Journal of Engineering and Sustainable Development
Vol. 22, No.02 (Part-5), March 2018
ISSN 2520-0917
10.31272/jeasd.2018.2.67

SUSTAINABILITY OF THE CONCRETE BY USING RECYCLED WASTE MATERIALS

Dalia Adil Rasool[1*], Mais Abdulrehman Abdulkarem[2], Mohammad Ali Abdulrehman[3]

1) Assistant lecturer, Material- Engineering-Department, Mustansiriayah University, Baghdad, Iraq.
2) Assistant lecturer, Material- Engineering-Department, Mustansiriayah University, Baghdad, Iraq.
3) lecturer, Material Engineering- Department, Mustansiriayah University, Baghdad, Iraq.

Abstract: Marble dust and brick waste materials taken from demolition of buildings create serious environmental problems so the main aim of this paper is to evaluate the potency of employing mixed (marble-dust and brick-powder) waste materials altogether as partly replace of cement and the fine-aggregate respectively in the composition of concrete which were mixed with a ratio of (1:2:4) and (W/C) ratio equal to (0.45). In this study the cement has been replaced by marble dust waste in the proportion of (0%,5%, 10%, 15%, 20%, 25%) and fine aggregate replaced by waste brick powder in the proportion of (0%,5%,10%, 15%,20%,25%) by weight of concrete mix simultaneously . In this paper the (compressive , flexural and split tensile) strength of the concretes mixtures were specified . The main results of this paper appeared that the (cement and sand) can be partially replaced by(marble- dust and brick- powder) in the concrete mixture and it has achieved the optimum percentage of replacement by (20)%. So that utilization of construction waste is required in an attempt to equilibrium between the construction request and environmental sustainability.

Keywords: *Marble Dust ,Brick Clay , Concrete Mix , Waste Materials, Sustainability*.

استدامة الخرسانة من خلال استخدام مواد النفايات المعاد تدويرها

الخلاصة: يؤدي استخدام غبار الرخام و نفايات الطوب المأخوذة من هدم المباني إلى حدوث مشاكل بيئية خطيرة، لذلك فان الغرض من هذا البحث هو دراسة إمكانية استخدام مزيج غبار الرخام ومسحوق الطوب في وقت واحد كبديل جزئي للاسمنت والركام الناعم على التوالي في مكونات الخلطة الخرسانية، التي تم خلطها مع نسبة (1: 2: 4) ونسبة ماء (W / C) تساوي (0.45). في هذه الدراسة تم استبدال الأسمنت بنفايات غبار الرخام بنسبة (0، 5 ،10، 15، 20 ، 25)٪ والركام الناعم محل مسحوق الطوب بنسبة (0، 5 ،10، 15، 20 ، 25)٪ من وزن خليط الخرسانة في وقت واحد. تم تحديد قوة الانضغاط، وقوة الانحناء، وقوة الشد للخلطات الخرسانة. تم تحليل نتائج الخواص الميكانيكية مقارنة بلعينات المرجعية. وأظهرت النتائج الرئيسية لهذا البحث أن خليط غبار الرخام ومسحوق الطوب يمكن أن يستخدم بنجاح كبديل جزئي للأسمنت والرمل في مواد الخرسانة وقد حققت النسبة المثلى للاستبدال بنسبة (20)٪. لذلك فإن استخدام نفايات البناء مطلوبة في محاولة لتحقيق التوازن بين طلب البناء والاستدامة البيئية.

1. Introduction

Concrete has many distinctive qualities (easily obtainable, relatively strong, and durable). so there is a big demand to the main concrete mixture components (fine and coarse aggregate).

*Corresponding Author engineeringgroup@yahoo.com

The rising utilize of the fine aggregate make an environmental imponderables are causing depletion of natural resources ,as well as the reduction of these sources in some areas of Iraq[1-2]. So it is necessary to replace the cement and fine aggregate in the industry of construction .It is very important to manage the waste and industrial products by (recycling these waste as a modified materials , finding appropriate combination, the needing of safe and economic disposal of waste materials and the need of preferable and more cost-effective construction materials)[3-4].

Hanifi Binici et al[5] (2007) found that (the marble dust concrete)has a better specifications than (lime stone dust concrete) which was prepared with the same prepared conditions (equal w/c and mix proportion).The resuls determined that the Marble dust concrete would have lower water permeability and higher compressive strength than (lime stone dust concrete).

