BABAK SALIMI

EXAMINING USE OF WASTE CONSTRUCTION MATERIALS AS AGGREGATES FOR PRODUCTION OF CONCRETE MASONRY UNIT IN NORTH CYPRUS

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A THESIS STUDY SUBMITTED TO
THE GRADUATE SCHOOL OF APPLIED SCIENCES
OF
NEAR EAST UNIVERSITY

By
BABAK SALIMI

In Partial Fulfillment of the Requirement for
the Degree of Master of Science
in
Architecture

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Approval of Director of Graduate School of Applied Sciences

Prof. Dr. İlkay SALİHOĞLU

We certify this thesis is satisfactory for the award of the degree of Masters of Science in Architecture.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

Concrete is one of the most energy intensive materials in the world. At the same time, it is one of the most commonly used construction materials worldwide. In fact, in North Cyprus construction practices, buildings and other structures have been building by using concrete as the dominant and base construction material. Therefore, it is appropriate to strive for more proper practice in utilizing this material, which would result in reduced environmental impacts. This study aims to examine the potential in use of waste construction materials as recycled aggregates in preparation of new batches of concrete that would be use for production of some concrete products, specifically to produce new concrete masonry unit (hollow concrete block). Concrete masonry unit due to its environmentally friendly advantages proposed as one of the most important sustainable construction materials by many research studies. Likewise, the result of this study determined that the combination of recycled aggregates in appropriate proportions with natural aggregates not only produce the lighter concrete masonry unit but it can also save proper characteristics of conventional product which can only be produced by natural aggregates. On the other hand, waste construction materials contain variety of harmful materials for the environment, which are dumped in landfills, causing environmental degradation. In addition, re-use of recycled construction materials have the potential to reduce further exploitation of natural resources in stone quarries to extract and utilize required aggregates to manufacture concrete and different types of concrete products.

***Keywords*:** Environment; waste construction materials; recycled aggregates; concrete; concrete masonry unit; Northern Cyprus

ÖZET

Beton dünyanın en aşırı enerji kullanılan malzemelerden biridir. Aynı zamanda, tüm dünyada en çok kullanılan yapı malzemelerinin biridir. Aslında, Kuzey Kıbrıs'ta yapı uygulaması, inşaat ve diğer inşaatın yapılar, neredeyse tamamen beton dan inşa edilmiştir. Bu nedenle, bu malzeme kullanılarak daha doğru uygulama için çaba uygundur, ki çevresel etkileri olan azaltma sonuçlanacaktır. Bu çalışma geri dönüşümlü agrega olarak atık inşaat malzemeleri kullanımında potansiyelini incelemeyi amaçlamaktadır, ki betonun yeni kümelerinin hazırlanmasında ve bu, bazı beton ürünün üretimi için kullanılacaktır, özellikle yeni briket üretmek için. Briket çevre dostu avantajları nedeniyle birçok araştırma çalışmaları ile en önemli sürdürülebilir inşaat malzemelerinden biri olarak önerilmiştir. Aksine, Atık inşaat malzemeleri çevreye çeşitli zararlı maddeler var, ki çöplüklere atılıyor ve çevresel bozulma neden olur. Ayrıca, geri dönüşümlü inşaat malzemeleri kullanımı ayıklamak ve beton ürünleri beton ve farklı üretimi için gerekli agrega kullanmak için taş ocaklarında doğal kaynakların daha sömürülmesini azaltma potansiyeline sahiptir.

***Anahtar kelimeler*:** Çevre; atık inşaat malzemeleri; geri dönüşümlü agregalar; beton; briket; Kuzey Kibris

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LIST OF ABBREVIATIONS

AASHTO:	The American Association of State Highway and Transportation Officials
ASTM:	American Society for Testing and Materials
CCA:	Commodity Chain Analysis
CCMPA:	Canadian Concrete Masonry Producers Association
CMU:	Concrete Masonry Unit
DW:	Dry Weight of sample
GDP:	Gross Domestic Product
GT:	Giga Tones
IISD:	International Institute for Sustainable Development
RA:	Recycled Aggregates
RC:	Reclaimed Concrete
RCA:	Recycled Concrete Aggregates
LCA:	Life Cycle Analysis
MC:	Moisture Content of Sample
MDF:	Medium-Density Fiberboard
NA:	Natural Aggregate
NC:	Northern Cyprus or North Cyprus
UNEP:	United Nations Environment Program
UN:	United Nations
WA:	Water Absorption
WBCSD:	World Business Council for Sustainable Development
WCM:	Waste Construction Material
WW:	Original Wet weight of sample

CHAPTER 1
INTRODUCTION

1.1 General Consideration

Consideration of true architecture is beyond many things, it starts from core complicated philosophical contents to technical aspects of realization of project, and it should pass through every issue with overall coordination and balance to all components. Gómez in book of “Built upon love” has noted some important points for having this combination in built environment issues while he referred to humanity and architects as the main points.

> “It is perhaps obvious that human desire has shaped the built environment, sometimes in ways that today we may judge as unsuitable for the common good. Impressive buildings were constructed to fulfill spiritual needs that seem almost absurd from a late-modern perspective—totally “impractical” edifices such as magnificent funerary monuments to commemorate the dead, and temples to celebrate strange divinities. Buildings have also been objects possessed by the wealthy and powerful, symbols of decadent consumption and means for an elite to exert control over the masses. Representing ideologies and institutions in the manner of false idols, they have often contributed to repressive environments.
>
> Modernity has rightly judged this sort of building practice faulty and dangerous. As a pragmatic alternative it has proposed that buildings should fulfill the wishes of individuals in a democratic society: a desire for shelter and protection from the elements, for a home and a place to work where humans may live their lives in as pleasurable a way as possible. In the wake of God’s demise, arguably nothing else may be necessary. More recently, under the rubric “sustainable development,” these aims have been interwoven with a sense of responsibility for the environment and the wellbeing of humanity at large. A meaningful architecture would efficiently fulfill humanity’s material needs, while at the same time remaining mindful of the world’s resources for the perpetuation of human civilization” (Gomez, 2006).

Therefore, take responsibility for doing any meaningful action is essential, while it should understand the nature of every entity and comprehend the concept of value, whereas human is the most effective ones amongst other and if human lost its humanity and replace it with carelessness and neglected attitude, everything will be damage, harm and lost by the end of any activity. So, considering the proper relation of value, environment and human would be the suitable guideline in this matter.

1.1.1 Value of biodiversity for sustainability

“Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs” Definition of Sustainable Development (UN, 1987).

Sustainability issues became one of the most attractive, necessary and remarkable matters of the world in the last decades. United Nation in Brundtland’s Report deliberated many different associated issues to the subject of sustainability. Amongst those the core concept of true sustainable development defined as accomplishment a proper balance within the convergence of ‘Economic development, Social Equity and Environmental Protection’ issues of any project. (Figure1) While any successful sustainable application should understand and apply the essence of sustainability which is decreasing the usage of raw materials from natural resources plus less production and intrusion of wastes to the environment (IISD, 2010).

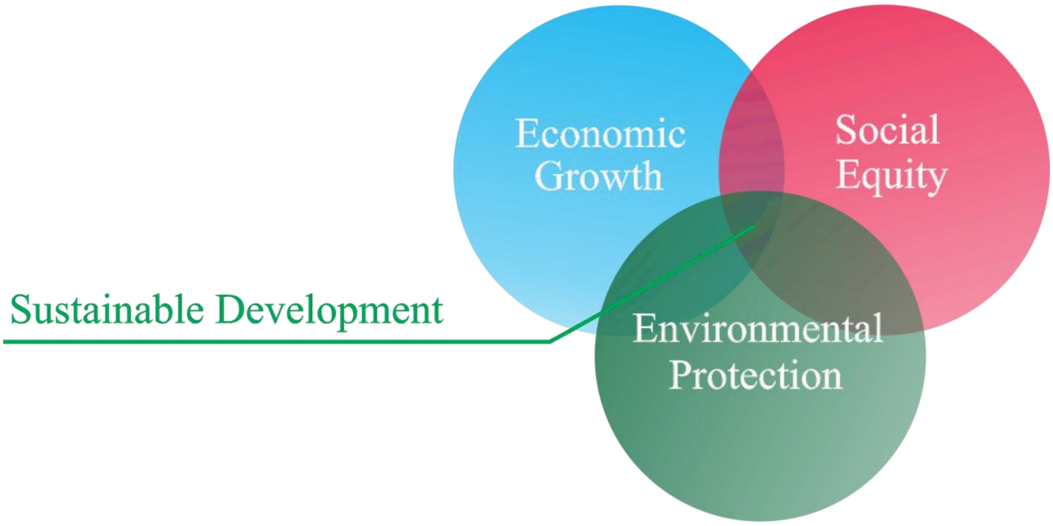


Figure 1: Illustration of Sustainable Development (Redraw of IISD, 2010)

There are various attempts proposing suitable strategies and systematic instructions for better approaches in dealing with complex and complicated issues of sustainability. These significant practices is undergoing by many distinct theorists and scientific practices including Ecological economics, Environmental economics, Utilitarian, Instrumentalist, Contractarians, Conservationist, Green architecture and many others. There are many highlighted points midst their research on direct and indirect effects of the subject of *value* to understand the fundamental of the sustainability issues. Benjamin Franklin, (1706-1790) highlighted the root of problem laid in this issue: “I conceived that the great parts of miseries of mankind are brought upon them by false estimates they have made of the value of things.” (Franklin, 1839).

In respect, it seems humans have made false assumptions about the value of everything, particularly the value of nature or more precisely in value of biodiversity.
It is vital to understand the value of biodiversity, since biodiversity is numerous goods and services that is offered to human and provides suitable living for humans on Earth. However, from one side humans receive services and from another side they destroy its resources. The book of “Paradise Lost?” noted that the current situation of human on Earth is like a foolish person who jumps from the top of the Empire State without a parachute and exclaims so far so good as he is falling down; also he had assumed within the second and first floors by a miracle he would develop a technology for a safe landing at the last moment; it clearly appears, this behavior is foolishly unreliable and dangerous (Edward et al., 2009).

These kinds of conditions claim the uncertain approach and ignorance of man to his most precious assets that is nature and its biodiversity. Biodiversity is the most and only valuable property of humans on Earth that human life undoubtedly and seriously depends on it. The problems of human ignorance about value of biodiversity and the false results of human practices in environment, has the foundation in two parallel and ground conditions. One is the extreme demand and consideration of human acquisition of immediate monetary benefit from everything, without considering the effects of future resulted situations; and then without thinking that the value of ethics is underestimated and ignored by these kinds of attitudes and behaviors.

Therefore, one of the important key factors for any successful, sustainable development project lies in a powerful and motivating economic engine. Economical advantages and clearance of systematic financial benefits is the attractive proposal for any successful sustainable developments.

Besides, it is necessary to draw attentions towards the moral issues and perceive concept of ethics. Understanding the value of ethic not only can directs economic concept in a better manner, but it also leads the whole process in a more proper and convenient procedure for success of an overall system of society.

There are social science philosophical ideas to manifest the importance of these issues. As a case, Arne Naess (Norwegian environmental philosopher, 1970) posed a theory of "deep ecology" (or "ecosophy"), that every species in nature has an equal and substantial role to save the balance of the ecosystem. He simply argued about the right of nature and all species of biodiversity, same as the right that humans would like to have for themselves (Brennan et al., 2011). Likewise, Christopher Stone claimed the essential concept of right for nature with his word in topic of his book, "Should trees have standing?" (Stone, 2010) In the content, Stone played as a role of defendant for trees and tried to manifest the value of nature and elaborate that humans have no right to harm it.

Nurturing such notion and applying it in reality, is offering a positive outlook for human life whilst adding harmony with nature. Hugh Barton in his interesting book of 'Sustainable Communities' (Barton, 2000) mentioned the fantastic value of environment which starts from a local community with all of its components; even from memories of neighborhood to economic success, from children and elderly situations in alleys and districts to sustainable development of a happy community. In another case, 'internationally transferable development rights' experienced some prosperity in Akamas Peninsula of Cyprus by proper compromise between local people and government to conserve the biodiversity of area (Edward et al., 2009).

The whole system of the environment with its countless biodiversity works properly and perfectly in balance to offer the best necessary needs for total health in its chain system-include human-through unavoidable and limitless interaction. Healthy life for humans and societies would be profitable and it is the vital result of fair interaction with nature and numerous services that it offers.

For instances, forest and natural resources are the main producer of fresh water and purification of water. Around the world, 35 largest cities provide their drinking water from protected forest area, demonstrating the fascinating economic value of nature; for example, in New York City purification of water by the forest is saving over $6 billion in total of its investment (Hussen, 2004). At the same time, the forest is the main sequestration of carbon and global climate regulation as well as flood and landslide prevention. Nevertheless, according to UN report since 1700 global forest area, approximately 40% has shrunk and forests have totally disappeared in 25 countries (Russi et al., 2013).

In addition, human acquire the basic nutrition needs from nature through domestic or wild life; from lands and forest to vast density of oceans. Further, it should not be disregard the excellent and value of recreational and aesthetic of biodiversity, which relate to human satisfaction. Simply, sometimes even looking to pure nature gives a fantastic feeling. In this case, the numbers of study including UN convention on biological diversity identified that concentrate on this significant attribute of environment and human interaction could offer a very fair outlook to the situation, whereas it provides numbers of direct and indirect employments and at the same time tourist attraction lead to increase the GDP of country to a great extent (Brink, 2011).

Those glimpse notes on topics and benefits of natural resources could reveal the correct clue for valuation of biodiversity and its different aspects and importance on human life and consideration of sustainability issues as a necessary topic to follow. Particularly, the various types of economical benefits show the great value of economic aspects of nature and potential of sustainable growth in respect and protection of biodiversity. However, generally and importantly environmental benefits are not limited to the local considered area whereas its hazards are not.

1.1.2 Sustainability and RCA

As mentioned earlier the core concept of sustainability is decrease in usage of raw materials from natural resources plus less production and intrusion of wastes to the environment. The main privilege use of recycled waste construction materials as alternative aggregates to produce new ready mixed concrete and its products has the potential and ability to meet both of the mentioned important aspects of sustainability. It would be accomplished by usage of construction waste as recycled materials instead of leaving them in the environment as well as prevention of extraction and damage to natural resources in stone quarries. In regard to this, there are globally various attempts and special classifications to vast areas of these activities.

Sustainable use of aggregates and proposing better environmentally alternatives for conventional aggregates mostly has been regarded as **R**ecycled **C**oncrete **A**ggregate. RCA can be divided in some branches by consideration of numbers of research studies. Some of the studies refer to reuse of only crushed concrete from demolished concrete structures as coarse aggregate for producing new ready mixed concrete which mostly it has been known as **R**eclaimed **C**oncrete (RC).

Another part relates to define the different types of waste material as aggregate for concrete production. These wastes could be some specific materials of municipal waste, for example crushed glass or scrapped tire. Other important parts of waste materials that can be used for concrete aggregates include waste construction materials which in regard to its benefits; it has been trying by numbers of researches and has been offering its application by some recycled factories. It means that RCA with its new proposed ingredients in technical aspect of practice could reach to the proper characteristics in production of a new batch of ready mixed concrete.

In respects, it should be considered that any concrete production in regard to its place of application has some specific issues to consider. Particularly, type and characteristics of the local aggregates is one of the main factors to shape any batch of concrete. Besides, for the special case of North Cyprus, there are many other different associated issues as well as dominant concrete applications of construction practices which should be considered with great precision.

First and foremost importance, North Cyprus should demonstrate more attempt to understand the importance of sustainability issues socially, and then try to introduce some proper proposals for this significant perspective. Besides, on the one hand, North Cyprus has extreme potential to manipulate sustainability factors; and on the other hand alike other islands on the planet faces more limitations in natural resources, to extract requirements or disposal of wastes. So, it is a crucial situation that should address solutions and take best action in each phase of these issues.

Concrete as primary construction material in North Cyprus and as an unsustainable construction material needs to be analyzed, studied and reconsidered to confront in order to reduce the environmental impacts. By the way, there is not too much existence of demolishing concrete structure to produce Reclaimed Concrete and its related concrete products, such as Concrete Masonry Unit (CMU); instead there are considerable amounts of waste construction materials in North Cyprus, due to inferior and substandard construction methods which can offer this potential of partially shifting to use the waste construction materials as new suggested aggregates in production of new ready mixed concrete and recycled CMU.

Legislation has a strong role in impacting whole aspects of society. Recently, new regulations that seem to last short periods of time in the area of Kyrenia city in North Cyprus, permission to build high rise buildings were issued. As a result, right now there are some activities to demolish some beautiful and old villas for constructing new apartment blocks. So, to some extent there is possibility to utilizing RC, but still the amounts of waste construction materials are much more considerable.

