Masonry Units (ASTM C331-05). The test result showed that the LWA samples produced in KISR satisfied the limit of "Percentage of clay lumps and friable particles" specidied to be lower than 2%, All LWA samples meet the maximum dry loose bulk density of 880 Kg/m^3 , LWA samples showed absorption values ranging between 15.1 to 21.8 %. The Visual inspection of all tested concrete samples containing LWA showed no sign of popout materials, and none of the samples showed any drying shrinkage that exceed 0.10% . As well, no measurable difference is noticed among the thermal conductivity values of the concrete samples produced using the five types of KISR-LWA (ranging between 0.45 W/m.K to 0.69 W/m.K). The thermal conductivity of KISR-LWA concrete is highly comparable to other conventional insulation materials for building walls and roofs, such as the hollow concrete blocks, concrete blocks, hollow clay tiles, and cement plaster , which makes it an economic competitive alternative insulation material.

3. Recycled aggregates from construction and demolition wastes

The total C&D waste production in Kuwait is around 1.6 million ton/year and there are four main C&D waste dumpsites in Kuwait with a total area of about 33 Km2 (Kartam. N., et al.; 2004). In 2001, the first concrete recycling project was established by the Environment Protection Industrial Company (EPIC). According to EPIC's marketing specialist, the construction waste recycling plant set up in 2001 was the first of its kind in the entire Middle East region and he plant receives anywhere between 7 to 20 thousand tons on a daily basis(Clean Middle East magazine). At present, Al-Dhow for Environmental Projects, a Kuwaiti Closed Shareholding Company established on 2006, manages two construction waste recycling plants by the Environment Preservation Industrial Company (EPIC) and Arab International Industrial Projects Company(AIIP). The Kuwait Municipality along with the Dumping Sites Rehabilitation Committee coordinates with the recycling plants to facilitate the transfer of construction and demolition waste to the sorting and recycling plants. The waste is reduced in size and fed to the crushing plant. The finished end product that is recycled aggregate gravel is categorized into different sizes, ranging from 5 to 50 mm. no further treatment is applied and the plants do not provide any known information about the parent concrete.

3.1. Quality of local recycled aggregates

In 2015, Kuwait institute for scientific research conducted a study to examine the major properties of recycled aggregates (Al-fadala. S; etc. 2015). The study was performed on samples collected from two local construction waste recycling plants and samples size collected were 3/4 in, and $\frac{1}{2}$ in, and 3/8 in in size. The characterization was performed according to ASTM standard methods as detailed in Table 6.

Table 6. Characterization Program of recycled aggregates

Test	Standard Test Method Used
Material Finer than 75 □m	ASTM C117-2013
Clay Lumps and Friable Materials	ASTM C142-2010
Los Angeles Abrasion	ASTM C131-2006
Soundness	ASTM C88-2013
Density and Absorption	ASTM C127-2012
Unit Weight	ASTM C29-2009

The results reported in table 7 showed the inferior quality of RA as highlited with the high absorption values, exceeding 3% which is the maximum absorption limits specified for natural coarse aggregates in GSO 1809 (2007). This may be attributed to the residue of attached mortar adhering to the original aggregate. These relatively high values of absorption demanded special care during the preparation of the new concrete since this will affect the workability and other properties of the new concrete mix. in addition, The abrasion loss values ranged between 35 to 44 which is lower than the maximum allowable L.A abrasion loss required in both the local specification for concrete applications GSO 1809 (2007) and ASTM C33 (2013) for all classes of aggregates and all types of weathering regions. Another study of recycled aggregates by (Al- Fadala, S. et al-; 2016) reported the presence of different contamination such as masonry, bituminous materials and glass. The classification performed according to the European Standard test method EN 933-11 (2009) on recycled batches showed variable compositions between batches and between sizes. Unbound aggregate, natural stone, and Hydraulically bound aggregate followed by Concrete, and concrete products shared the dominant percentages. This study proposed setting up a well-established demolition protocol for the best recovery of demolition waste materials for beneficial reuse and recycling. An example of the variation in the constituents of coarse recycled aggregate is reported in Fig. 3.

