

## Requirements for Managing the Recycling of War Debris in the Gaza Strip

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### Abstract

*Over the past ten years, the Gaza Strip has witnessed several wars that resulted in vast quantities of rubble and debris. Therefore, authority-affiliated institutions have worked on the disposal of these quantities through recycling.*

*This study aimed to evaluate the recycling operations which have been carried out in the Gaza Strip through identifying the framework adopted, finding whether there are regulations for managing and reusing the rubble, as well as identifying the strategies adopted in processing the rubble and specifying essential requirements for the recycling process.*

*Regarding the study approach, both the analytic and descriptive approaches have been applied to the results of interviewing a sample of 17 specialists in recycling from governmental bodies and international institutions.*

*The results of the study indicated that the Project outputs were compatible with the public needs for the Gaza strip, that there is no framework for managing rubble recycling operations in Gaza, and the available mechanisms are the result of accumulated experience of the work of experts in governmental and international institutions, and the requirements for rubble recycling process have included the availability of:*

*experience and technical capability, financial support, technical and environmental regulations, advanced technology, proper market – determination of the required concrete properties, and environmentally fitting place for work.*

*Among the study recommendations, Objectives must be predetermined and must include economic aspiration, community and environment need. And basically, sustainability objectives must be sated (present and future objectives).*

**Keywords:** Rubble, Wars, Framework, Gaza Strip, Recycling requirements.

## 1. Introduction

Since Palestinian territories in general, and the Gaza Strip in particular, are hot spots of wars and military conflicts which target basic elements of life such as destroying residential buildings and infrastructure, disposal of rubble left by wars is not an easy process, and making use of it through recycling is also a complicated process. In addition, reconstruction and rubble recycling cannot be a random process, for randomness would mean a multitude of risks.

Following each war, rubble of destroyed buildings of the Palestinians piles up in the Gaza Strip, which is one of the world's most densely populated regions, with an area of 365kmsq, and a population of 1.99 Million people (PCBS 2019).

The Gaza Strip is seen as a battlefield, with Israeli attacks occurring from time to time. This tiny region has gone through three wars over the past ten years, including 2008, 2012 and 2014 wars and hundreds of military actions.

Palestinian ministries, namely Ministry of Public Works and municipalities, have worked on the removal of rubble, as well as considering the prospects of recycling and reusing it within limited capabilities, resources and experience in this field.

## 2. Study Problem

The study covers the subject of evaluating Palestinians' experience in recycling rubble after wars and disasters which have taken place in the Gaza Strip from local and international institutions perspective.

In the light of the throttling blockade on Gaza, the shortage of natural resources and the constant closures of crossings, evaluation of rubble recycling operations and using it in the development of infrastructure, as well as identifying the strategies and approaches has been inevitable.

**The following question outlines the study problem:**

What are the procedures of rubble recycling operations, and how is the rubble used in infrastructure from partner's perspective?

The study attempts to answer the following sub-questions:

- Is there a framework adopted in the process of recycling and reusing rubble in infrastructure, and are there regulations for managing and reusing the rubble?

- What are the strategies adopted in dealing with the rubble, starting from work until the end of recycling process? What are the programs for rubble recycling and using it in infrastructure?
- What are the essential requirements for rubble recycling as independent categorization: technical capabilities, resources and teamwork, funding capabilities, abiding by law, technology in use, skills and other qualifications.
- Has recycling achieved the planned objectives?
- Are there any plans for rubble recycling projects, and have they matched the standard of compatibility of the project outputs and objectives as planned?

### 3. Methods and Approaches

The researchers applied both the analytic and descriptive approaches to the results of interviewing 17 recycling specialists in the Gaza Strip, and others – from governmental and international institutions – who have taken part in the management of rubble recycling operations, as well as contracting and construction companies.

The Study Sample:

Table (1) presents the study sample that is represented by decision makers, specialists and experts working in the construction field, where the number of experts and specialists is (17).