1.1.3 Environment and law

Apart from philosophical meaning and a deep understanding of law and its different aspects, simply law adjusts relationship of all people of a society in appropriate manner by its rules. It actually starts from respect to ethic and justice; it places above everyone in any community and society. Some of the rules of law in controlling society that is related to the government are critically important and its breach is known as crime. Committing crime causes different types of punishment that is related to the level of the breach. Law divided in private (property, family, tort, probate, and corporate) and public law (constitutional, criminal, administrative). Recently, environmental law added to the laws' categories, which through the national law has connection to the international law (Schubert, 2012; Gates, 2013).

Whatever and whenever the pollution and environmental degradation is, it related to the whole planet, whereas pollution and its impacts of environmental drawbacks will not affect only its place of origin. This is the reason for consideration of environmental problem under international law (through adaptation of local government) and categorized under criminal law by the United Nations and in Europe by the European Court of Justice, the Council and the European Parliament on 24 October 2008. The main consideration is based on "polluter pays principles" subject and labeled Environmental crime as below (in short) (European Commission, 2015):

> "Environmental crime covers acts that breach environmental legislation and cause significant harm or risk to the environment and human health. The most known areas of environmental crime are the illegal emission or discharge of substances into air, water or soil, the illegal trade in wildlife, illegal trade in ozone-depleting substances and the illegal shipment or dumping of waste. Environmental crimes cause significant damage to the environment in Europe and the world. At the same time they provide for very high profits for perpetrators and relatively low risks of detection. Very often, environmental crimes have a cross border aspect. Environmental crime is a serious and growing problem that needs to be tackled at European level." (European Commission, 2015).

Also, there are some interesting notions of law, like concept of "tort", which seems prone to apply for saving nature and variety type of its biodiversity. Tort is notable concept in the legal system of developed countries that is base on personal safety and personal's private right to prevent any harm to people even by negligence or irresponsibility and accidental issues by others (Dam, 2009).

Likewise, there are some specific and similar rules that were published in the Turkish by parliament of Northern Cyprus and issued on line by court of Northern Cyprus on 24 January 1989 with number of 10/1989 as constitution of 94(2) article. The topic refers to the "Environmental Protection Agency (Establishment, Duties and Working Principles) Law". The main attention was related to every type of environmental pollution and duties of employees and authorities to address these issues. It mentions that:

> "All kinds of activities as a result of the people on the air, water and soil with disruption of the ecological balance and occurrence of the negative developments of the same activities resulting odor, noise and waste in the environment that constitute the undesirable results must investigate, prevent and protect from further issues." (North Cyprus parliament, 1989).

Also there are other rules, under 18/2012, 64/1994, 1960ing that support environmental protection rules. It seems with these rules, numbers of different activities of waste disposal may be basically illegal in N.C and some of the construction activities may cause serious judicial problems and contraverse the law.

1.2 Scope of the Study

Offering environmental protection would be the essential reason for this study. Due to the special geographical situation of Cyprus, natural resources are limited, compared with other places in the world, which this matter draws attention towards two important sides affects of this problem.

One: Limitations of natural resources to extract sand and gravel from stone quarries which not only cause damage and destruction to the limited mountains but it also destroy the finite, wild and sometimes rare types of vegetation in the area; because it is much easier to extract widely rather than deeply into the ground for miners; so there are much more visible destruction in natural resources. Two: beside those mentioned factors, North Cyprus as an island faces limited capacity space for disposal of waste and specifically construction waste; this matter gets worse as North Cyprus does not have any specific technically defined landfill for waste construction materials and any serious jurisdictional authority to control the related activities.

Therefore, this study targets two different major benefits with its proposition which is mainly expected to reduce the environmental impacts resulting in extraction of natural resources and also the disposal of waste. At the same time, it will be resulting less energy usage in quarries for extracting aggregates by machinery systems; so there will be reduced CO_2 emissions, as well as cost reduction of machinery systems. While it employs wastes-with less Financial Cost- to manufacture the environmentally friendly product that is a new ready mixed recycled concrete in first step and then production of concrete block. As a result, this statement also offers a great deal of economical advantages.

In regard to achieving proper results, concrete production from its early step till the end of usage analyzed, as well as comparison analysis of actual practices of concrete industries. Then related data of concrete, concrete products, construction waste management and outlook of activities in North Cyprus generated for potential usage of recycled construction material in technical and validity aspects of activities. There are three endeavor possibilities to achieve by this inquiry. These start from social issues then new workable proposal legislation to economical and technical aspects of problems that is illustrated in the framework outlook of study (Figure 2 Outlook structure of study and three possible approaches). Whilst examining the condition, any result from all three proposals would be satisfactory. Understanding of society and its long term adaptation with current construction activities would be the priority to achieve a successful project.

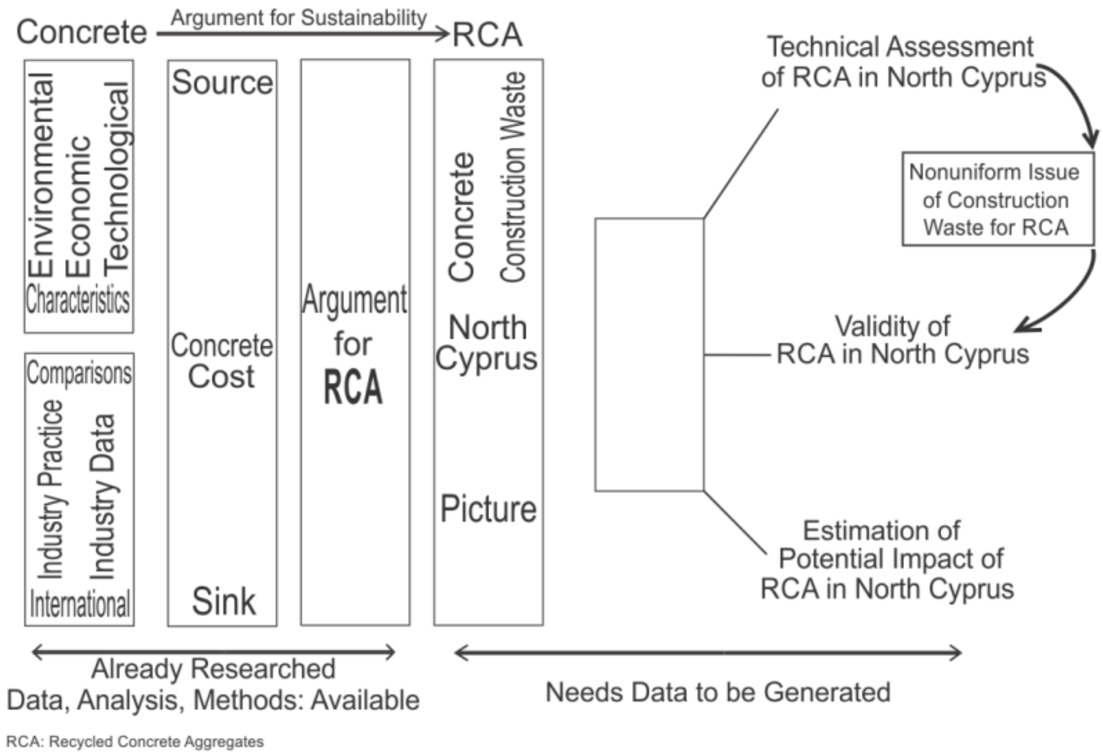


Figure 2: Outlook structure of the study and possibilities to approach

1.3 Methodology

Concerning the recently published studies in this area, the present inquiry intends to be a proper collection of those related data and knowledge, like books and essays for the best empirical guidance. In addition, by surveying some data has been collected from local construction activities, interviews performed with local manufactures of concrete and concrete masonry units to get real experience and information, whilst also testing required numbers of specimens in the laboratory to provide viability of study, demonstrating the real experimental action in construction practices of North Cyprus (Figure 2 displays the process of study).

CHAPTER 2
LITERATURE REVIEW AND BACKGROUND

2.1 Overall Concrete Analysis

Concrete is a worldwide commonly used construction material that has 11.5 billion tons consumption per year and it has estimated to reach a peak of about 18 billion tons in year by 2050 (Mehta and Monteiro, 2008). In North Cyprus production goes around 2.9 million tons by consideration of concrete as dominant construction material of area with its ten active concrete manufactures (Salimi, 2015). The amount shows 0.00026% contribution of North Cyprus in world concrete production, while its population is 0.00016% of the world population (Central Intelligence Agency, 2014). It means world consumption is 1.75 tons per capita and NC consumption is 10 tons per capita.

Concrete has variety of applications which the main ones can be include for structure of buildings, infrastructure systems and even application for finishing of many different types of structures as well as many different types of concrete products which concrete block or concrete masonry unit is one of the most popular and useful concrete products. Some of the benefits and reasons to use the concrete in wide ranges of different applications include; broad availability of its components (Cement, aggregates-sand and gravel- and water) then the easiness and flexibility involved in process from production to the final used at construction sites with possibility to manipulate it at almost everywhere (Glavind, 2009) and many different related applications. Concrete measures by (m^3- cubic meter) for using, and each m^3 of concrete has a weight around 2300 kg- 2400 kg (CCANZ, 2010). However, depends on type of concrete, its weight might be changed. The most considerable component by its amount refers to aggregate that affect the total weight of concrete and by price refers to cement contents of concrete. In addition, components to produce CMU are very similar to grading type of concrete products.

2.2 Disadvantages of Concrete

Concrete is one of the most energy intensive materials and it also has direct and indirect destruction effects to the environment that causes concrete to be considered a harmful construction material (Calkins, 2009). These numbers of critical drawbacks of using concrete come by production and utilization of each components of concrete (cement, aggregates, water) as well as production and usage of concrete itself.

2.2.1 Cement

First and foremost, concrete has serious role of carbon dioxide emissions to the atmosphere. The major amounts of emissions are resulted from the production of 1.6 billion tons of worldwide cement production per year in 2002 (Mehta, 2002). And it is estimated to be around 3.5 billion tons in 2020 (US Geological Survey, 2006) (Glavind, 2009). During production of 1 kg cement approximately 0.8-0.9 kg carbon dioxide (CO_2) is emitted to the environment (Glavind, 2009). This means the entire amount of 5% emissions of carbon dioxide (CO_2) that is about 30 GT to the atmosphere is the direct result of Portland cement production in global scale (Figure 3) (IEA 2009; Battelle 2002).

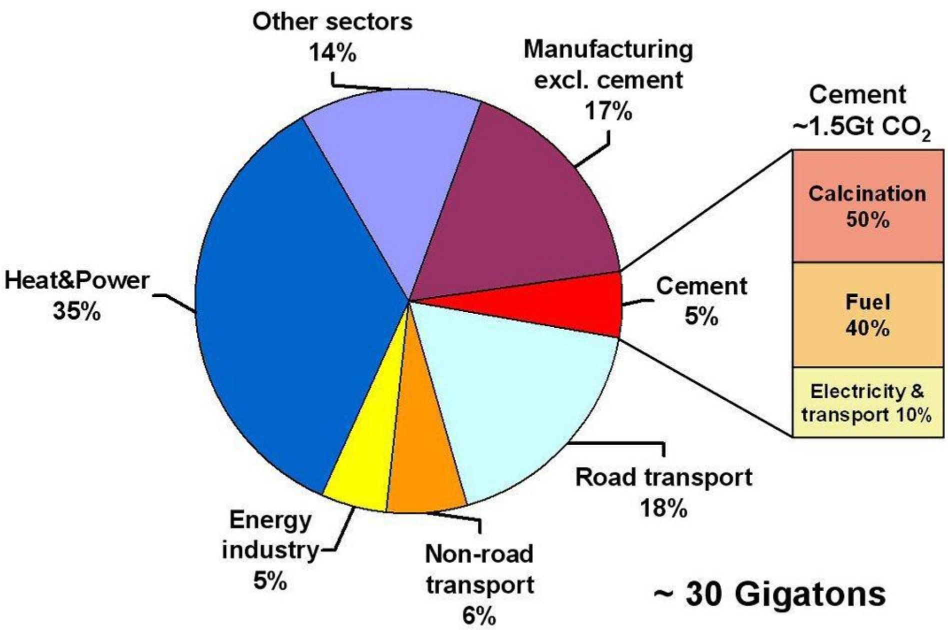


Figure 3: Contribution of cement to Co2 emissions of the world (IEA 2009)

In addition, during manufacture process of cement; there are diverse environmental impacts by dust and noise, which are the results of quarry and manufacture activities as well as other heating and chemical emissions to the environments that are the result of 1870^{oc} heating of limestone in kiln. (Figure 4 Illustrating process of cement production and it’s environmentally drawbacks.) However, by vast research activities and the concern of some of the first world governments in this issue, the proposal of different types of green cement can be the proper solution to end its drawbacks factors.

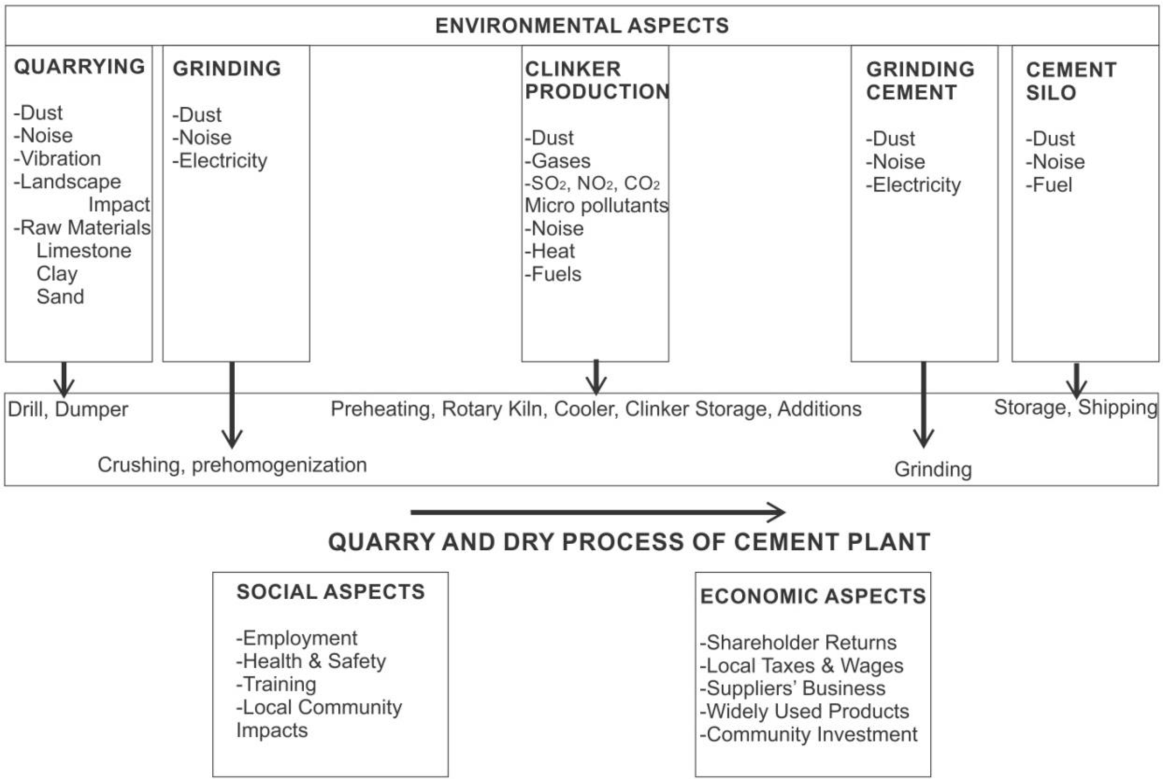


Figure 4: Cement production and its environmentally impacts (Redraw of WBCSD, 2009)

2.2.2 Water

Production of concrete and concrete products depends on consumption of large amounts of clean and potable water, which studies have revealed to be approximately one billion tons in the year 2002 worldwide and had estimated to be approximately around 1.6 billion tons for years 2050 only for concrete production by the fix growth rate (Mehta, 2002). In addition to concrete production, also a significant amount of water consumes for keeping the concrete wet after pouring concrete to prevent damage and cracks in the surface of its structures and products; plus cleaning mixer trucks and mixing parts of factory pursuing each time concrete is used. Table 1 shows world water consumption in concrete production with comparison to NC situation.

Table 1: Water consumption in concrete production (Mehta, 2002; Salimi, 2015)

YEAR	WORLD Concrete Production	N. CYPRUS Concrete Production	N. CYPRUS Mixer Cleaning
2002	1 Billion tons		
2014-2015	1.4 Billion tons	21000 Tons	7500 Tons
2050	1.6 Billion tons		

2.2.3 Aggregates

Due to the largest percentage of aggregates (around 75%) in preparation of concrete, there are large amount of excavation and digging works as part of extraction in natural resources; where there is availability of sand and gravel by the river or a possibility exist to acquire them from stone quarries around the world to produce different types of aggregates that are used to manufacture the base and important components of concrete. These activities offer destruction to natural resources and pollute air and water by dust spreading to the environment (Glavind, 2009) and by fossil fuel operation systems. It is 16.5 billion tons by value of $70 billion worldwide for producing aggregates. In the United States each 100 m^2 housing construction needs 123 tons aggregates; it means 10 tons per person per year is the aggregates consumption of USA (AGI & USGS, 2004). In the NC aggregate consumption is about 215 tons / 100 m^2 for new construction of residential buildings (Salimi, 2013). Figure 5 displays aggregate production and air pollution by dust spreading in NC.