Ali et al [6] (2014) used the powder –crushed- brick (PCB) with 5%, 10%, 15%, 20% and 25% as a cement substitution in the mortar. Results set that the using highest cement substitution (25%) of powder clay- brick as a partial substitution of cement reduces the compressive strength of the mortar cement of about (28.2)% in 28 days.

Thaniya Kaosol [7] (2010) has made many studies on the reusing of waste concrete materials as crushed stone for the hollow concrete . In order to achieve the possible benefit and making a sustainable and profitable disposal alternative for the concrete waste.Many attempts were made for this purpose and several percentages have been tried the amount (i.e. 0%, 10%, 20%, 50% and 100%). The results confirmed that the waste concrete can be used to produce hallow concrete block masonry units

Manaseeh Joel [8] (2010) was appropriated for crushing the fine granite in order to replace river sand in concrete production Slump, compressive and indirect tensile strength tests were performed on fresh and hardened concrete. Twenty eight days peak compressive and indirect tensile strength values of 40.70 N/mm2 and 2.30 N/mm2 respectively were obtained with the partial replacement of river sand with 20% CGF, as against values of 35.00N/mm2 and 1.75N/mm2 obtained with the use of river sand as fine aggregate. The results confirmed that the river sand replaced with 20% of(crushed fine granite) is recommended for use in the production of concrete also it is a better way for for get rid of wastes.

Bouziani et al[9] (2011) found that the increasing of the Marble Powder (MP) content in concrete Sand , from 150 kg/m3 to 350 kg/m3, modifies the properties at fresh state by decreasing v-funnel flow time (from 5s to 1.5s) and increasing the mini-cone slump (from 28cm to 34cm). In other hand, the 28 days compressive strength decreases with an increase of MP content.

Omar et al [10] (2012) studied experimentally the effect of partial replacement of limestone waste and/or marble powder of sand on the concrete properties. The percent of replacement limestone waste of sand was 25%, 50%, and 75%. While, the mixes present of marble powder were 5%, 10% and 15%.The results confirmed that the slump test was modified with the using of limestone. Also, they notice good performance in presence of limestone with marble powder.

Veena, G. P., Gulfam, P. [11] (2014) studied the Feasibility and the need of using (Waste Marble Powder) in Concrete Production. This paper presents the benefits of the substitution of cement by marble waste to achieve economical and environmental

savings. The tests results confirmed that the optimum percentage of replacement was(10)% which will increase the strength of marble dust concrete when compared from 14 days to 28 days.

The main purpose of the research is to offer an additional information in the field of developing the concrete mixture by using recycling brick- clay and Marble- powder which were used in the construction to explore the possibility of employing these recycled materials in concrete mixture.

Also this research offers a comprehensive study on the using of the wastes brick-powder (which was produced from clay-brick destruction of buildings) and marble-powder (which was produced from processing factories of marbles).The aim of this study are:

1) studying the effect of using the wastes (marble dust and brick clay) on the mechanical properties of concrete mixture.

2) comparing(the compressive, flexural and tensile) strength by using the wastes (marble dust and brick clay) with the given design concrete mixture.

3) establishing alternatives for the main components of the concrete mixture (cement and sand)with partial substitution of the wastes (marble dust and brick clay).

2. The materials

2.1. *Cement*

Iraqi ordinary Portland Cement was used in the preparing of the specimens of this study to avoid the harmful effect of humidity on the cement it was stored in dry place. The table (1) illustrates the chemical and physical properties of cement which was conformed to Iraqi Standard Specification (IQS No.5/1984) [12].

Table (1) The chemical and physical properties of cement and Chemical Compound of fine aggregate

Chemical Compound	Composition (%) of cement	Composition (%) of fine aggregate
Magnesia ,MgO	3.62	0.81
Lime ,Cao	64.53	5.4
Ferric oxide ,Fe_2O_3	2.95	0.59
Silica ,SiO_2	19.51	83.52
Alumina ,Al_2O_3	4.58	0.5
Sulfuric Anhydride ,SO_3	0.97	2.67
Loss on Ignition	4	5.56
The Physical- Properties of cement		
Specific Gravity	3.34	
Passing sieve No-200 (%)	95	

2.2.The Fine Aggregate

In this study the fine aggregate used from Al-Nabaey region.Table (1) and (2) illustrates the grading of fine aggregate which correspond with the requirements of Iraqi Specification No.45/1984, zone 3[13].