**Table 1: Study Sample from the Stakeholders in the Construction Field**

Name	Workplace
Shafiq janda	Professor and academic of the Islamic University
Youssef Al-Ghariz	PhD in Civil Engineering and a consultant to the Qatar Reconstruction Committee
Nasr al-Din Sadiq al-Muzaini	PhD in Civil Engineering and Academic of the Islamic University
Imran Al-Kharoubi	Master of Civil Engineering and Project Manager, UNDP Gaza
Naji Sarhan	Master of Civil Engineering and Undersecretary of the Ministry of Works and Housing
Abdul Rahman Shahabir	Master of Civil Engineering and works in the Ministry of Works and Housing
Zuhdi Al-Ghariz	Master of Civil Engineering and Head of Department at the Ministry of Local Government
Wahed Albursh	Master of Civil Engineering and Director of the Solid Waste Department, North Gaza
Muhammad Mustafa Qasim	Bachelor's degree in civil engineering and head of the UNDP project
Muhammad Abu Shaban	Master of Civil Engineering and UNDP Project Manager
Basam Nassar	Director of a maintenance company
Adel Hamad	Master of Civil Engineering and Head of Materials and Soil Laboratories at the Islamic University
Ahmed Amer Al-Kurd	Master of Civil Engineering and Director of Materials and Soil Laboratory at the Islamic University
Farid Zaqqout	Executive director of the Industrial and Construction Union
Bahaa Al-Din Youssef Al-Agha	Master of Environment Director in the Ministry of Environment
Mesbah Abu Harb	Head in the quarries department of the Ministry of Economy
Hassan Al-Serhi	Director in the Ministry of Economy

#### 4. The Study Previous Studies

This Palestinian hands-on experience of dealing with the rubble in the Gaza Strip needs consideration and evaluation in order to improve the performance and achieve best results, that evaluation, in essence, is an education and development oriented process, not a matter of accountability. Also, Sustainability is regarded as an ultimate goal of the process.

In addition to finding a national methodology or strategy that establishes rules and sets out priorities in the process of rubble recycling in Gaza strips, as well as encouraging enlightened thinking to find systematic approaches, documenting the ideas of previously adopted strategies and fulfilling the purpose of evaluation by considering the results, adjusting future works and formulating policies.



Construction waste, as well as the waste of demolished old frames, is a cause for concern all over the world. Hence, recycling and reusing this waste may help reduce dependence on natural resources. It may also help preserve the environment through the policy of sustainability in reserving natural resources (Behera et al, Li X.2008).

Some studies have shown that recycled rubble affects mechanical properties. Consequently, the higher the rate of recycled rubble, the lower the compressive strength and modulus of elasticity in the mixture. Studies have also confirmed the possibility of using recycled rubble in bendable components without a drop in resistance (Mmqubbl, 2014). In addition, studies have confirmed the possibility of using recycled rubble in concrete mixtures on its own or mixed with natural materials of certain qualities and standards through setting Palestinian national qualities and standards (Alghuraiz, 2011).

Despite the economic and environmental advantages of recycling and using rubble in construction, Canadian contractors are reluctant to use it. This could partially be attributed to the fact that they don't want to be held responsible for the dangers linked to the guarantee of quality of the material about which data, technical and field experiments and experience are limited ( Butler, West, Tighe, 2012 ).

Hence, studies must be conducted in terms of chemical and metallic formula, usage-related pollution and the economic feasibility to produce concrete masses from recycled components (Sabai et al, 2013 ), as well as carrying out studies related to the social, economic and environmental effects in the official sectors working on recycling waste (Shukla et al, 2008 ).

The 2014, 51-day war on the Gaza Strip left waste estimated to 2.5 million tons of buildings and institutions rubble: 15671 buildings and houses, of which 2276 were completely destroyed and 3395 partially damaged, amounting to four times as much as the rubble of 2008-2009 war, according to the statistics of the Ministry of Public Works and Housing. This urges serious thinking of strategies to make use of the rubble or remove it to protect people and environment (Al Hadath Newspaper, 2014 ). Also, 10% of the rubble is described as dangerous materials that haven't yet exploded (El Kharouby, 2011).

The Gaza Strip is exposed to several crises such as recurrent wars and military conflicts, as well as landfills, which needs requirements for managing these crises. For example, the ability to identify, analyse and evaluate the risks and specifying the needs, resources and abilities required for management of risks and crises (Musalam, 2019).