Figure 5: Air pollution by aggregate production, NC Stone quarry (Salimi, 2013)

Table 2 demonstrates the summary and comparison of aggregate production in NC and in the world.

Table 2: Aggregate production

YEAR	WORLD Aggregates Production	N. CYPRUS Aggregates Production	N. CYPRUS 100 m^2 Housing
2009	1 Billion tons		
2014-2015	16.5 Billion tons ($70 B/y)	14.5 Million Tons ($90 M/y)	215 Tons
2050	1.6 Billion tons		
CR	2.26 T/capita	48 T/capita	

CR: Consumption Rates

2.2.4 Machinery systems

Operation of all machinery systems that are involved in concrete production, starting from quarries in which lime stone is extracted for cement and aggregates are obtained for concrete to distribution of these components manifest the huge amount energy consumption by fossil fuel system operations. And as a result again, great rate of carbon dioxide emissions. Energy consumption can be consisting by usage of diesel, refined used oil, explosion, natural gas and electrical energy use by cement and concrete plants due to their electrical system operations (AGI & USGS, 2004). Overall contribution of this industry reported about 5% of whole industrial energy consumption in the world (World Energy Council, 1995). In N.C operation systems of stone quarries use about 3.9 million liter diesel per year (Salimi, 2015).

2.3 Recycled Concrete Aggregates

There are some points of consideration about Recycled Concrete Aggregate RCA whereas this research study has considered the **W**aste **C**onstruction **M**aterials WCM as the main replace components for RCA.

Waste Construction Materials can contain a variety of materials which depend on construction type and place of application. For example based on construction practice in USA, wooden debris is the largest construction waste material (USGS, 2006) and North Cyprus produces waste cement plaster and broken earthen bricks instead. It has been reported the production of waste construction material is more than 10 billion tons yearly worldwide and definitely had a growth of 5% in its production (Mehta, 2002).

Characteristics of construction wastes resemble the characteristics of conventional concrete aggregates and as a result, there is a potential to reach the characteristics of conventional concrete for recycled concrete aggregates which include strength, durability, workability, fire resistance and structural performance (Glavind, 2009). Moreover, its production process would be started from collecting, crashing, separating and preparing as new and similar conventional aggregates material.

Further, in the production process of concrete, even a small nonstandard change in proportion of concrete components could lead to failure of concrete quality and its characteristics. Different types of concrete have different ratios of cement/water which is very important while also the amount of fine and coarse aggregates should be considered correctly. Whilst, it is one of the critical factors to cause fail in concrete's characteristics. (Haejin, 2009). However for CMU fine and average size of aggregates should be used.

There were technical problems achieving the proper quality of recycled concrete during the initial attempts to find a way for applying recycled aggregate to ready mixed concrete; thus, researchers were proposing RCA just for use of infrastructure systems. For instance, covering the network of piping systems in urban infrastructure or in large construction sites (commercial or big residential), or building slabs under pavements. However, recent trends in researches about RCA have been concerning to switch the usage of RCA from infrastructure systems to the structural use which were successful.

Also there are some similarities between researches in topics of these kinds of studies but each research has its own unique points which the essential ones relate to place of application whereas it causes differences between qualities of aggregates that have serious impacts to the quality production of concrete. At the same time, feasibility of proposal in social, economic and technical aspects is really crucial.

For instance, it has been reported that the Ministry of Construction in Japan prepared the standard specification for producing aggregate from recycled demolished concrete RC. But, the program has been executed with difficulty as a result of high cost of application. Part of the inquiry describes more feasible methods to apply to the program while it could keep qualified characteristics for concrete. The proposal concerned simple ways of separation recycled aggregates on construction site and different methods of mixing contents (Eguchi et al., 2005).

Another study about concrete industry in New Zealand defined, Recycled Concrete Aggregate (RCA) can be a viable and proper alternative to the conventional concrete even for structural use if the proportions of components, particularly recycled aggregate with cement and water and also mixing process are designed accordingly. To be more accurate in the result they started by crushing of concrete slab and chose the best aggregates form for mixing to other components of fresh concrete (Zhang and Ingham, 2010). Also another study by Concrete Technology Unit, Department of Civil Engineering at University of Dundee in UK noted that, right proportion of new aggregates is important to access the convenient result in new RCA product (Limbachiya et al., 2000).

Likewise, a study in Taiwan demonstrated the same result with testing in New Zealand, the proposal defined a method of "orthogonal array and two-level factor" to decrease the normal necessary experiments numbers for examining the characteristic of concrete (Lin, et al. 2004). Experimental study at Notre Dame University displayed that the workability of concrete is affected by RCA but compressive strength and elastic modulus are not affected by new mixture (Knaack and Kurama, 2012). Therefore, there is a possibility for the specific application with total or mostly replacement of natural aggregates by RCA.

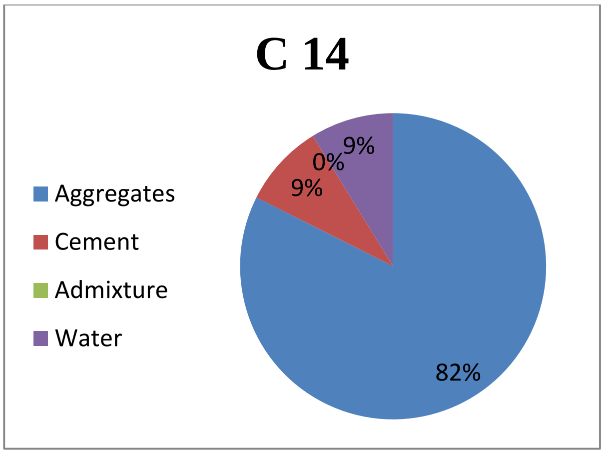
Again there is possibility to replace up to 100% of natural aggregates by RCA with adding new proportion of fly ash to admixture of concrete. A related study from the University of China mentioned that "The ratio of tension strength to compression strength and the ratio of splitting tensile strength to compressive strength of RCA both increased" by augmenting fly ash to materials (Yin et al., 2010).

A study in Hong Kong has expressed the urgent situation in wastes disposal landfills of Hong Kong because of limitation in space for disposal the huge amounts of construction wastes. It studied the case that used recycled construction wastes in their structure, particularly with crushed bricks and tiles. The study noted about detail proportion of RCA components that had good result in application of case study. Therefore, because of massive content of crushed bricks in construction wastes of Northern Cyprus similar to the experience of Hong Kong; that study can be the good guidance for similar researches (Poon and Chan, 2007).

A study relating to USA stated to implement the Recycled Concrete Aggregate in infrastructures of construction sectors immediately. For example, applications including pavements and building slabs, which there is viability to apply it without any doubt. It mentioned a numbers of benefits with prevention of the disposal of construction wastes to the environment (Thompson and Bashford, 2012).

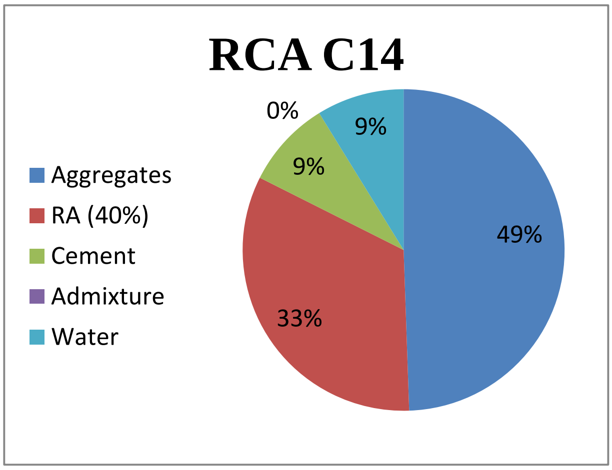
Technical assessment of RCA defined in production of concrete C14 up to 40% of conventional aggregates has the possibility to replace recycled aggregates. This amount is 33% of whole weight of concrete. Construction practices use concrete C 14 for infrastructural applications. In the United States the same application of the amount of 8 million tons RCA-C14 with value of 54 million dollars used (USGS, 2006). Alike another study in Japan stated, definite cost benefits of RCA usage in construction (Eguchi, 2007).

Figure 6 shows conventional components of C14 in NC (Salimi, 2013) and Figure 7 is approval amount replacement of RA for RCA of C14.



Type / Aggregates	c-14
0-5 ml	1175
5-12 ml	175
12-19 ml	525
T.Aggregates	1875
Cement	200
Admixture	
Water	200
Total weight kg	2275

Figure 6: Components of concrete C14 (Salimi, 2013)



Type / Aggregates	c-14
0-5 ml	865
5-12 ml	65
12-19 ml	195
T.Aggregates	1125
R.A % 40	750
Cement	200
Admixture	
Water	200
Total weight kg	2275

Figure 7: Components of RCA C14

Figure 8 indicates amount of C14 that use in normal construction practice of NC for infrastructures applications which would be replaced by RCA, C14 instead.

Figure 8: Infrastructure usage of C14 in NC (Salimi, 2013)

In addition, because of a precisely defined program in Germany for utilizing RCA there are some successful constructions that were built with RCA since 1998. Vilbeler Weg office building with usage of 480 m^3 RCA and Wald Spirale residential building with usage of 12000m^3 RCA contents where located in Darmstadt of Germany 1997-1998 by Building material circulation in Concrete (BIM Baustoffkreislauf im Massivbau, 1998).

2.4 Concrete Masonry Unit (Concrete Block)

Concrete **M**asonry **U**nit (CMU) or concrete block is one of the fundamental construction materials used in the masonry construction of walls and it is one of multiple precast concrete products used in construction. It is produced as fully solid and more popular type is with two hollows inside. The surface is fine and sometimes with manipulate of decorative mold would be used as finish surface. A normal CMU weight is around 17.2-19.5 kg. It has different dimension in its thickness while normally its height and length are fixed. Most popular used dimensions are demonstrated in Table 3 (Hornbostel, 1991).

Table 3: Common CMU dimensions (Hornbostel, 1991)

Width mm	Length mm	Height mm
100	400	200
150	400	200
200	400	200
250	400	200
300	400	200

Generally, the used concrete for blocks is a mixture of sand, gravel and cement. This has to be in a higher percentage of sand and a lower percentage of gravel and water than the normal concrete mixtures used for general construction purposes. Also usage of appropriate admixture would give the same action of general concrete mixture. This should generate a very dry and firm mixture that is necessary to hold its shape when it is removed from the block mold. The most convenient ingredients content of CMU for production of 1m^3 required concrete is illustrated in Table 4 (Jablonski, 1996). However depends on the characteristics of aggregates the proportion of ingredients may change.

Table 4: Proportion contents of CMU (Jablonski, 1996)

Contents	Weight
Cement	205
Sand 0-5mm	1158
Gravel 5-10 mm	957
Water	50
Total Weight	2370 kg

After preparation of a batch of concrete, the compressed molding process is needed for producing CMU. Alike concrete production, the block needs to be constantly checked for the height and density. Temperature and humidity must be maintained for right curing of blocks. In this respect the profitable curing process in a kiln with temperature of 66-74°C is advised (Hornbostel, 1991). Finished blocks should be tested for the strength, height, density, water penetration, fire proof, thermo, sound transmission and shrinkage. **(**The Compressive strength test varied depends on manufacture and type of application; while the current test is based on ASTM advices and application methods of TS EN for CMU**)**

The study in Lebanon has shown that use of recycled concrete into the new production of concrete blocks needs to remain under 50% of the total aggregates otherwise it needs to add extra amount of cement in regard to obtaining the same compressive strength of conventional concrete block; while components also absorb more water for proper result in the test. Therefore, it is not recommended to manipulate RC, whereas cement itself is not sustainable material as well as extra usage of water would be considered as non sustainable and non economical activity (Matar and El Dalati, 2011).

Because of some beneficial points, it is possible to claim concrete block as a sustainable construction material and utilizing different types of waste construction materials to produce the 'recycled concrete blocks' would be extra advantages and goals for producing and utilizing this material in more environmental friendly manners (Hornbostel, 1991; Koski, 1992).

2.4.1 Advantages of CMU

Concrete masonry unit (CMU) has some advantages for being a sustainable construction material. For instance, based on ecological building reports, CMU is thermal insulation, it has less water absorption by 3-4% and less air conduction loads approximately by 50% (Ecologic Building System, 2009).

In addition, with the possibility of adding some other waste materials to its normal mixture the resulting CMU would be reaching to more sustainable and strong material. However, definitely the right proportion of new mixture is crucial. The materials could include WCM, granulated coal, slag, fly ash and volcanic cinders. Adding these materials to CMU would be resulting in different color and weight of outcome products. The examined proportion indicated in Table below 5 (Jablonski, 1996). Note that, unfortunately because of unavailability of these materials, this study could not examine them in testing process of laboratory.

Table 5: Proportion use for some waste materials in CMU (Jablonski, 1996)

Type of Aggregate	Range of Ratios (Cement: Aggregate)
Pumice	1:4 to 1:6
Cinders	1:6 to 1:8
Slag	1:5 to 1:7
Fly ash	

2.5 Literature Review Summary

An overall evaluation of literature review revealed that there is the possibility to keep appropriate characteristics of ‘Recycled Concrete Aggregate’ by using waste construction materials even to be implemented in structural use, however it must be correct mixing proportion of integration recycled aggregates, cement and water to produce new proper batch of concrete and its related concrete products. Otherwise, it might be cause extra demands of cement and water to reach the proper property of concrete that would not be a sustainable practice.

Furthermore, because of variety types of aggregates and proposed waste aggregates to produce new batches of concrete the test result of specimen is important.

Utilizing RCA in producing ready mixed concrete and its products offers reduction in degradation of natural resources to extract aggregates and disposal waste as well as reduction in consumption of fossil fuels in different effective levels of production aggregates.

There are small proportions of chemical admixtures that are used to produce ready mix concrete which they employ according to their required performance, but they are very useful to modify some specific properties of concrete; such as increase strength, durability, workability and more resistance to some situation that can be more operational for application considered in this research study. It also has the ability to control the level of consumption of cement or water in concrete (CCANZ, 2010).

There is a need to adjust the situation in society and technical aspects for the possibility of manipulating RCA in concrete structure and concrete products, while RCA usage for infrastructure application is undoubtedly clear. Noting that, according to the amount of production of construction waste in a considered area; there is a need for recycling plants to recover the waste to new aggregates by separating, crushing or both.

CHAPTER 3

DISCUSSION- EXPERIMENTAL APPLICATIONS

3.1 Concrete in North Cyprus

Concrete as prevalent construction material in North Cyprus has ten manufacturers to produce and deliver concrete to the construction market of North Cyprus. Some of them own two or three concrete central plants to supply the market and as a result, there are plenty of mixer trucks and pump trucks to deliver concrete.

Table 6 illustrates amounts of concrete components to produce 1 m^3 of different types of concrete in approximate actual construction practice of North Cyprus (Salimi, 2013). The amount of production is about 75,000 m^3 per month for all concrete manufactures to deliver in construction sites of North Cyprus in normal conditions of construction activity. In some pick conditions, it simply can go around 100,000 m^3 and more per month. For example, it happened during years of 2004 and 2005 or year 2015. (Result of author survey from different responsible people) By the way, the amount of concrete products excluded whereas the related collected data were not reliable to note.

Table 6: Amounts of concrete components to produce 1 m^3 concrete in NC (Salimi, 2013)

Type / Aggregates	c-14	c 16	c 18	c 20	c25	c 30	c 35	c 40	Grading 1	Grading 2	Plaster
0-5 ml	1175	1125	1100	1080	1050	1020	1000	980	1500	1500	1800
5-12 ml	175	200	190	210	215	250	250	260	350	350	
12-19 ml	525	550	570	560	580	570	580	590			
Aggregates	1875	1875	1860	1850	1845	1840	1830	1830	1850	1850	1800
Cement	200	225	240	260	310	330	350	370	220	225	310
Admixture		1	1	2	2	2	2.5	2.5	1.5	1.5	3
Water	200	200	200	205	210	215	215	220	220	250	235
Total weight kg	2275	2301	2301	2317	2367	2387	2397.5	2422.5	2291.5	2326.5	2348

Likewise, as mentioned earlier and it is clear in Table 6 and charts (Figures 9 and 10), the amount weight of aggregates are the most among other components while it is among the least worth components of concrete; on the other hand, the cement content of concrete is among the lowest components in weight while it has highest monetary value among other components. This matter causes in definite less care in extract and usage of aggregate in variety of its application. Figures 9 and 10 display the comparison between price and weight contents of concrete. In comparison the demonstration of concrete C25 considered whereas in ratio is the most consumable one amongst others (Salimi, 2013).