2.3. The Coarse Aggregate

In this study the coarse aggregate used from Al-Nibaey region with maximum size of its particles reached to(12) mm ,shown in Table (2).

Table (2) The physical properties of coarse aggregate

Property	ASTM	Coarse- Aggregate	Fine- aggregate
Bulk specific Gravity	ASTM C127 and C128	2.628	2.62
Apparent specific Gravity	ASTM C127 and C128	2.689	2.690
Percent wear (Loss –Angeles Abrasion)	ASTM C 127 and C128	26.1	.....
Present water absorption	ASTM C127 and C 128	0.586	0.614

2.4.The Marble Dust

It is one of the important materials used in the decoration of buildings. The marble powder is produced from the processing of the factories of marbles .About (25)% of this marble was transformed to a powder form. Table (3 and 4) illustrates the physical and chemical properties of Marble.

2.5.Brick Clay

Use of brick powder produced from clay brick wastes taken from demolition of buildings in concrete industry. Bricks clay were placed inside the impact crusher to diminish their size approximately to 5 mm as to facility the process of grinding. Table5 show the chemical properties of brick powder.

Table3:The Physical Properties of Marble

Physical Composition of Marble	
Compressive Strength	1800 to 2100 kg/m^2
Density	2.3to 2.5 g/cm^3
Porosity	Quite low
Water Absorption	Less than 1%
Hardness	3 to 4 on Mohr's Sc
Weather Impact	Resistant

Table4: The Chemical Properties of marble

Chemical Composition of Marble	
Alumina (Al2O3)	2-4%
Loss On Ignition (L.O.I)	30-33%
Lime (CaO)	36-42%
Silica (SiO2)	20-24%
Other Oxides like Mg, Na	1.4 -2.5%

Table 5 Chemical Composition of brick powder

Percentage	Materials
SiO2	57 - 65 %
Al2O3	30 - 40 %
Fe2O3	2 - 2.5 %
L.O.I	12.49

4. The Mixture Proportions

The concrete mixtures were made with 760 kg/m^3 of sand, 1520 kg/m^3 of gravel, 380 kg/m^3 of cement, and w /c ratio of 0.45 as shown in table (8).The specimens of modified concrete were prepared in five mixes using waste marble dust to replace the cement with the percentages (5, 10, 15,and 20)%, respectively and using the waste brick powder to replace sand with the percentages(5, 10, 15,and 20)% respectively as shown in table (8).All specimens were water cured for 28 days to investigate the effect of increasing the percentages of wastes adding on the strength of the concrete mixtures.

Table 6. Mixture Proportions of Modified Waste -Concrete Mixes

Proportion Mix%	Cement kg/m^3	Sand kg/m^3	Coarse kg/m^3	Waste materials aggregate Kg/m^3		W/C
				Marble by weight of cement	Brick by weight of sand	
0%	380	760	1520	-	-	0.45
5%	361	722	1520	19	38	0.45
10%	342	684	1520	38	76	0.45
15%	323	646	1520	57	114	0.45
20%	304	608	1520	76	152	0.45
25%	285	570	1520	95	190	0.45

5. Concrete Mixing

A topical bag (0.5 bag cement) was used according to their weights. The dry materials were mixed with sand, gravel and cement first , then water was added and later the worked test samples were then tested for concrete at a rate of (3) cubes (10*10*10)cm per mixture and one cylinder (15*30)cm as an average for each mixture for testing. In the Preparation of specimens. The mold and base plate were cleaned and were used with oil in order to prevent the concrete mixes from sticking to the side of the cube. The cubes were filled with concrete with three layers which were compacted for 25 times. The compaction was done uniformly to all the surfaces of the concrete mixtures. The surface of concrete must be smoothed in order to gain the same level with the upper side of the mold. The cubes and beams were de-molded after 24 hours from the casting .During the mixing process, the operability of the concrete mixtures was examined to check the slump of the missing cone. This test was done according to standard condition B.S.1881: Part 102[14].