The process of rubble recycling includes a number of basic steps:

1. Picking out recyclable construction materials from destroyed buildings
2. Categorizing debris and taking out dangerous materials.
3. Manufacturing recyclable products via proper equipment.
4. Marketing recycled products

Recyclable materials from debris (Basel Convention, 2013)

Vast quantities of construction and demolition waste are disposed of at building and renewal sites; this waste can beneficially be recycled into products such as:

Concrete: it can be recycled to be used in different applications that are now used in limestone.

Asphalt: large quantities can be recycled through crushing and reusing in paving.

Pure, unprocessed wood: this type of wood can be recycled to produce geometrical boards or fuel for kilns.

Metals: there are different types of recyclable copper, metal and aluminum.

Gypsum: it can be removed off walls and recycled so that it can be applied to new gypsum walls, producing cement or used for agricultural purposes.

## 5. Results and Discussion

The results of personal interviews with specialists working in the field of construction and recycling the rubble resulted from the Israeli aggressions on the Gaza Strip, which has experienced several aggressions, notably the 2008, 2012 and 2014 aggressions. They left thousands of tons of rubble and debris which were used in

reconstructing the enclave by partners, following Israel’s ban on the entry of construction materials into the Strip and the harsh blockade.

The following table shows the physical properties of rubble (UNDP,2009), it is possible to say that recycled Concrete Rubble (RCR) seems to have satisfying properties for the most common exposure conditions (El Kharouby,2011; Qaraman, 2019).

**Table 2: Physical Properties of Rubble Aggregate Fraction**

Size Fraction (mm)	50 mm
Coefficient of smoothness	6.87
Total dry weight of the aggregate	2.2
Sample absorption ratio	5.7%
The maximum dry density of Modified Compaction Test	1.933 g / cm <sup>3</sup>
CBR of these materials at the rate of 100%	212
Los Angeles test	42%
The percentage of coarse aggregate in the sample reaches	82%.
The percentage of sand	18%

The interview questions have touched on different aspects, so that it encompasses everything related to the operations and management of rubble recycling that took place in Gaza, as well as identifying obstacles and handling the problems of these operations.

Table (3) shows questions about the nature of the framework adopted in the rubble recycling operations and the ways they are used in reconstructing the Gaza Strip.

**Table (3): Framework for Rubble Recycling Operations.**

	Answer	Notes
Is there a framework adopted recycling and reusing rubble into infrastructure, and are there regulations for managing and reusing the rubble?	<ul style="list-style-type: none"> <li>• There is no framework, and we followed foreign standards and experience in the field.</li> <li>• The UNDP incorporates a clear written programme for removing rubble from the Palestinian territories.</li> <li>• There are regulations for this work.</li> <li>• Ministry of National Economy had a vital role in this concern through recycling a great portion of this rubble via the major rock crusher in City Khan Younis.</li> </ul>	The Environment Authority issued environmental terms of operating rock crushers in general. These terms were in 2012

Table (4) shows the availability of strategies and programmes for rubble and debris recycling and how it is used in reconstructing the Gaza Strip.

**Table 4: Adopted Strategies for Dealing with the Rubble and Recycling Programmes**

	Answer	Notes
<p>What are the strategies adopted in dealing with the rubble, from the beginning of work until the end of recycling?            What are the programmes for recycling and using rubble into infrastructure?</p>	<p>Strategies adopted start from quantitative and qualitative compilation of the rubble and the possibility of it containing dangerous materials. Then setting out removal priorities, after that preparing removal programmes that include categorization on-site, explosive materials test, removal methods, transportation and compilation in special dumps, recycling and reusing.</p> <p>Agreement with financing institutions to compile this rubble from different agencies which signed a contract with the Ministry of Public Works and Housing in order to remove the rubble.</p> <p>Evaluating buildings based on partial and total destruction.</p> <p>Categorizing and crushing operations are compliant with requirements.</p>	<p>Demolition is carried out via government bodies or contractors in partnership with the UNDP and the house owners.</p>



Table (5) shows requirements for rubble recycling operations, including technical capabilities, qualifications, rules, etc...