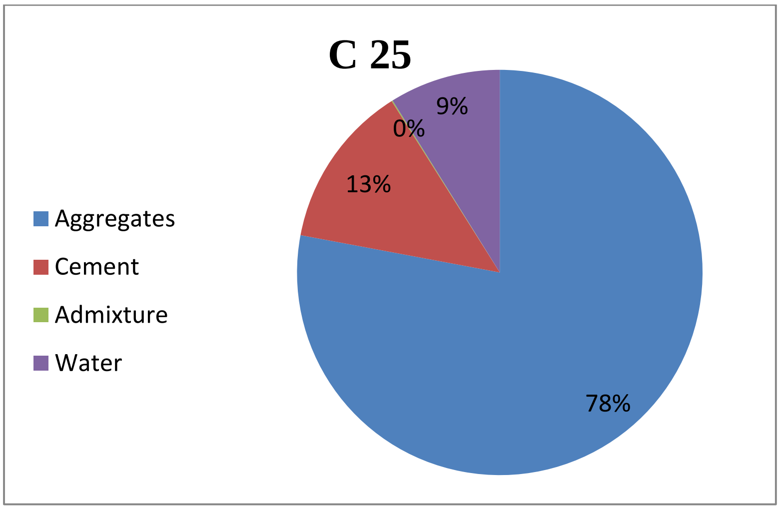


Figure 9: Percentage of weight contents of concrete C25 (Salimi, 2013)

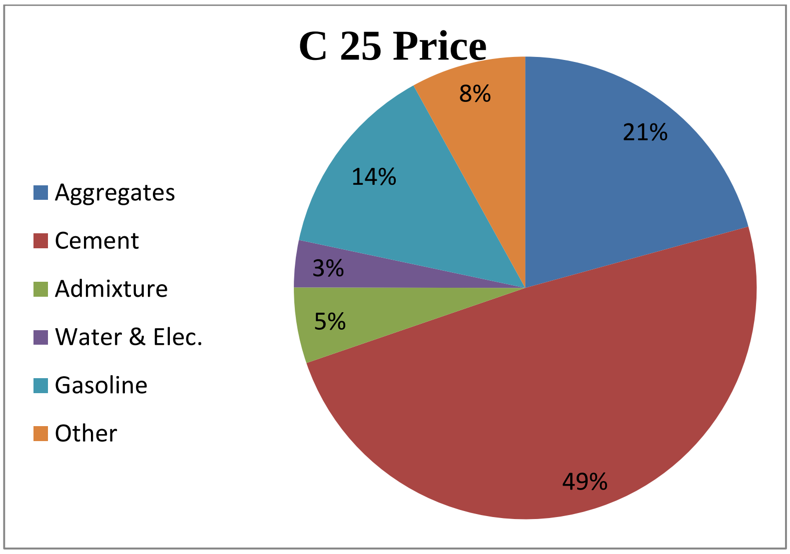


Figure 10: Percentage of price contents of concrete C25 (Salimi, 2013)

Furthermore, there are numbers of companies producing concrete products who own their small concrete plants to supply their needs. Their main productions consist of numbers of precast concrete materials; for instance: CMU, concrete curbstone, concrete pipes, concrete manhole, concrete water channel and concrete pavement slabs in different form and dimensions. For various reasons, numerous pavements in North Cyprus are covered by concrete slabs instead of asphalt covering.

3.2 Aggregate Production in North Cyprus

Concrete suppliers of North Cyprus mostly have own their stone quarries to produce required aggregates. These activities mostly occur around the Five Fingers Mountains that located along east to west of the island and between Nicosia and Kyrenia. These practices have demonstrated huge destruction in the natural resources of mountains; particularly during the last 10 years of extreme construction activities in North Cyprus. Total extraction of aggregates in N.C is around 1.2 million tons per month with consume of about 327 thousand liters diesel per month. Among those, about 135000 to 180000 tons per month relate to concrete production (Salimi, 2013). To compare with the world wide consumption of 16.5 billion tons per year (USGS, 2006) the role of North Cyprus is 8×10^{-4} in world scale consideration.

Figure 11 (Source Google Earth) shows this trend during the last few decades in most active parts of the Five Finger Mountains. The picture shows aggregates extracting approximate in 8 km long by five stone quarries indicating they are going to join together eventually. As a sample site "A" indicated to show differences during the years. Figure 11 took in the year 2013 with approximate 735,000. m^2 area for site "A".

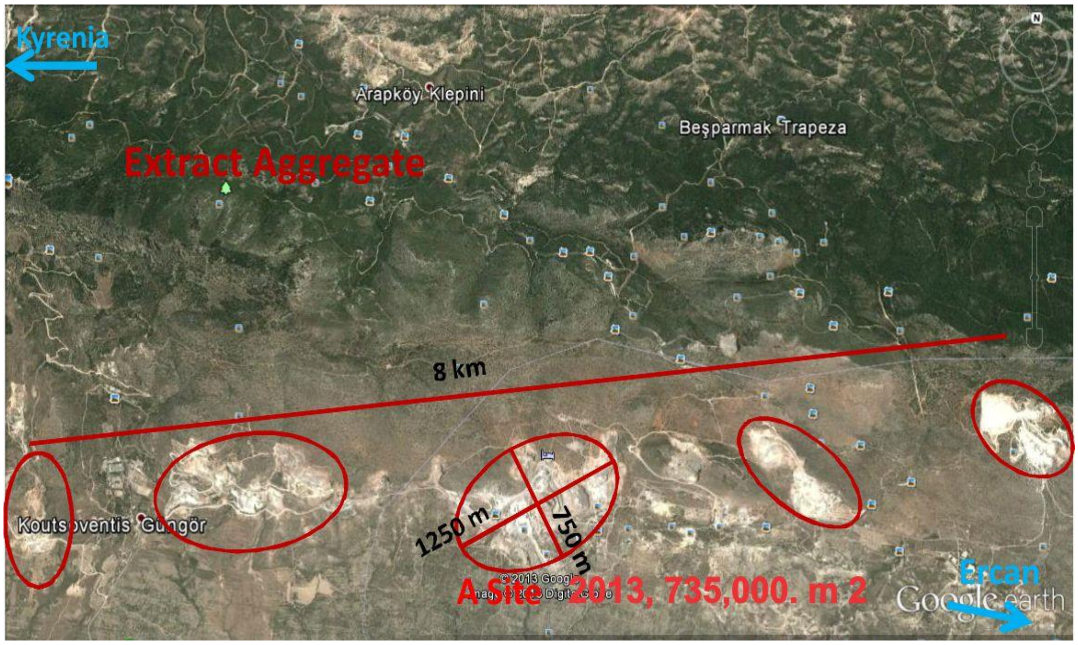


Figure 11: Aggregate extraction in Five Finger Mountains, NC in 2013 (Google Earth)

Pictures 12 and 13 are showing the approximate comparison situation of site A from year 2003 and area of 32,500 m^2 to the year 2015 and occupation area of 834,000 m^2. Pictures simply express the gradual decline of environmental degradations during these years.

Figure 12: Example of site A in year 2003, NC (Google Earth)

Figure 13: Expansion of aggregate extracting site A in year 2015, NC (Google Earth)

Figure 14: Upper side of the site A, view from the road (Salimi, 2014)

3.3 Waste Construction Disposal

The environment and natural resources of North Cyprus are in danger, whereas there is not any technically defined landfill for the disposal of construction waste; these types of construction activities pose more than regular amount of WCM in North Cyprus.

Production of WCM in North Cyprus varies; residential construction mostly produces crushed bricks, waste mortar, waste concrete and sometimes waste gypsum plaster (because of high level of humidity in climate of Cyprus nearly most of the construction practice execute by cement based mortar for finishing of interior, instead of using gypsum). In larger construction sites, like commercial constructions, there are much more varieties of WCM, which consist of those mentioned above and wooden parts, rebars, aluminum tins, metals, plastic and metal pipes.

The amount of construction waste generation in NC is approximately seven tons per 100 m^2 for small residential and about nine to ten tons per 100 m^2 for commercial and big construction sites (Salimi, 2013. Appendix 1 shows the method used for recording data) Figure 15 presents unauthorized landfill and Figure 16 illustrated different types of WCMs in different areas of NC while the amount is significant (Amount of rebars excluded).

Figure 15: Nonstandard WCM's landfill in Five Finger Mountain (Salimi, 2013)

Figure 16: WCM in different areas of North Cyprus (Salimi, 2013)

In addition, there is some non standard general waste land fill around the Northern part. It includes Dikman Koy and Hamit Koy near Nicosia, a site near Morpho (Guzelyurt) and inside the Five Finger Mountain, the last one belongs to WCM only. General dump areas are prepared by government agencies (Environment Protection Department and municipality) for disposal of overall waste of North Cyprus in one concentrated location. (However it is not land fill rather it is an open furnace of waste). Tables below demonstrated the amounts and types of waste that were disposed in Dikman dump area. The amount of waste construction materials are significantly more than others, including municipal waste generation (Table 7 and Table 8) (Master Plan on solid waste management, 2007).

Table 7: Evaluated overall waste generation in Northern Cyprus, kg per capita per year

(Master Plan on solid waste management in N.C, 2007)

Type	Average generation, kg per capita per year	Per cent
Household waste	276.6	25.2%
Commercial waste	127.8	11.6%
Municipal waste	404.4	36.9%
Construction/demolition	**487.0**	**44.4%**
Green waste	56.2	5.1%
Industrial waste	149.1	13.6%
Total	**1,096.8**	**100%**

Table 8: Evaluated annual waste generation in Northern Cyprus (Master Plan on solid waste management in N.C, 2007)

Waste type	Generation, thou. tonne per year
Household waste	73.3
Commercial waste	33.9
Municipal waste	107.2
Construction/demolition waste	**129.1**
Green waste	14.9
Industrial waste	39.5
Total waste generation	**290.8**

3.4 CMU production in North Cyprus

CMU production in North Cyprus belongs to some specific companies who have activities in manufacturing the all precast concrete products. It includes CMU, concrete pavement blocks, street curb, garden curb, concrete pipes in different dimensions, etc. The related factories need small concrete plant with supporting aggregates belt mixing and compacting system for molding different products. Mold makes two separate parts of heavy iron to compress mixture and filling it. Moreover, it must have an equipped laboratory to test the products, kiln to dry and proper storage place. Figure 17 shows related parts of plant.

Figure 17: Precast concrete central plant, Nicosia (Salimi, 2014)

Design combination of material to produce CMU is very important. Some plants uses 600 kg blend of 3-8 mm or 3-10 mm aggregates with 100 kg Portland cement to generate around 60 pieces of 20 or 25 cm (width) CMU. Total hardening time of cement is 28 days which CMU could reach to its stiffest property, but their operation is around 21 days without a kiln to dry faster. Figure 18 is some of the result of manufacturing in racks.

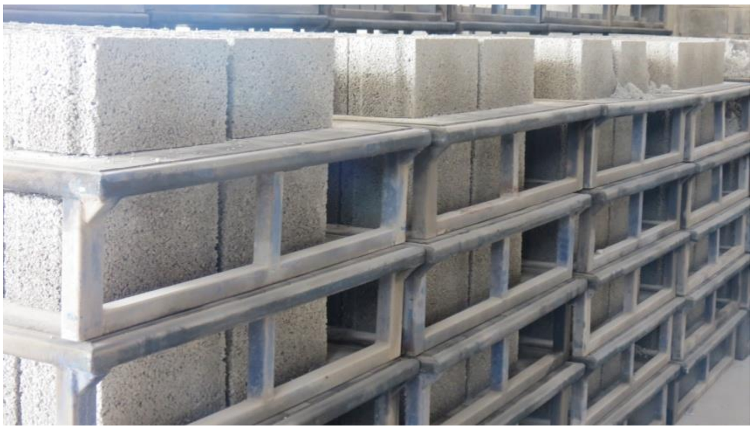


Figure 18: Produced CMU in rack (Salimi, 2014)

3.5 Recycled CMU production in laboratory

A suitable mix design must be applied to accomplish a proper result in generating any concrete product and specifically for Recycled CMU. However, it should again be mentioned that the outcome production of concrete and its products, depend on the type of mixing aggregate in great extent. Because of this, all concrete samples must undertake examinations. Particularly production of CMU has mentioned as trial and error experiment in many manufacture activities and research studies. But this study based on overall literature review attempts to propose a model for its mix design ratio.

3.5.1 Cement

Cement is the important factor to generate the strong concrete. For this reason it must be apply precisely, whereas extra usage it is not proper and it is not a sustainable practice. Concerning this, Portland cement C II 42.5 R applied for examination.

3.5.2 Water

Experimental research performed with available potable water in the Civil Engineer laboratory of the NEU. This water is the source for these types of examinations in laboratory.

3.5.3 Aggregate

As noted earlier, aggregate component of concrete is very considerable, whereas:

1. It is the highest ratio among other components.
2. It is the cheapest one among other components and this can cause less care in its usage.
3. It is a necessary component in the cast of proper concrete.
4. Its extraction has significant destruction to natural resources.
5. There are many alternatives as recycled aggregates to replace it.

3.5.3.1 Natural Aggregate

Natural aggregates from stone quarry in western parts of the Five Finger Mountains considered. The crushed stone and sieved passed of 0-5 and 5-10 used for production of different types of conventional concrete obtained. Figure 19 top overall collection areas of aggregates; bottom “a” Figure is 0-5 and bottom “b” Figure is 5-10 type of aggregates.

(a) 0-5 mm (b) 5-10 mm

Figure 19: Aggregates collection site (Salimi, 2015)

3.5.3.2 Recycled Aggregate

Since the main purpose of this study is utilizing WCM in lieu of natural aggregates, some points has considered and performed during the practice to demonstrate the possibility of same operation in actual practices. For example, WCM was collected from a residential construction site without separating or crushing and direct lead to sieve analysis in laboratory. It is an important point that the collected WCM does not need too much crushing for this type of concrete product, because as normal required size of aggregates (0-5 mm and 5-10 mm) could pass through the sieves easily.

Mostly production of WCM in construction activities of residential section occur after the phase of wall and plastering operations that generate waste broken brick (from earthen brick that mostly made of clay) and waste cement plaster, thus is very similar to sand from stone quarry, apart from its larger and harder parts. Therefore, collection of WCM from one construction site without separating and crushing performed. WCM contained mostly those two components of broken brick and waste cement plaster similar to most other construction sites in N.C. (However plastic bags did not collect) Figure 20 is WCM in construction site and Figure 21 shows collected WCM from the related construction site in the laboratory.

Figure 20: Considered WCM for collection in construction site (Salimi, 2015)

Figure 21: Collected WCM in laboratory (Salimi, 2015)

3.5.3.2.1 Sieve application for RA

As mentioned earlier there is need of 0-5 mm and 5-8 mm or 5-10 mm aggregates for casting CMU. So, for separating WCM in laboratory two available sieves of 0-4.75 mm and 5- 9.75 mm that demonstrated in picture 22 were used to detach the WCM in required sizes. (The crushing process excluded whereas required sizes of aggregates passed easily from sieves). Almost 20% of the collected WCM was bigger than 0-10 mm was not needed for this study; about 50% was 0-5 and 30% was belonged to 0-10 mm particles of RA. In addition, this practice demonstrated that manipulating WCM in large scale for these types of concrete and concrete products does not need too much crushing, consequently offering great economical benefits and energy saving.

Figure 22: Two sieve of 0-4.75 and 5- 9.75 mm (Salimi, 2015)

Figure 23 presents the filled sieves with WCM direct from wheelbarrow.

Figure 23: Separating process (Salimi, 2015)

After passing from the sieves the outcomes aggregates that were contained of some small amount of wooden parts considered for preparing of mixing mortar. Figure 24 shows aggregates after sieve process that left Figure (a) 0-5 mm (0-4.75 mm) and right Figure (b) is 5-10 mm (5-9.75 mm) of outcome Recycled Aggregates.

(a) 0-5 mm (b) 5-10 mm

Figure 24: RA after sieve process (Salimi, 2015)

Larger parts than 10 mm remained in the top sieve (Figure 25) that is not related to general usage of this study but it is suitable for production of recycled concrete.