6. Results and Discussion

6.1.The Compressive Strength Result

Table(7) and Figure(1) illustrate the results of the compressive strength . The results evince that the wastes (marble dust and brick powder)content increases by adding the percentages (5,10,15 and 20)% to the concrete mixture, the values of the compressive strength tend to increase above that for the plain mix by (9.89%) of 20 % ,then they decrease with increasing the modifying wastes. This increasing could be refer to the high specific gravity of the marble dust powder and its effect as a filler material because it has finer particles than fine aggregate in addition to the pozzolanic reactivity of super fine portion of powder brick aggregate. This finding agrees with Rabah Chaid et al[15].

Table 7. Results of compression tests of the marble dust and brick powder-concrete mixtures

Comp. Strength (MPa) ratio	Sample 1	Sample 2	Sample 3	Average (MPa)
0 % Control concrete (1:2:4)	31.6	31.72	31.54	31.62
5%	31.95	31.88	32.08	31.97
10%	32.58	32.55	32.43	32.52
15%	33.35	33.46	33.3	33.37
20%	34.82	34.73	34.7	34.75
25%	32.85	32.86	32.93	32.88

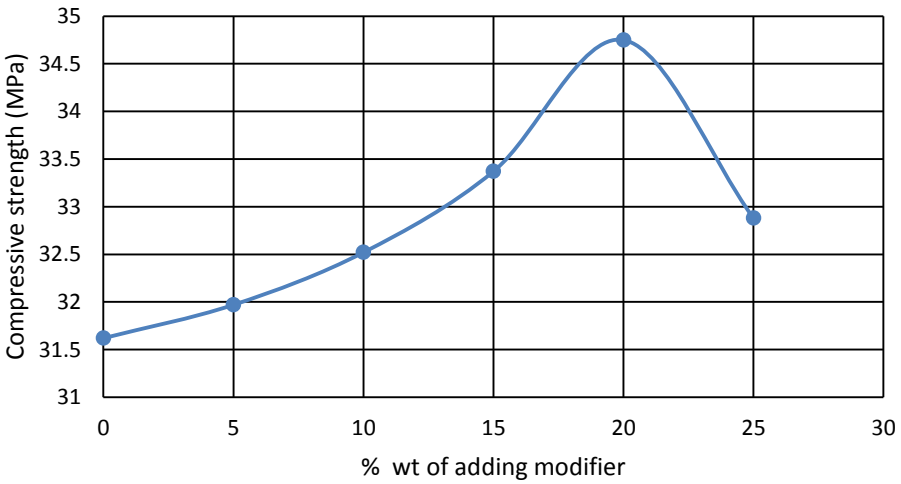

Figure 1. Compressive Strength for Plain and Waste- Modified Concrete Mixes at 28 Days.

6.2. The Flexural Strength Result

It was observed that the flexural strength follow the same trend of the compressive strength. The values of the flexural strength tests presented in the Table 8 and Figure 2 shows that flexural strength increases with increasing marble dust and brick powder percentages (5,10,15 up to 20)% ,the values of the flexural strength increase above the plain mix value by (6.58%) of 20 % ,then they decrease with increasing marble dust and brick powder. This finding agrees with Ali Hussin et al [16].

Table 8. Results of Flexural Strength test of the marble dust and brick powder-concrete mixtures.

Flexural strength(MPa) ratio	Sample1	Sample2	Sample3	Average (MPa)
0 % Control concrete (1:2:4)	4.15	4.37	4.23	4.25
5%	4.34	4.25	4.28	4.29
10%	4.31	4.45	4.32	4.36
15%	4.53	4.41	4.38	4.44
20%	4.56	4.57	4.46	4.53
25%	4.35	4.38	4.44	4.39