Table 7. Properties of local recycled aggregates

Average Test Result	Aggregate Source	
	1	2
Bulk Density (kg/m3)	1335	1357
Specific Gravity (Oven Dry)	2.3	2.3
Water Absorption (%)	6.2	5.2
L.A Abrasion Loss , %		
Grading B (19 mm to 9.5 mm)	35	37
Grading C (9.5mm to 4.75 mm)	44	41
The Percentage of Clay Lumps and Friable Particles		
Grading B (19.0 - 9.5)	0.5	0.4
Grading C (9.5 - 4.75)	0.6	0.6
the amount of material finer than 75 microns, %		
$\frac{3}{4}$ in	.02	.01
$\frac{1}{2}$ in	.07	.06
3/8 in	.06	.07

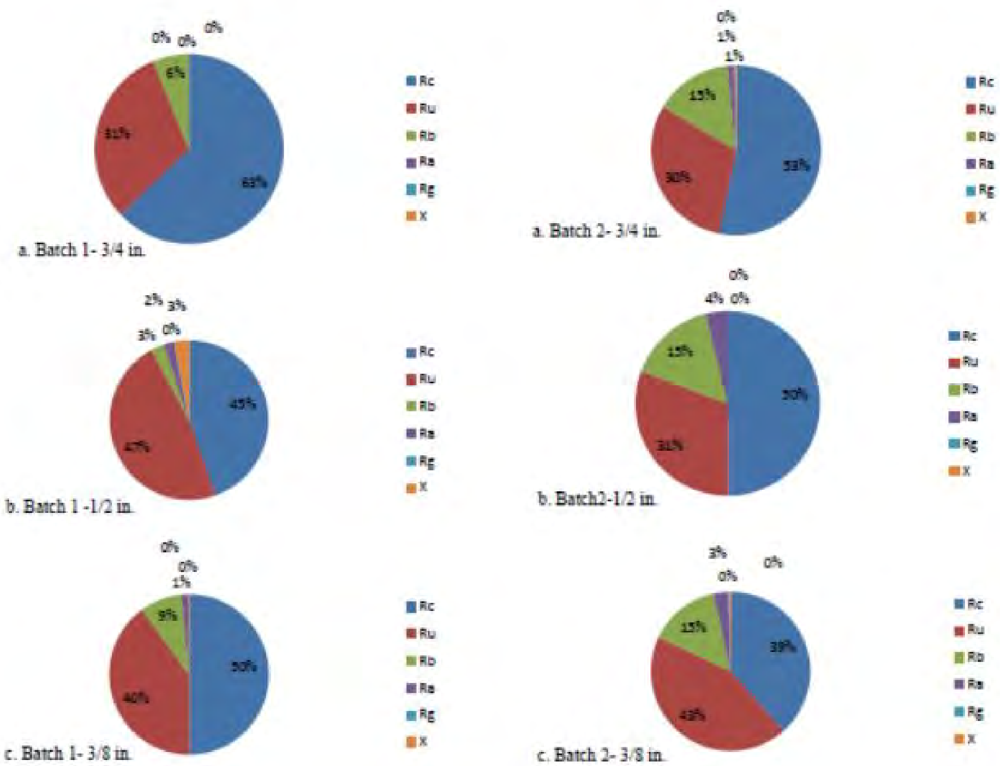


Figure 3. The proportions of constituent materials ofrecycled aggregates.

3.2. Research studies on recycled aggregate from construction and demolition wastes in Kuwait

Several studies were conducted in Kuwait to study the potential of recycled aggregates and recycled concrete aggregates (RCA) in concrete industry. Kuwait institute for scientific research conducted a research study on the use of RA in new concrete and the utilization of grind recycled concrete and masonry in the production of autoclaved lime-silica bricks. The study highlighted the inferior quality of RA compared to new aggregates and the additional use of superplastizer to achieve the same slump. Results also reported a reduction in compressive strength, split tensile strength and flexural strength. The study also showed that ground RA may be used in the production of lime-silica bricks and the resulting bricks were found to exceed the specification requirements, illustrating the potential of the proposed procedure in brick production. (El-Hawary, M.; etc., 2008). Kuwait University researched RCA application in concrete by a study of the flexural strength of concrete mixes in which RCA was used in beams and slabs. Beams made with 100%, 50% and 0% RCA as coarse aggregates were tested for flexural strength. Results were within the acceptable range when compared with ACI Code requirements. The permeability tests were conducted on slabs made with 100%, 50% and 0% RCA and results showed that the permeability of the concrete was not affected significantly by the introduction of the recycled aggregates. (AlMutairi, N. and AlKhaleefi,2007). Another study was performed to study some of the mechanical properties of concrete using RCA as compared to those of the conventional natural aggregate concrete. The reported results show that the 28-day cube and cylinder compressive strength, and the indirect shear strength of recycled aggregate concrete were on the average 90% of those of natural aggregate concrete with the same mix proportions that of the target strength.(Rahal,2005).

3.3. Local Specifications of recycled aggregate from construction and demolition wastes

The first gulf specifications of recycled aggregates from construction waste to be used in construction works is issued in 2015 (GSO 2489, 2015). The specification GSO 2489 identifies different classes of construction wastes as detailed in Table 8.