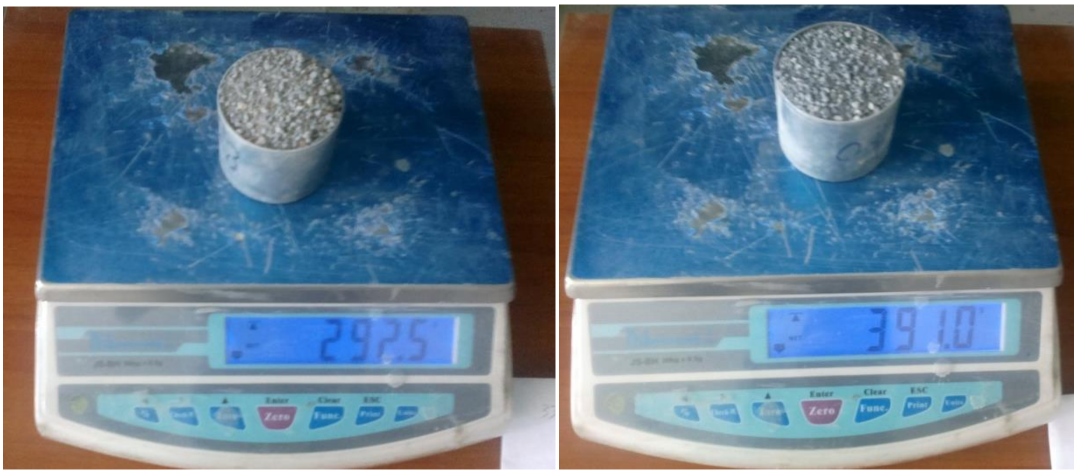
Figure 25: Remained larger parts of RA after sieve application (Salimi, 2015)

3.5.4 Aggregates comparison

In order for better recognition of the aggregates and use of them in more efficient ways, comparison of natural and recycled aggregates in some specific tests may be profitable.

3.5.4.1 Aggregates weight

A measuring cup with the volume of 2.27×10^{-4} m^3 considered for weight measuring of both natural and recycled aggregates of (0-5 mm) and (5-10 mm). As it shows in Figure 26 there is 98.5 gr. discrepancy in measuring cup of 0-5 mm type of aggregates which the recycled aggregates are lighter than conventional natural aggregates. In 1 m^3 of these aggregates the differences goes to 434 kg. Figure 26 (a) left is RA and (b) right is NA.



(a) Recycled Aggregate (b) Natural Aggregate

Figure 26: Weight comparison of NA and RA in 0-5 mm range (Salimi, 2015)

The result was the same in comparison of 5-10 mm type of aggregates, and difference was 132 gr. It means in 1 m^3 the differences is 582 kg by lighter condition of recycled aggregate as shown in Figure 27 that left (a) is RA and right (b) is NA.

(a) Recycled Aggregate (b) Natural Aggregate

Figure 27: Weight comparison of NA and RA in 5-10 mm range (Salimi, 2015)

Result of comparison shows the product made of RA should be lighter and if it can keep its strength properly, it could be a considerably better practice. Table 9 shows the detailed result of this test.

Table 9: Result of weight comparison of aggregates

Content	Aggregate	Weight/Cup	Difference/Cup	Weight/1m^3	Difference/1m^3
R.A	0-5	0.2925	0.0985	1288	434
N.A	0-5	0.391		1722	
R.A	5-10	0.225	0.132	991	582
N.A	5-10	0.357		1573	

N.A: Natural aggregate, R.A: Recycled Aggregate, Weights are per kg

3.5.4.2 Aggregates' moisture content

Moisture content of aggregate demonstrates the level of free water in pores or surface of aggregate. The crucial point refers to the proper ratio of water/cement that proposes the strength of any batch of concrete. Whilst examining the existing level of water in aggregate, in the mixing process the accurate level of water required would be added to the mixture of concrete. As a result, the produced batch of concrete will have the better characteristics in workability, strength, etc. (ISU & NCP, 2008).

For this reason based on Dry-test guideline of Iowa State University two samples of NA and RA in range of 0-5 mm were considered. Test performed as below order: (Fick, 2008)

1. Aggregates washed and extra water depleted from plates, Figure 28 left (a) RA and right (b) is NA.

(a) Recycled Aggregate (b) Natural Aggregate

Figure 28: Preparing aggregates for dry test in oven (Salimi, 2015)

2. Their weight measured and recorded, Figure 29 left (a) RA and right (b) NA.

(a) Recycled Aggregate (b) Natural Aggregate

Figure 29: Aggregate weight before dry test (Salimi, 2015)

3. Aggregates were put in the oven on a metal plate for dry test while the oven was adjusted to 105^{o}C for 24 hours (Figure 30).

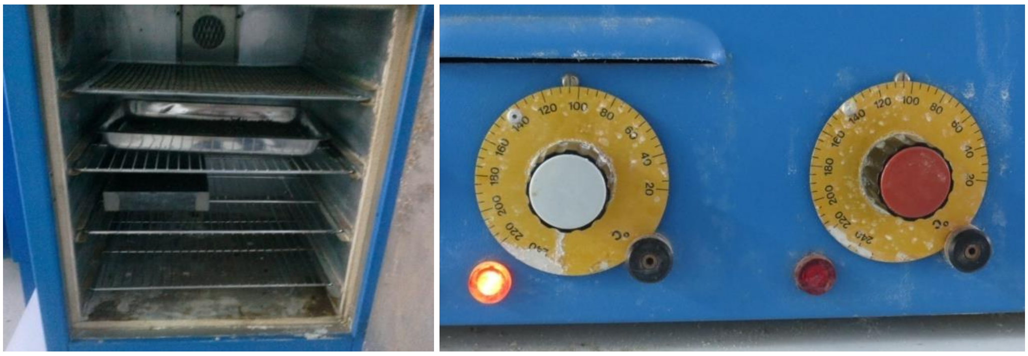


Figure30: Preparing oven for 24 hours in 105 ^{o}C (Salimi, 2015)

4. After the appropriate time (24 hours), the samples were brought out of the oven, their weight measured and recorded Figure 31, left (a) RA and right (b) NA.

(a) Recycled Aggregate (b) Natural Aggregate

Figure 31: Aggregates weight after oven time (Salimi, 2015)

5. Based on references the amount of moisture contents measured and comparison illustrated in Table 10 (AASHTO T 255).

Calculations for Moisture Content

WW = original wet weight of sample, (gr)
DW = dry weight of sample, (gr)
MC = moisture content of sample, (%)   **MC** = $\frac{\mathrm{WW-DW}}{DW} \times 100$ **(3.1)**

NA Sample:

WW = original wet weight of sample, (gr): 450.2 gr

DW = dry weight of sample, (gr): 371.2 gr

MC = $\frac{\mathrm{W-D}}{D} \times 100 = \frac{450.2-371.2}{371.2} \times 100$ => 21.28 % => <u>21%</u>

RA Sample:

WW = original wet weight of sample, (gr): 516 gr

DW = dry weight of sample, (gr): 451.8 gr

MC = $\frac{\mathrm{W-D}}{D} \times 100 = \frac{516-451.8}{451.8} \times 100$ => 14.21 % =><u>14%</u>

Table 10: Result of calculations for moisture content of aggregates

Content	WW/gr.	DW/gr.	MC	Water Need L/1m^3
N.A	450.2	371.2	21%	39.5
R.A	516	451.8	14%	43

3.5.5 Mixing design for casting concrete

Proposal for experimental applications is 25%, 30% and 40% replacement of WCM for ordinary aggregates that obtained from quarries of Five Finger Mountains (Beşparmak). Replacements performed respectively for three sample cubes of 15 cm ×15 cm ×15 cm by 0-5 and 5-10 type of conventional aggregates by 0-5 and 5-10 type of sieve passed WCM in laboratory and one as reference cube by NA. Also, two casts for CMU production by 25% replacement of RA and one by NA as reference specimen were considered. The amount of cement remained constant to see the differences in characteristics of grout. Amount of water needs to be considered as determined in the dry test. These combinations would be produced 1 m^3 concrete with the approximate weight of 2370 kg (Table 11). (Isler, 2012). Table 11 shows the propose module.

Table 11: Model proposal for experimental application in laboratory

Conventional CMU		Recycled CMU			
		Sample	Mix 1,%25	Mix 2,%30	Mix 3,%40
Contents	Weight	Contents	Weight	Weight	Weight
Cement	205	Portland	205	205	205
Sand 0-5mm	1158	Normal	869	810	695
Sand 0-5mm		Recycled	289	348	463
Gravel 5-10 mm	957	Normal	718	670	575
Gravel 5-10 mm		Recycled	239	287	382
Water	50	Potable	64.5	67	68.5
Total Weight/kg	2370 kg		2384.5	2387	2388.5

Based on the above module and consideration of water contents of aggregates, mixing process started as below order:

1. Weight of all the materials measured and they poured for mixing (Figure 32).

Figure 32: Materials ready for mixing (Salimi, 2015)

2. Dry materials mixed properly before adding water to the mixture (Figure 33).

Figure 33: Mixing dry materials (Salimi, 2015)

3. Final Mixing Process applied with adding required potable water of laboratory to the prepared dry mixture. Mixing process continued, but mortar could not find its property of paste and coherence, therefore little by little water was measured and added to the mixture while the quality of mixture defined lack of enough cement is another reason for coherence deficiency. Thus, weight of extra cement measured and added gradually to the mixture to achieve a proper paste of mixture. After finding suitable form in mortar, mixing continued for five minutes to conform completely a good mixture. Based on the ASTM the prepared mortar should get a shape in hand by compression that would be defining the proper characteristics of the mortar. This defies the produced CMU can release of mold simply, too. Figure 34 shows coherence of mortar in hand. The reason for this kind of trial and error experiments determine the importance of local aggregates that shape the characteristic of outcome mortar in great extent. Even the reference specimen of mixture that was prepared only by NA needed some changes in the amount of its materials. Consequently, new module in Table 12 with its changes for these amounts of components determined as below. Also as mentioned in section 2.4 and Table 3 availability of some combination like pumice, cinders, slag and fly ash could help the mortar for better paste and coherence.

Figure 34: Achieve proper mixture (Salimi, 2015)

Table 12: Actual experimental application in laboratory for $1m^3$ concrete

Conventional CMU		Recycled CMU			
		Sample	Mix 1, %25	Mix 2,%30	Mix 3,%40
Contents	Weight	Contents	Weight	Weight	Weight
Cement	215	Portland	225	225	225
Sand 0-5mm	1158	Normal	869	810	695
Sand 0-5mm		Recycled	289	348	463
Gravel 5-10 mm	957	Normal	718	670	575
Gravel 5-10 mm		Recycled	239	287	382
Water	62	Potable	78.5	82	88.5
Total Weight/kg	2392 kg		2418.5	2427	2428.5

3.5.6 Casting specimens

By achieving to suitable mixture in form, three different specimens of recycled aggregates and one reference from conventional aggregates were considered to pour in four cubes of 15×15×15 cm. Also two samples for CMU mold of 40×20×20 cm poured; that one of them belonged to mix No.1 and another for casting by reference mortar (natural aggregates). Samples were examined upon their characteristics in physical aspects. Cubes and special molds for CMU filled and compressed. The strength test was carried out after 28 days of complete hardening while samples located in curing system during this time. Figure 35 shows two cube samples in mould and Figure 36 four cubes samples in curing systems.

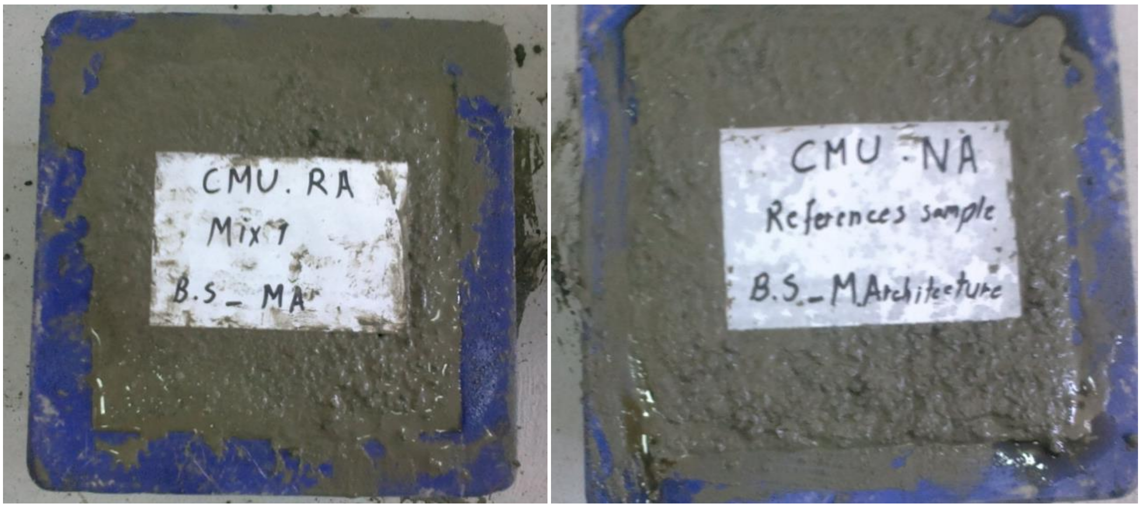


Figure 35: Specimens in 15×15×15 cm cubes (Salimi, 2015)

Figure 36: Specimens located in curing for 28 days (Salimi, 2015)

Figure 37 illustrates CMU mold by MDF and Figure 38 shows that they were filled and compressed by reference sample that was produced by natural aggregates (right Figure, a) and mix No1 (left Figure, b) that produced with 25 % replacement of RA (mix No.1).

Figure 37: Mold of CMU (Salimi, 2015)

(a) Recycled Aggregate (b) Natural Aggregate

Figure 38: Mold filling by two different types of aggregates (Salimi, 2015)

(a) Recycled CMU by mix No1 (b) CMU by Natural Aggregate

Figure 39: Removed two CMU from molds (Salimi, 2015)

Figure 39 shows two samples of CMU that were produced by NA and RA after removal of molds. And Figure 40 shows the specimens in the curing system.

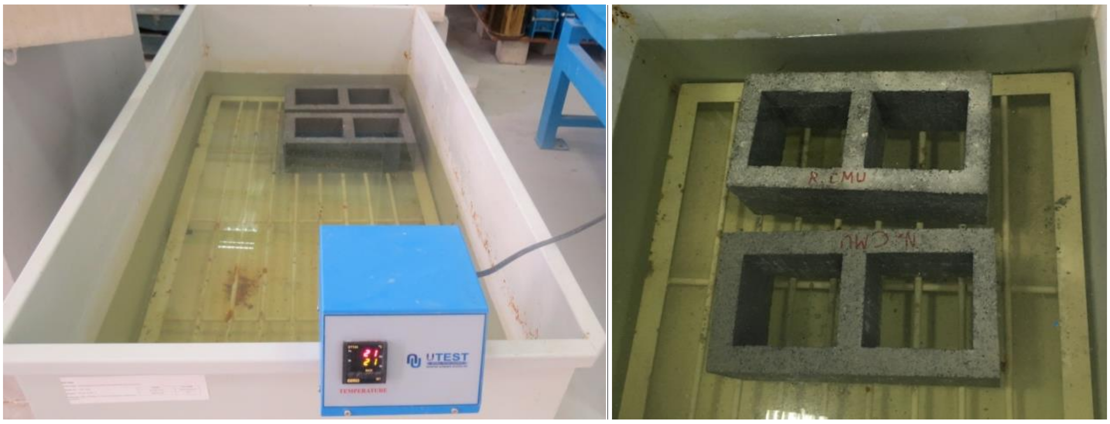


Figure 40: CMU specimens in curing system (Salimi, 2015)

3.5.7 Comparison of specimens

Two types of specimen (cube and CMU) in test application were compared by their weight, water absorption and compressive strength test.

3.5.7.1 Comparison of cubes

Two types of NA and RA of cubes were compared by weight, water absorption and compressive strength.

3.5.7.1.1 Weights of cubes

Cubes measured and recorded after removal of cubes' molds, with expectation increase the percentage of RA caused decrease in weight of cubes and reference cube is heavier than the others. Table 13 below describes the relationship of their weights.

Table 13: Specimen cubes weights

TYPE	Reference Cube	Mix 1, 25% RA	Mix 2, 30% RA	Mix 3, 40% RA
WEIGHT	8.135 kg	7.736 kg	7.601 kg	7.150 kg

3.5.7.1.2 Compressive strength test for cubes

Compressive Strength Test performed after 28 days of casting concrete for cubes' specimens. Firstly, cubes were removed from the curing system and left approximately three hours to dry completely. Then the weight of the cubes measured before the test, as expected the weight increased because of water absorption while in RA the contents were approximately the same and more than NA as shown in the dry test. Table 14 shows the weight result of samples.

Table 14: Specimen cubes weights after 28 days

TYPE	Reference Cube	Mix 1, 25% RA	Mix 2, 30% RA	Mix 3, 40% RA
WEIGHT	8.210 kg	7.807 kg	7.522 kg	7.236 kg
W.A*	0.075 kg	0.071 kg	0.079 kg	0.086 kg

(*W.A: Water absorption)

After that, strength tests were applied to the cubes by a universal testing machine with identification of UTC-4231 (detail in Appendix1). By expectation in the result of test, increase the amount of RA content and decrease the weight from one side; the results of strength test demonstrated decreasing from other side, Table 15 (Original in Appendix 3).