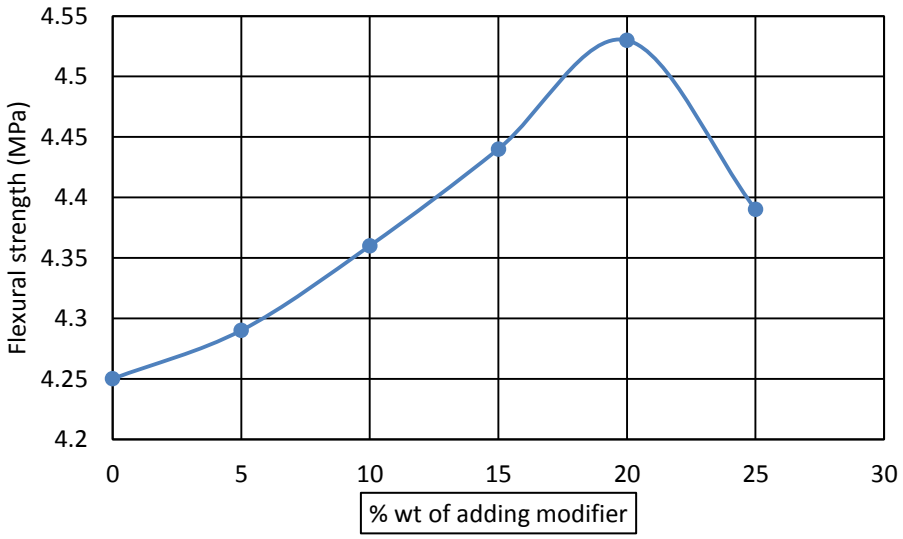

Figure 2. Flexural Strength for Plain and Waste- Modified Concrete Mixes at 28 Days

6.3.The Splitting Tensile Strength Result

From the table 9 and figure3, it was observed that up to 20% substitution of cement and sand with the marble dust and brick powder waste respectively , there is a gradual rise of split tensile strength, the values of the splitting tensile increase above the plain mix value by (10.82%) of 20 % , but beyond which there is reduction in split tensile strength.

Table 9. Results of Split Tensile Strength test of the marble dust and brick powder-concrete mixtures.

Tens. Strength (MPa) ratio	Sample 1	Sample 2	Sample 3	Average (MPa)
0 % Control concrete (1:2:4)	2.64	2.73	2.67	2.68
5%	2.82	2.69	2.71	2.74
10%	2.87	2.79	2.77	2.81
15%	2.86	2.95	2.83	2.88
20%	2.9	2.94	3.07	2.97
25%	2.75	2.74	2.79	2.76

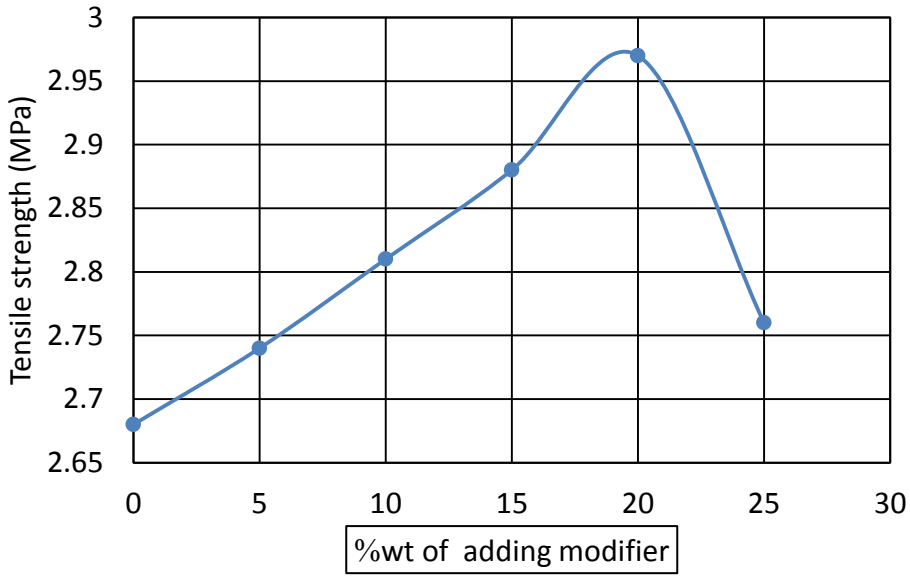

Figure 3. Splitting Tensile Strength for Plain and Waste -Modified-Concrete Mixes at 28 Days.

7. Conclusions

This study was explain the effect of employing the wastes mixed (marble dust and brick powder) as a partial substitutional materials of cement and fine aggregates respectively on the mechanical properties of concrete mixes. Based on the experimental work results for the conventional and waste modified concrete mix, the main conclusions are:

1 – The marble dust and brick powder are a good modifier to modify the mechanical properties of concrete mixtures.

2- The optimum percentage of replacement was 20 %, above this ratio, the results of the concrete mixture tests begin to decrease because of the weak bonding of the concrete mixture components with the increasing of replacement percentages.