Table 8. Construction waste classification according to Gulf Specifications

Class	Definition
Construction waste	Waste generated from excavation and/or demolition of concrete structures
Concrete construction waste	Waste generated from demolition of concrete structures in general.
Solid concrete construction waste	Waste generated from demolition of concrete structures including columns, foundations, and mass concrete blocks.
Excavation waste	Waste generated from excavation natural earth in construction sites.
Mixed construction waste	Waste generated from excavation and demolition of concrete structures
Mixed recycled aggregates	Mixture of coarse and fine recycled aggregates

The specifications govern the use of recycled aggregates and the percentage of replacement according to class of waste being recycled. GSO 2489 limits the use of recycled aggregate for the production of structural concrete having a maximum strength of 30 Mpa and for non-structural concrete having a maximum strength of 40 Mpa. The specifications governs the physical, mechanical, and chemical properties of recycled aggregates with-out any differentiation according to the class of waste. The standard specification considers the use of recycled aggregate as coarse and fine aggregates. The comparison of absorption, L.A abrsison and soundness limits specified for recycled aggregates to be use as coarse aggregate in structural and non-structural concrete with the same specified for natural coarse aggregates to be use in concrete specified in GSO 1809 (2007) is presented in Table 9. The comparison showed more stringent limits for recycled aggregates in toughness and soundness and similar absorption limit when used in structural concrete . for soundness limit, the precision of soundness test specified in ASTM C88 (2013) is poor and it may not be suitable for outright rejection of aggregates without confirmation from other tests more closely related to the specific service intended” as stated in ASTM C88 (2013), therefore performance records of local recycled aggregates under real servise conditions and under real local environment where freezing and thawing is not a concern must be established rather than relying on ASTM C88 as a test for rejection an aggregate source.

Table 9. Comparison of RA limits and virgin aggregate limits for concrete use

Standard Limit		
	GSO 2489 (2015)	GSO 1809(2007)
Water Absorption (%) Structural Concrete	3.0	3.0
Non-Structural Concrete	4.0	3.0
L.A Abrasion Loss , %	30.0	50.0
Soundness (%5 cycles of MgSo3) (%)	15.0	18.0

4. Conclusions

Total dependency on import to feed the construction demand for aggregates. In addition, the research was with environmentally focused on recycling waste and preserve the environment. The first sustainable source investigated is the production of synthetic lightweight aggregates utilizing combinations of argillaceous indigenous and waste materials, KISR were able to produce different sizes LWA for LWA concrete specimens that meet the ASTM requirements of light weigth aggregates for masonry (ASTM C331-05). The primary raw material used in the production of LWA is aggregate wash which is a waste byproduct resulting from sand washing processes performed at the local sand quarries. KISR registered the process used in the manufacturing of LWA as a patent registered by the United States Patent and Trademark Office (Albahar , S and etc,2016). Currentley, KISR is marketing this patent by conducting a proof of concept activity to prove the applicability of this work on industrial scale. The second source investigated is recycled aggregates from construction and demolition wastes. The quality assessment of the local recycled aggregates showed the inferior quality of RA as a coarse aggregates when compared to the natural coarse aggregates. The local RA investigated showed higher water absorption, and lower abrasion resistance than virgin coarse aggregates. The local specifications of RA issued under the gulf specification organization GSO 2489 (2015) is showing stringent limits on the mechanical, chemical and physical properties of recycled aggregate to be used in concrete and this is causing the concrete industry to decline accepting local RA as a sustainable source of coarse aggregate. The research studies conducted on the local RA judged the strength and the mechanical characteristics of RCA concrete but no proven studies are available on durability performance of concrete made with RCA. The absence of aggregates quarries in Kuwait and the total rely on the imported sources of coarse aggregates, coupled with the growing environmental concerns asking for sustainable concrete industry, the local authorities are urged to consider RA as a sustainable concrete constituent. A national scale initiative must be established to start utilizing the recycled aggregates. The quality of RA must be exposed to long term monitoring to ensure quality consistency of RA produced from each crushing plant. In addition, the current demolition procedures must be investigated and the different type of waste generated from demolition must be identified and classified according to quality. A well-established demolition protocol for the best recovery of demolition waste materials for beneficial reuse and recycling is required. A governmental initiative in cooperation with local industry must encourage the use of RA in precast concrete products low strength, and non-reinforced concrete for use in exposure environment with no risk of corrosion or attack. Performance based approach of evaluation of manufactured end products must be established with the national research bodies to address the durability performance of concrete made with RA under Real-life conditions.

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