Table 15: Result of compressive strength of four cubes specimens

TYPE	Stress (Mpa)	crushing strength(KN)	Weight (kg)	Unit Weight (kg/m^3)
Reference	29	657.3	8.210	2.433
Mix1,25%RA	28	643.6	7.807	2.313
Mix2,30%RA	21	479.4	7.522	2.229
Mix3,40%RA	16	359.9	7.236	2.144

Figure 41 is partial demonstrating of compressive strength result rest.

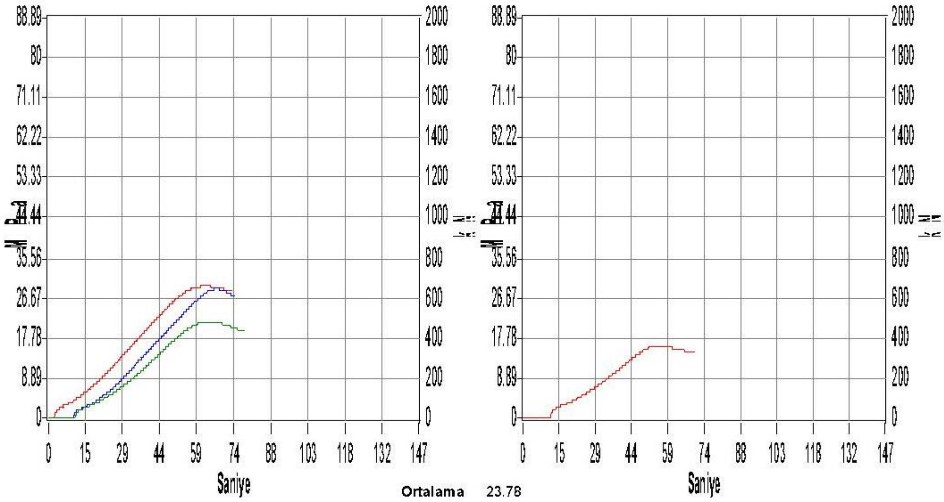


Figure 41: Graph demonstration of compressive strength of cubes.

3.5.7.2 Comparison of CMUs

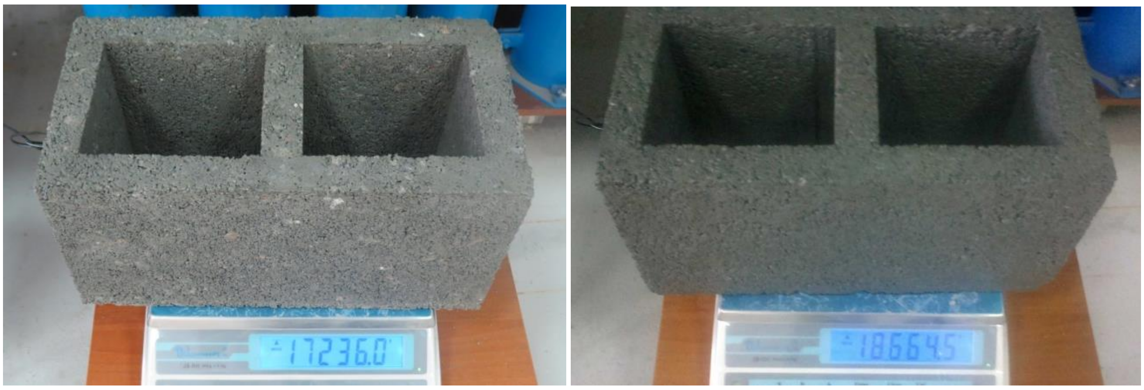
Two types of NA and RA of CMU were compared by weight, water absorption and compressive strength.

3.5.7.2.1 Weights of CMUs

As it displays in table 16 and Figure 42 left (a) the weight of recycled CMU is 1,428.5 kg lighter than conventional CMU (left Figure, b) that normally is about 17-19 kg. Table 16 shows details of their weights and differences.

Table 16: Weights of CMUs

TYPE	After Casting	Differences
N.CMU	18.664,5 kg	1.428 kg
R.CMU	17.236 kg	



(a) Recycled CMU (b) Normal CMU

Figure 42: Weight of the two CMU (Salimi, 2015)

3.5.7.2.2 Moisture content of CMUs

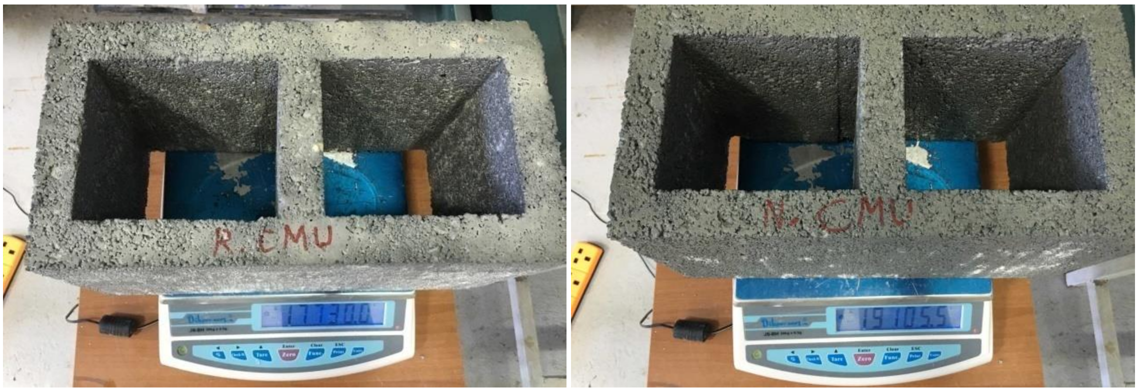
After 28 days samples removed from the curing system, their weights measured and then put into the oven for 24 hours with 105°C and again their weights measured and recorded to specify the net weights of specimens and amount of water contents of samples. The summary of results illustrated in table 17. Overall comparison specified the water content of normal CMU is more than recycled CMU, whereas its absorption was less. Result is similar to dry test result of aggregate in section 3.5.4.2. Therefore, this is the reason of more water needs in preparation of recycled specimens.

Table 17: Moisture content of CMUs

TYPE	After Casting	After Saturation	W.A	After Oven	Differences
N.CMU	18.664,5 kg	19.105 kg	0.441 kg	17.814,5 kg	1.291 kg
R.CMU	17.236 kg	17.730 kg	0.494 kg	16.154 kg	1.576 kg

(*W.A: Water absorption)

Also Figure 43 shows their weights after saturation, when they removed from curing system and recorded their weights that left (a) is recycled CMU and right (b) is natural CMU. Figure 44 demonstrates them inside the oven with considered degree.



(a) Recycled CMU (b) Normal CMU

Figure 43: CMU after saturation, ready for dry test (Salimi, 2015)

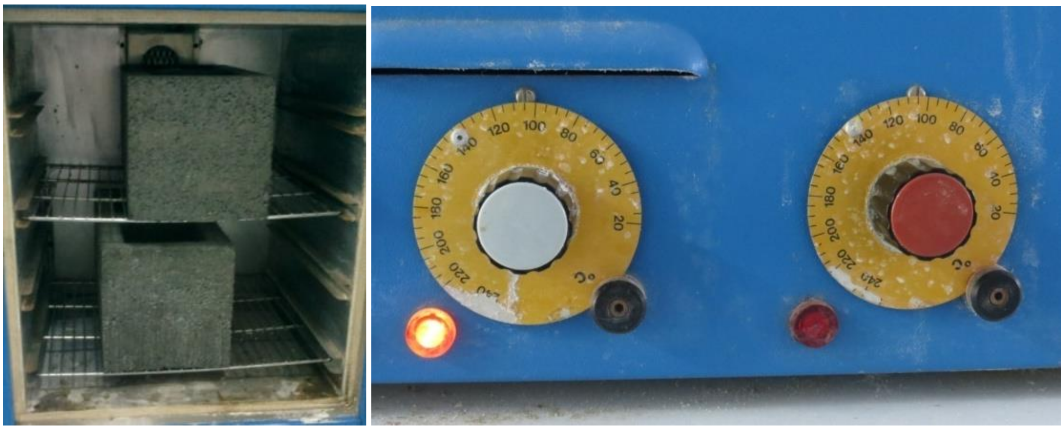
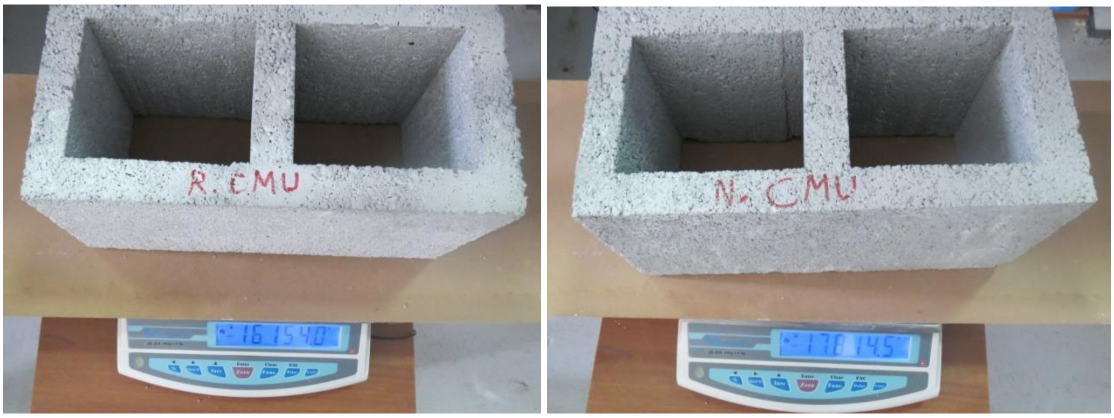


Figure 44: Normal and recycled CMU inside the oven (Salimi, 2015)

Figure 45 shows the weights of two CMU after removing from oven for the last record and demonstration of amounts of water that they lost or amounts of their water contents in their normal conditions.



(a) Recycled CMU (b) Normal CMU

Figure 45: CMUs after oven time (Salimi, 2015)

3.5.7.2.3 Compressive Strength Test for CMUs

It has been noted that the compressive strength of CMU after 28 days of casting has a variation number between 3.5 MPa and 8.5 MPa. Differences related to type of cement, aggregates, production process and different shapes of CMU. The importance of acceptable results of the compressive strength test refers to usage of CMU in masonry structure. (Sturgeon, 2012) However, non load bearing walls have little sensitivity for proper compressive strength result; but still should be in a way to tolerate its own weight properly. Universal testing machine with identification of UTC-4231 (detail in appendix1) considered to perform the compressive strength test of CMUs that were cast one month prior. The result demonstrated in Table below 18 and figure 47 shows two CMU in machine during test. (Original in Appendix 4) Note that, this test performed at laboratory of chamber of civil engineer of NC.

Table 18: Results of compressive strength test of CMUs.

TYPE	Stress (Mpa)	crushing strength(KN)	Weight (kg)	Dimension
Reference	2.98	238.46	17.814 kg	200×400×200 mm
Mix1,25%RA	2.11	168.53	16.154 kg	200×400×200 mm

(a) Recycled CMU (b) Normal CMU

Figure 46: Two CMU during compressive strength test (Salimi, 2015)

3.5.8 Note on specimen preparations and failure of compressive strength test

As noted earlier the right proportion of ingredients of concrete mixture and particularly the type of water has a vital role to complete the process in an acceptable condition. Testing the specimens in first preparation and examination resulted in failure. The reasons were related to some errors that occurred during the mixing phase. First, non-potable water used for casting the grout and second the mixture did not achieve its proper paste form, thus adding extra amounts of water for offsetting the problem also washed away the cement content of the mixture. As a result the reference sample that normally should have the highest strength, achieved the lowest amongst the specimens. Table 19 shows the result of compressive strength test and Figure 47 shows partial graph of original test result (Original is in Appendix 5).

Table 19: Result of compressive strength of four specimens in first test

TYPE	Stress (Mpa)	crushing strength(KN)	Weight (kg)	Unit Weight (kg/m^3)
Reference	9.4	212.3	7.688	2.278
Mix1,25%RA	19.1	428.7	7.657	2.269
Mix2,30%RA	24.5	550.3	7.510	2.225
Mix3,40%RA	32.6	732.9	7.457	2.209

Figure 47 is partial demonstrating of compressive strength test result of four cubes in first examination (Original is in Appendix 5).

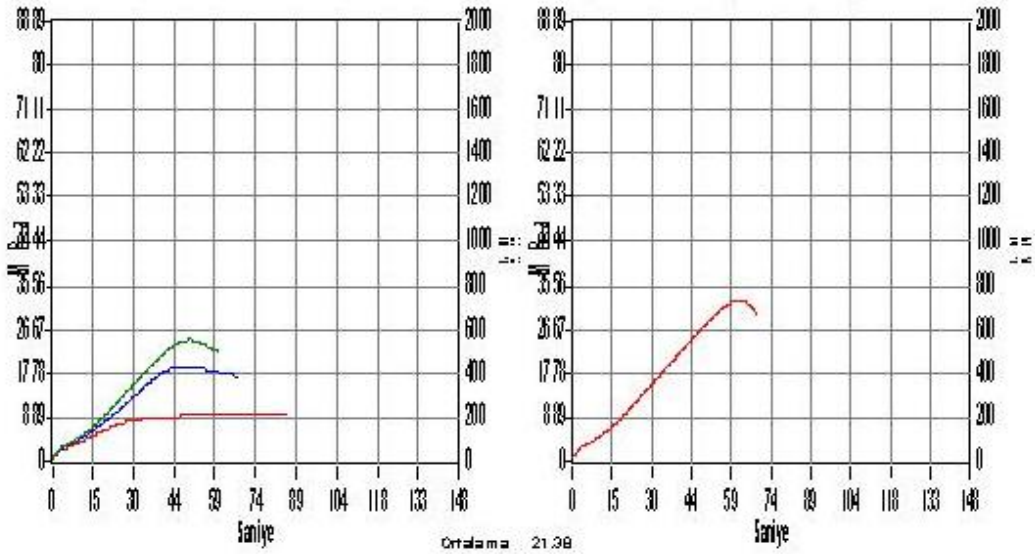


Figure 47: Graph demonstration of compressive strength of cubes in first test

CHAPTER4
CONCLUSION & RECOMMENDATIONS

4.1 Conclusion

The limited natural resources of North Cyprus are critically endangered by ignorance in uninformed society. With current practices of extracting enormous amount of natural aggregates from natural resources and disposal the waste to it, it is possible to observe much more clearly the destruction and degradation in nature by inappropriate activities over short period of time. Feasible, logical, scientific and acceptable instructions by authorities and society in general, not only can offer environmental protection, but it also can improve and change the destructive practices to become more environmentally friendly actions. Also powerful inspection to control and guide the practices is very important. However, these are achieved by understanding the genuine value of Nature and its Biodiversity, as well as comprehension of a true concept of ethics and respect to right of all other components of this huge biodiversity that provide everything from fresh air and water to food and raw materials, from health to balance of the whole ecosystem.

In this respect educating the whole society by wise, discerning, truthful and loyal people from local level to higher education system, manufacturers and the construction industry has a vital role to successful achievement of project. Particularly, choosing the truly mentors who responsible to teach the children would be the most important aspects to generate a successful society. Likewise, motivating a variety of research by higher education through sustainable development practices can lead to elaborate more environmentally practices that are more in coordination and friendly manner with nature for manipulating in real construction works.

Not only disposal of construction waste but the whole system of waste disposal management in Northern Cyprus also needs to be revised wisely. In this respect, definitely build a recycle plant would be the better option for organizing the situation of waste disposal in the whole island.

First and foremost significant point of this research study that would be the motivating engine for real practice is the whole process of this proposal regarding variety types of economical benefits in different stages of its practice. The amount is about $1.37/ton and $7 million/year, where there will be using waste construction materials instead of raw materials from stone quarries; second RCA in general has attained its proven and applied application in operation of infrastructure (RCA-C14) as well as structure in many places. Therefore, it is appropriate not to lose this opportunity for use in different sides of construction sector.

Specifically, casting and testing recycled CMU in laboratory identified the reliability of replacing specific amount of Waste Construction Materials by Natural Aggregates for producing CMU. Testing numbers of specimen in laboratory indicated the produced CMU by least amount (25%) of replacing Recycled Aggregates that is WCM is lighter in weight about 1.5%, while CMU can keep its strength characteristics in acceptable point. Recycled CMU with 40% replacement of recycled aggregates (WCM) still has its viability to use. Use of WCM to produce CMU does not need any crushing like usage of reclaim concrete, and this is one of the reasons of economical advantages for this research study.

Overall study determined the necessary situation to exchange usage of WCM instead of NA in a short period of time, to prevent more destruction and degradation of natural resources that is not accordance with national and international environmental laws.