2- The compressive strength at 28 days augment with the addition of marble dust and brick powder waste, and the highest improvement (9.89%) was obtained for samples with 20wt% of modify waste. .

3- Flexural strength and split tensile strength of marble dust and brick powder waste-concrete mix was higher than control samples for 28 days. These enhancements are about 6.58 % and 10.82% respectively.

4-The modified concrete mixture can be used in the columns and beams of buildings.

8. Refrence

1. Cyr, M., Aubert, J.E., Husson, B., Julien, S., Clastres, P. (2005) . *"Gestion des résidus minéraux dans les matériauxcimentaires*". 23ièmes Rencontres Universitaires de Génie Civil, risque & environnement.
2. Thanoon, A.T., Mazin, T.H., and Eman, A.Q. (2005*). " Utilization of By-Products from Cutting Limestones as Fine Aggregate in Mortars* .Al-Taqani Journal for

Engineering Researches, Foundation of Technical Education , Vol. 18 , No.2 , pp. 15-21.

3. Dalia, A. R. (2014) . *"Utilization of Waste Plastic Water Bottle as a Modifier for Asphalt concrete Mixture Properties"* . M.Sc. Thesis, Department of Materials Engineering; AL-Mustansiriya University, Iraq.
4. Kovler, R. N. (2011) . *"Properties of fresh and hardened concrete* ". Cement and Concrete Research, Vol. 41, pp. 775-792.
5. Hasan, K., Hanifi, B. and Salih, Y. (2007). " *Influence of marble and limestone dusts as additives on some mechanical properties of concrete*". Scientific Research and Essay, Vol. 2 (9), pp. 372-379.
6. Ali, A.A., Abd-Elmoaty, M. , and Hany H. H. (2014) . *"Utilization of crushed clay brick in concrete industry*" .Structural Engineering Department, Faculty of Engineering, Alexandria University, Egypt, Vol.53, pp. 151-168.
7. Thaniya, K. (2010) . *"Reuse concrete waste as crushed stone for hollow concrete masonry units*". The 3rd Technology and Innovation for sustainable development international conference (TISD2010), Faculty of engineering, Khon Kaen University, Thailand , pp. 176.
8. Manasseh, J. (2010) .*"Use of crushed granite fine as replacement to river sand in concrete production* ". Leonardo Electronic Journal of Practices and Technologies, ISSN 1583-1078, issue 17, pp. 85-96.
9. Bouziani, T., Benmounah, A. , Bederina, M., and Lamara, M. (2011) . "*Effect of Marble Powder on the Properties of Self-Compacting Sand Concrete*". The Open Construction and Building Technology Journal, Vol.5, pp.25-29.
10. Omar, M.O., Ghada, D.A. ,Mohamed, A.S. ,Hassan, A.M.(2012) . *"Influence Of Limestone Waste As Partial Replacement Material For Sand And Marble Powder In Concrete Properties"* . Hbrc Journal, Vol. 8 , No. 3 , pp. 193–203.
11. Veena, G. P., Gulfam, P. (2014) . *"Feasibility and Need of use of Waste Marble Powder in Concrete Production*". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, PP 23-26.
12. Iraqi Standard No. (5). (1984) . *"Portland Cement"*, Central Organization for Standardization And Quality Control, Baghdad.
13. Iraqi Standard No. 45. (1984) . *"Rubble of Natural Resources Used in Concrete Construction "* Central Agency for Standardization and Quality Control, Baghdad.
14. British Standard Institution .(1952) . *"Methods of Testing Concrete"*. B.S.1881, part 102, BSI, London.
15. Rabah, C., Arnaud, P., and Youcef, G. (2015) . *"Durability of Concretes with Marble Powder "* .International Conference on Environment Science and Engineering DOI: 10.7763/IPCBEE. V83. No. 6.
16. Ali, H.A., Eman, A.Q. , and Mazin, T.H. (2011) .*"Production Of Light-Weight Concrete Blocks Using Crushed Limestone As Fine Aggregate and Crushed Clay Brick AS Coarse Aggregate"* . .Al-Taqani Journal for Engineering Researches, Foundation of Technical Education ,Vol. 24 **,**Issue**.**6 ,PP. A53-A63**.**