4.2 Recommendations

There are two important types of considerations for improving the situation in organizing operating system of using natural resources and waste disposal that described in following orders.

4.2.1 Recycle plant

It is not only WCM that has the most amount of waste production in North Cyprus but whole waste materials of the island need recycling, instead of being dumped in nonstandard and unauthorized landfills and sites in different parts of island. Therefore, it is appropriate and necessary to prepare and propose a serious research study to build a required recycle plant to salvage all waste in a proper manner.

Recycle plant operation system need collection, transportation, separation, crushing and different related applications due to the material types, for example incineration for municipal waste that could generate energy or sanitary disposal for medical waste. For construction and demolishing waste the process is almost the same. U.S. Geological Survey determined the chart summary (Figure 49) for overall operation of recycle aggregates plant. Transportation is not included in this diagram and by locating different screens in the operation processes the critical phases could relate to separation of materials. In addition, the study noted about 4.52 dollars per tons as expenditure for operation of medium size recycle aggregate plant in USA (Wilburn and Goonan, 1998).

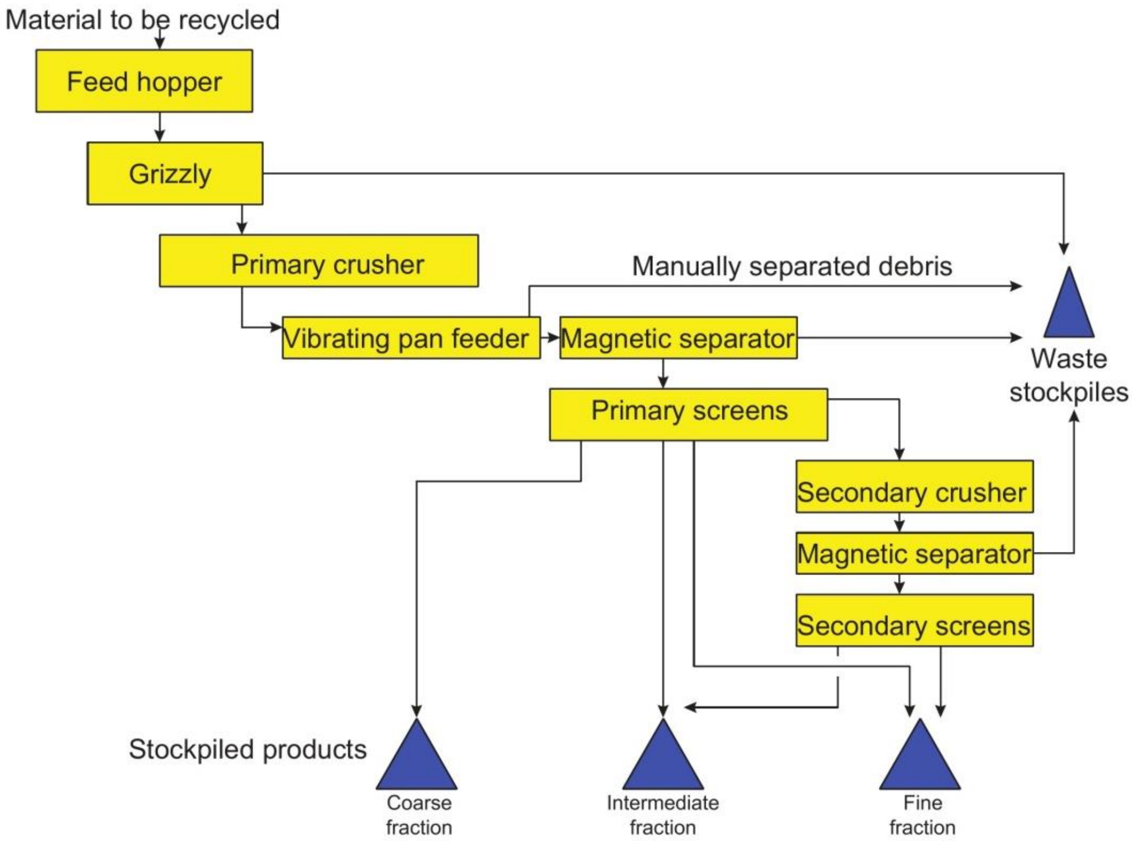


Figure 48: Recycle aggregate plant (Wilburn and Goonan, 1998)

4.2.2 Life cycle analysis and commodity chain analysis

Life **C**ycle **A**nalysis (LCA) is a great help for environmental issues as it offers understanding of environmental impacts of any product or practice in each step of its process. It is also known as cradle to grave analysis, which means too much detailed information would be analyzed from beginning life of any product till end of its existence in environment. LCA prepares strategic planning to least demand for raw materials and energy with the combination of some risk analysis, like hazardous waste management. Overall LCA proposal process indicates some environmental protection standards that aim to achieve some distinctive goals by its sequence analysis in its process (Svoboda, 1995; Laboratory, 2006).

First, is the Life Cycle Inventory that goes to define the energy and raw materials that are needed for any product. Then it indicates the water borne effluents and other solid wastes generation from production process. Second, it is impact evaluation on the ecosystem of the environment. For instance, analyze the effects on human health, social and cultural; as well as economy and its cost effectiveness. Afterward, it is Improvement Analysis in each step of the defined problem to mitigate environmental impacts of activity in quantitative and qualitative aspects of practice (Svoboda, 1995; Laboratory, 2006).

Commodity **C**hain **A**nalysis (CCA) tracking monetary value of product and goods in each step from producer to consumer. It can indicate a better market place or create a new one in appropriate phase or in a considered gap for a product.

An appropriate research study should follow the combination of LCA's indications and CCA to propose the liable and environmentally friendly practice in any market place. It would be an improvement analysis of opportunities to mitigate impacts of product by quantitative and qualitative measurements. Whole industrial processes of product design, raw material usage, waste management and consumer usage would be considered.

In North Cyprus some of the standard of economic assumptions about disposal the waste would need to be re-thought and re-consider, it could also be applied through the new regulatory regime that applies to better waste disposal and particularly wastes construction materials in its application. Creation of a more attractive market in the subject area could also be one of the solutions.

One of the best sources to provide the wide range of instructions for manipulating the life cycle analysis and commodity chain analysis is U.S. Environmental Protection Agency that could guide to a better management of any project.

Consequently, overall conditions of North Cyprus for LCA and CCA would be a suitable and useful study to guide other research studies. It is possible to summarize LCA in a schematic form of Figure 50 for a general overlook that has the possibility to be updated for any similar practice (Braunschweig et al., 2011).

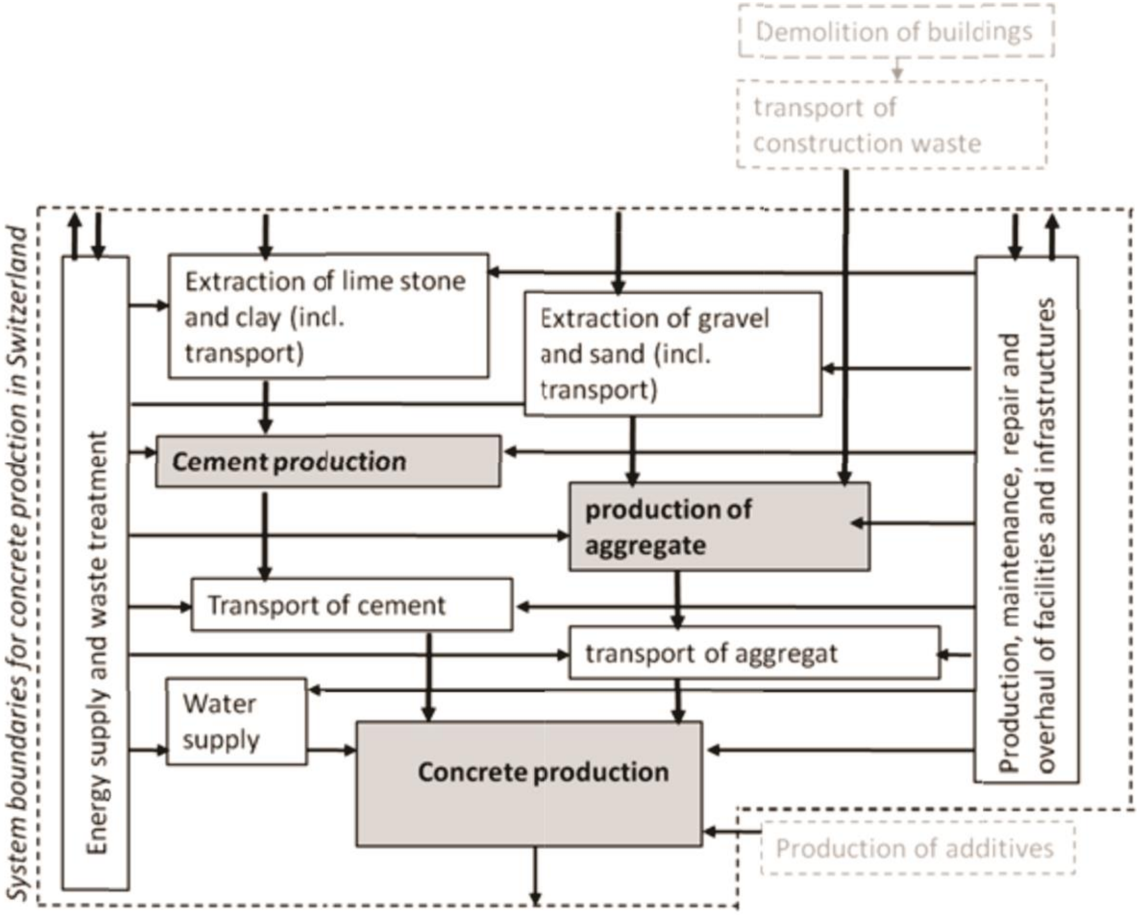


Figure 49: Schematic form of LCA (Braunschweig et al., 2011)

REFERENCES

AASHTO T 255. (n.d). Total Moisture Content of Aggregate by Drying. Retrieved January 25, 2015 from http://www.in.gov/indot/div/mt/aashto/testmethods/aashto_t255.pdf

American Geological Institute. (2004). Aggregate and the Environment. Retrieved Dec. 24, 2013 from http://www.agiweb.org/environment/publications/aggregate.pdf

Barton, H. (2000). Sustainable communities: the potential for eco-neighborhood. London: Earthscan Publications.

Battelle (2002). Toward a Sustainable Cement Industry, Sub study 8: Climate Change. Retrieved June 5, 2014 from http://www.wbcsdcement.org/pdf/battelle/final_report8.pdf

BIM Baustoffkreislauf im Massivbau. (1998). RCA Projects Constructions, Retrieved February 25, 2013 from http://www.b-i-m.de/projekte/projframe.htm.

Braunschweig, A., Kytzia, S., & Bischof, S. (2011). Recycled concrete: Environmentally beneficial over virgin concrete. From Towards Life Cycle Sustainability Management, The dahlem cube Berlin, Germany. Retrieved January 19, 2014 from www.lcm2011.org/paper.html,6_Braunschweig-Recycled_concrete 669_b.pdf.

Brennan, A., & Lo, Y.-S. (2011). Environmental Ethics, The Stanford Encyclopedia of Philosophy. Retrieved January 2, 2013 from http://plato.stanford.edu/archives/fall2011/entries/ethics-environmental.

Brink, P. (2011). The economics of ecosystems and biodiversity, for National and International policy makers, Responding to the value of nature. *In Proceeding of the International Conference of Integration of the ecosystem services in the economy NIS*. (pp. 394-429) Moscow: settlement Dubrovsky, Institute for European Environmental Policy (IEEP).

Calkins, M. (2009). Materials for Sustainable sites. New Jersy: Lohn Wiley & sons, Inc.

CCANZ Cement & Concrete Association of New Zealand. (2010). Guide to Concrete Construction. New Zealand, publication of the Cement & Concrete Association of New Zealand. Retrieved June 13, 2014 from http://www.ccanz.org.nz/files/documents/3cfd6003-4808-4130-b53db09fc74d24ea/NZ_Guide_to_Concrete_Construction.pdf

Central Intelligence Agency. (2014). The world Fact Book, Publication. Retrieved Jun 30, 2015 from https://www.cia.gov/library/publications/the-world-factbook/geos/cy.html

Chi. P., & Chan. Di. (2007). The use of recycled aggregate in concrete in Hong Kong. *Resources, Conservation and Recycling,* doi:10.1016/j.resconrec.2006.06.005

Dam, C, V. (2009). European Tort Law. Oxford: Oxford University Press.

Ecologic Building System. (2009). Advantages of Hollow Concrete Blocks**,** Retrieved May 11, 2014 from http://www.ecologicbuild.com/advantages_of_hollow_blocks.pdf

Edward B., Joanne, B., Burgess, C., & Folke, C. (2009). Paradise Lost? The Ecological Economics of Biodiversity. London: Earthscan.

Eguchi, K., Teranishi, K., Nakagome, A., Kishimoto, H., Shinozaki, K., & Narikawa, M. (2007). Application of recycled coarse aggregate by mixture to concrete construction, *Construction and Building Materials*, doi:10.1016/j.conbuildmat.2005.12.023

Etxeberria, M., A. R. Marı., & E. Va´zquez. (2007). Recycled aggregate concrete as structural material, *Materials and Structures,* doi:10.1617/s11527 -006-9161-5

European Commission. (2015). Environmental Crime, Retrieved October 31, 2013 from http://ec.europa.eu/environment/legal/crime/index.htm

Franklin, B. (1839). The Life and Miscellaneous Writings of Benjamin Franklin, London: william and Robert Chambers.

Fick, G. J. (2008). Testing Guide for Implementing Concrete Paving Quality Control Procedures, Center for Transportation Research and Education, National Concrete Pavement Technology Centre, ISU, USA. Retrieved Feb. 25, 2015 from, http://ntl.bts.gov/lib/44000/44200/44272/testing_guide.pdf

Gates, B. (2013), What is law? North Carolina, institute of government, Retrieved December 8, 2013 from http://www.attorneygates.com/images/introlawnc.pdf.

Glavind, M. (2009). Sustainability of Cement, Concrete, and Cement Replacement materials in Construction. In J. M. Khatib, (Eds), *Sustainability of construction materials* (pp. 120-146). Cambridge UK: Woodhead Publishing Ltd.

Gómez, A. P. (2006). Built Upon Love, Cambridge, Massachusetts: The MIT Press.

Haejin, K. (2009). Crushed Returned Concrete Aggregate in New Concrete: Characterization, Performance, Modeling, Specification, and Application, Graduate School of the University of Maryland, Retrieved 17.06.2013, from http://drum.lib.umd.edu/bitstream/handle/1903/10029/Kim_umd_0117E_11016.pdf?sequence=1&isAllowed=y

Hornbostel, C. (1991). Construction Materials: Types, Uses and Applications, 2nd Edition. London: John Wiley and Sons, Inc.

Hussen, A. (2004). Principles of Environmental Economics and Sustainability: an integrated economic and ecological approach. New York: Routledge Publication.

IEA International Energy Agency. (2003). Energy to 2050: Scenarios for a sustainable future. International Energy Agency, France. Retrieved June 22, 2015 from https://isulibrary.isunet.edu/opac/doc_num.php?explnum_id=348

IEA International Energy agency. (2009). Cement Technology Roadmap 2009, Carbon emissions reductions up to 2050, IEA, Retrieved October 20, 2013 from https://www.iea.org /publications/freepublications/publication/Cement.pdf.

IISD. Drexhage, J., & Murphy, D. (2010). Sustainable Development: From Brundtland to Rio 2012, International Institute for Sustainable Development (IISD), United Nations Headquarters: New York. Retrieved February 24, 2014 from http://www.un.org/wcm/webdav/site/climatechange/shared/gsp/docs/GSP16_Background%20on%20Sustainable%20Devt.pdf

Isler, J. W. (2012). Assessment of Concrete Masonry Units Containing Aggregate Replacements Of Waste Glass And Rubber Tire Particles. Denver: University of Colorado.

Jablonski, N. (1996). Mix designs for concrete block, The Aberdeen Group Publication, Retrieved Jan. 28, 2015 from, www.theconcreteproducer.com/Images/Mix%20Designs%20for%20Concrete%20Block_tcm77-1306028.pdf

Knaack, A. M., & Kurama, Y. C. (2012). Rheological and Mechanical Behavior of Concrete Mixtures with Recycled Concrete Aggregates. *Structures Congress*. ASCE. doi: 10.1061/9780784412367.198

Koski, J. A. (1992). How Concrete Block Are Made, Efficient material handling and automated manufacturing processes combine to produce a versatile, economical building material (Masonry Construction). Retrieved May 05, 2015 from http://www.masonryconstruction.com/concrete-materials-and-admixtures/howconcrete-block-are-made.aspx

Langer, W. US Geological Survey. (2009). Sustainability of aggregates in construction. In J. M. Khatib, (Eds), *Sustainability of Construction materials* (pp. 1-30). Cambridge: Woodhead publishing Ltd.

Limbachiya, M., & Leelawat, C. T. & Dhir, R. K. (2000). Use of recycled concrete aggregate in high-strength concrete. *Materials and Structures*, doi:10.1007/BF02480538

Lin, Y-H., Tyan, Y-Y., Chang, T-P. & Chang, C-Y. (2004). An assessment of optimal mixture for concrete made with recycled concrete aggregates. *Cement and Concrete Research*, doi:10.1016/j.cemconres.2003.12.032

Master Plan on solid waste management in North Cyprus part B, (2007). Retrieved Feb. 07, 2015 from www.greencyprus.infohttps://www.google.com.cy/webhp?ei=EdwTV7ubIoW-aLutiZAB&ved=0EKkuCAUoAw#q=Master+Plan+on+solid+waste+management+in+North+Cyprus

Matar, P., & El Dalati, R. (2011). Strength of masonry blocks made with recycled concrete aggregates, *Physics Procedia*, doi:10.1016/j.phpro.2011.10.027

Mehta, P. K. (2002). Greening of the Concrete Industry for Sustainable Development, *Concrete International*, 24, 23-28.

Mehta,P.K., & Monteiro, P.J.M. (2008). Concrete and the Environment, Berkeley: Berkeley University Press.

North Cyprus parliament, (1989). Environmental Protection Agency (Establishment, Duties and Working Principles) Law. Sayı:10/1989. (1989). Retrieved July 18, 2013 from www.mahkemeler.net/birlestirilmis/10-1989.doc

SAIC Scientific Applications International Corporation. (2006). Life Cycle Assessment: Principles and Practice. Cincinnati, Ohio: U.S. Environmental Protection Agency. Retrieved Nov. 6, 2013 from https://www.semanticscholar.org/paper/Work-Assignment-Manager-CurranGutierrez/5f99a6900925d095d6251092ce771e07a5df3d42/pdf

Salimi, B. (2013). Average results of interview with different concrete manufactures and recording different data from different construction sites in Northern Cyprus.

Schubert, F. A. (2012). Introduction to Law and the Legal System. N.Y: MPS Limited, Macmillan Company.

Stone, Ch. (2010). Should trees have standing? Oxford: Oxford University Press.

Sturgeon, G. (2012), Metric technical manual-Physical Properties, CCMPA. Retrieved Dec. 26, 2014 from http://www.ccmpa.ca/wp-content/uploads/2012/02/Final2013Sec4.pdf.

Svoboda, S. (1995). Note on Life Cycle Analysis. University of Michigan: National Pollution Prevention Center for Higher Education. Retrieved Apr. 05, 2014 from http://www.umich.edu/~nppcpub/resources/compendia/CORPpdfs/CORPlca.pdf.

Russi D., ten Brink P., Farmer A., Badura T., Coates D., Förster J., Kumar R. & Davidson N. (2013) The Economics of Ecosystems and Biodiversity for Water and Wetlands. IEEP, London and Brussels; Ramsar Secretariat, Gland. Retrieved July 05, 2013 from http://www.teebweb.org/publication/the-economicsofecosystemsan dbiodiversity-teeb-for-water-and-wetlands/.

Thompson, J.D., & Bashford, H. H. (2012). Concrete Recycling and Utilization of Recycled Concrete: An Investigation of the Barriers and Drivers within the Phoenix Metropolitan Area. *Construction Research Congress,* pp. 1682-1688. ASCE 2012. doi: 10.1061/9780784412329.169

United Nation, (1987). Report of the World Commission on Environment and Development: Our Common Future, Retrieved Oct. 02, 2013 from http://www.un-documents.net/our-common-future.pdf.

US Geological Survey. (2006). Cement Statistics 2006. Retrieved June 22, 2013 from www.minerals.usgs.gov.

WBCSD. (2009). Cement Technology Roadmap 2009, World Business Council for Sustainable Development (WBCSD) Retrieved January 05, 2014 from http://www. wbcsdcement.org/index.php/about-cement/cement-production.

Wilburn, D. R. & Goonan, T. (1998). Aggregates from Natural and Recycled Sources, U.S. Geological Survey Circular, 1176. Retrieved Dec. 23, 2013 from http://www.uky.edu/KGS/pdf/usgeC1176. pdf.

World Energy Council. (1995). Efficient use of energy utilizing high technology: An assessment of energy use in industry and buildings. London, UK. Retrieved March 24, 2015 from http://www.wbcsdcement.org/pdf/battelle/final_report8.pdf

Yin, J., Chi, Y., Gong, Sh., & Zou, W. (2010). Research and Application of Recycled Aggregate Concrete. *Paving Materials and Pavement Analysis*. doi:10.1061/411 04(377)19

Zhang, W., & Ingham, J. M. (2010). Using Recycled Concrete Aggregates in New Zealand Ready-Mix Concrete Production. *Journal of Materials in Civil Engineering*, Retrieved October 15, from http://dx.doi.org/10.1061/(ASCE)MT.1943-5533.0000044

APPENDICES

APPENDIX 1

METHOD OF RECORDING DATA OF WCM PRODUCTION AMOUNT IN NC

Presented information is the average result of recorded data by researcher's observation of this study from twenty five different construction activities in N.C. As a sample one of them presented as an experimental implementation:

Whole construction process of one residential apartment building takes under precise investigation. Total built area is 1850 m^2 and construction practices produced 19 trucks of debris with load capacity of 10 tons. As a result this construction practice produced around 10.2 tons per 100 m^2 till phase of wall making and cement plastering. Figure shows building under construction in phase of wall making (left) and cement plastering (right).

Figure 50: Building under construction, NC (Salimi, 2013)

Figures show the loader during loading the debris onto the truck.

Figure 51: Transport of construction debris, NC (Salimi, 2013)

APPENDIX 2
DETAILED INFORMATION OF COMPRESSIVE STRENGTH TEST MACHINE

Model: UTC-4231

Capacity: 2000KN

Speed: 1KN/25

Sensitivity: 0.3%

Plate: 55 HCR

Radius: 300 mm

Distance: 50 mm

Power: 750 W

Weight: 800 kg

Dimension: 800×425×694

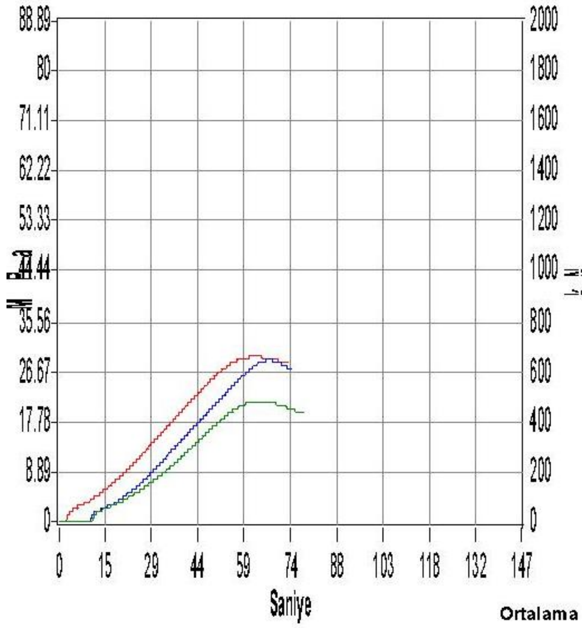
APPENDIX 3

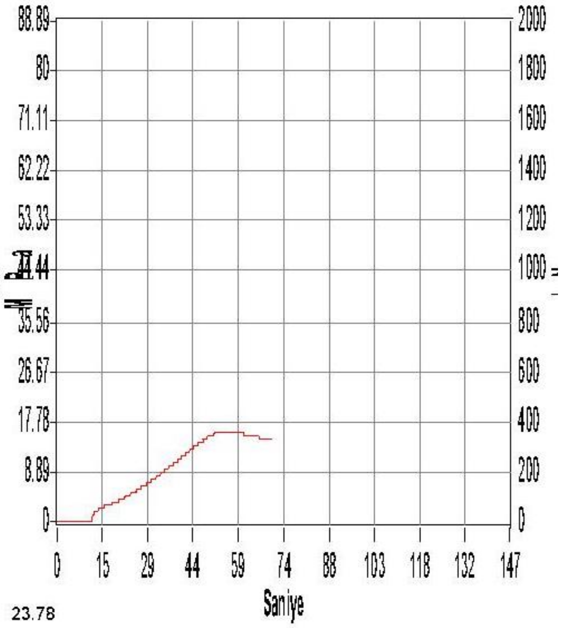
COMPRESSIVE STRENGTH TEST RESULT DOCUMENT OF SAMPLE CUBES

YAKIN DOĞU ÜNİVERSİTESİ LABORATUVARI BETON BASINÇ DAYANIM DENEY RAPORU

Rapor Tarihi	27.07.2015			Referans No	

FİRMA VE ŞANTİYE BİLGİLERİ		DENEY SONUÇLARI			
İnşaat Sahibi	ARCHITECTURE DEP.	Gerilme (Mpa)	Kırım Kuvveti (KN)	Ağırlık (gr)	Birim Ağırlık(Kg/m3)
Deneyi Yaptıran	THESIS RESEARCH STUDY	29.2	657.3	8210.0	2.433
İnşaat Adresi		28.6	643.6	7807.0	2.313
Standart	**TS EN 206-1 / TS EN12390-3**	21.3	479.4	7522.0	2.229
		16.0	359.9	7236.0	2.144
NUMUNE BİLGİLERİ		0.0	0.0	0.0	0.000
Numuneyi Alan	BABAK SALIMI	0.0	0.0	0.0	0.000
Üretici Firma					
Döküm Tarihi	29.06.2015				
Kırım Tarihi	27.07.2015				
Alındığı Yer (Kiriş,Kolon vs)	LABORATUVARDA ÜRETİLMİŞTİR	ne Adedi	4 ADET		
Beton Sınıfı		Yaş 1	28 DAYS		
Numune Boyutları	Küp 150.0x150.0x150.0	Yaş 2			





Ortalama 23.78

DENEYİ YAPAN

MUSTAFA TÜRK

İNŞAAT MÜHENDİSİ Lab Sorumlusu

ONAYLAYAN

Yrd. Doc. Dr. PINAR AKPINAR

İNŞAAT MÜHENDİSLİK BÖLÜM BAŞKAN VEKİLİ

APPENDIX 4

COMPRESSIVE STRENGTH TEST RESULT DOCUMENT OF TWO SAMPLES OF CMU

K.T.M.M.O.B.
İNŞAAT MÜHENDİSLERİ ODASI
MehmetGöze(Asi)YapıMalzemeleri
İMO ve Zemin Mekaniği Laboratuvarı

Referans : 2015-T01

Rapor Tarihi: 02/12/2015

Konu: Kıbrıs Türk İnşaat Mühendisleri Odası Yapı Malzemeleri Laboratuvarında yapılan Beton Bloklar Basınç Deneyi sonuçları aşağıdaki gibidir.

Deneyi Talep Eden : Babak Salimi

Numuneye Ait Bilgiler:

Üretici Firma : -
Numune Adeti : 2
Boyutları : 200X400X200 mm

Numune Tanımı : Beton Blok
Numunenin Rengi : Gri
Numunenin Şekli :

Yapılan Deney Sonuçları:

Deney Sonucu Bulunan Değerler		
Numune No	Kırılma Yükü kN	Eğilme Dayanımı MPa
1	238,46	2,98
2	168,53	2,11
Ortalama	203,50	2,55
Minimum	168,53	2,11

Not: Bu sonuçlar laboratuvarımıza getirilmiş olan numuneleri kapsar.
Testler TS EN 771-3: 2011 Standartlarına göre Uygulanmıştır.
1nolu numune normal agrega, 2 nolu numune ise geri dönüşüm malzeme kullanılarak imal edilmiştir.

Deneyi Yapan
Enver Töker
İnşaat Mühendisi

Onay
Gürkan Yağcıoğlu
İMO YK Lab. Sorumlusu

K.T.M.M.O.B.
İnşaat Mühendisleri Odası
Tel.: 225 05 69 - YK 284

Adres: Organize Sanayi Bölgesi
5.Sok. No.13 Lefkoşa.KKTC
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e-mail:laboratuvar@ktimo.org

Tel : +90 392 225 6569
Tel : +90 392 228 5210
Fax : +90 392 225 6547

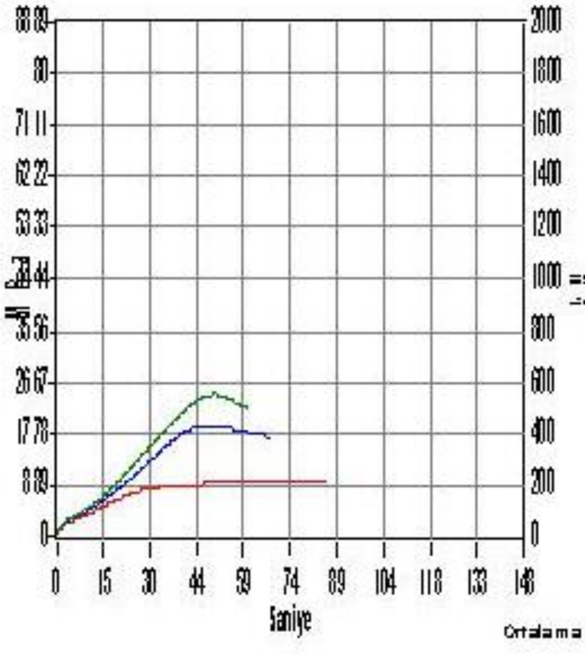
APPENDIX 5

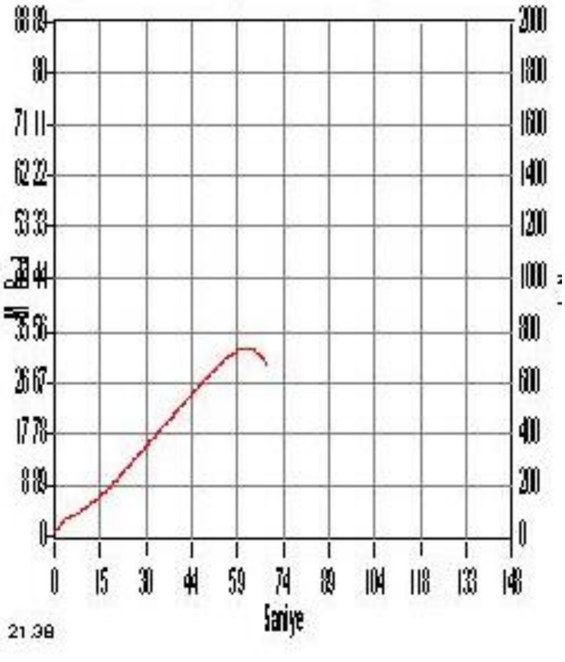
COMPRESSIVE STRENGTH TEST RESULT DOCUMENT OF FIRST TEST

YAKIN DOĞU ÜNİVERSİTESİ LABORATUVARI BETON BASINÇ DAYANIM DENEY RAPORU

Rapor Tarihi	26/06/2016			Referans No	

FIRMA VE ŞANTIYE BILGILERI		DENEY SONUÇLARI			
İnşaat Sahibi		Gerilme (Mpa)	Kırım Kuvveti (KN)	Ağırlık (gr)	Birim Ağırlık (Kg/m3)
Deneyi Yaptıran	TEZ ARAŞTIRMASI MİMARLIK	9.4	212.3	7689.0	2.278
İnşaat Adresi		19.1	428.7	7667.0	2.269
Standart	TS EN 206 1 / TS EN12390 3	24.6	550.3	7510.0	2.225
		32.6	732.0	7467.0	2.200
NUMUNE BILGILERI		0.0	0.0	0.0	0.000
Numuneyi Alan	BABAK SALİMİ	0.0	0.0	0.0	0.000
Üretici Firma					
Döküm Tarihi	28/05/2016				
Kırım Tarihi	26/06/2016				
Alındığı Yer (Kiriş.Kolon vs)		Numune Adedi	4		
Beton Sınıfı		Yaş 1	28 GÜN		
Numune Boyutları	Küp 150.0x150.0x150.0	Yaş 2			





Ortalama 21.38

DENEYI YAPAN

MUSTAFA TÜRK

İNŞAAT MÜHENDİSİ Lab Sorumlusu

ONAYLAYAN

Yrd. Doç. Dr. PINAR AKPINAR

İNŞAAT MÜHENDİSLİK BÖLÜM BAŞKAN VEKİLİ

Bu RAPOR Z NSZ OLARAK ÇOĞALTLAMAZ UZER NDE DEĞ Ş KL K YAP LAMAZ

Bu RAPOR SADECE DENEY YAP LACAK NUMUNELER Ç N LABORATUVAR MIZA GET R LM Ş NUMUNELER KAPSAR