**Table 5: Requirements for Rubble Recycling Operations**

	Answer	Notes
What are the necessary requirements for the rubble recycling process as an independent classification	<p>Harmony between agencies concerned with recycling operations.</p> <p>Availability of technical instructions.</p> <p>Providing machinery as the crushing machines available is very simple.</p> <p>Providing machinery for rubble categorization.</p> <p>Identifying required qualities of concrete.</p> <p>Finding proper market that can accommodate the produced materials so that they don't become burden on the environment.</p> <p>Reinforcing public awareness for using the produced materials.</p> <p>Estimating recycling cost and considering feasibility.</p> <p>Providing technological equipment. I saw the Italian crushing machine; it has a huge magnet that separates metals, but in the local ones there is no such a thing.</p> <p>Accumulation of good experience.</p>	<p>Providing requirements:</p> <ul style="list-style-type: none"> <li>- Engineering equipment</li> <li>- Experienced individuals</li> <li>- Work teams of engineers and supervision</li> <li>- Providing safety regulations for the project and the strategy of rubble recycling</li> </ul>

Table (6) shows availability of plans for rubble recycling projects and their compatibility with the output.

**Table 6: Rubble Recycling Project Plans**

	Answer	Notes
<p>Are there plans for rubble recycling projects? Did they meet compatibility standards of the project, or fulfilled projects objectives as planned?</p>	<p>There are plans for transporting war waste through compiling the rubble and transporting it into the landfills within standards.</p> <p>They started to think of how to make use of 2.5 tons of rubble. It was emergency, something we didn't plan for: it was allocated for something, but we used it another as emergency solution ( reaction ).</p> <ul style="list-style-type: none"> <li>• They weren't official plans, only attempts to facilitate life concerns in the Gaza Strip due to the lack of aggregate and limestone.</li> <li>• It fulfils the compatibility criteria by removing debris and making use of it on the roads.</li> </ul> <p>We are plagued by the vast amounts of rubble resulting from three wars, particularly 2008,2012 and 2014 wars. Consequently, there was serious thinking of benefiting these amounts.</p> <p>There was experience based on the use of settlement buildings rubble.</p> <p>There were plans that resolved an economic crisis caused by the lack of construction materials on the market. Recycling met compatibility standards and fulfilled the objectives planned.</p>	<p>There are no written plans, but there are experienced individuals who have dealt with rubble.</p> <ul style="list-style-type: none"> <li>•Projects met compatibility standards ( acceptance of the status quo resulted from Palestinian division and the blockade imposed by Israeli occupation</li> <li>•Projects output were compatible with the public needs.</li> </ul>

Table (7) shows to what extent ultimate objectives of buildings debris recycling and infrastructure projects are fulfilled.

**Table 7: Fulfilment of Recycling Projects Objectives**

	Answer	Notes
Has recycling achieved the stated objectives?	<ul style="list-style-type: none"> <li>It has achieved objectives, even if not planned.</li> <li>It has achieved objectives, regardless of the fact that there was no organized framework. It had economic feasibility as it reduced cost.</li> <li>Previous projects provided job opportunities</li> <li>Produced construction materials that were used during the blockade</li> <li>Saved nearly 2 million dollars from that were replaced with recycled materials.</li> </ul>	<p>Recycling has achieved the stated objectives through providing construction materials that weren't available on the market, as well as job opportunities.</p> <p>The rubble was used in roads, infrastructure and sub-base beneath asphalt. We also noticed uses in ports, al-Nasr Street, in addition to expanding the area of berths and building supporting concrete barricades to prevent erosion of beaches.</p>

**Conclusion:**

- There is no official framework for managing recycling projects in the Gaza Strip
- The available mechanisms are the result of accumulated experience from the work of experts from governmental and international institutions.
- There is a consensus among those concerned on the requirements for rubble recycling operations.
- There are no written plans, but there are experienced individuals who have dealt with rubble.
- Projects met compatibility standards ( acceptance of the status quo resulted from Palestinian division and the blockade imposed by Israeli occupation
- Projects outputs were compatible with the public needs.
- Requirements for rubble recycling process have included the following:
- Availability of experience and technical capability – financial support availability – availability of technical and environmental regulations – advanced technology availability – proper market availability – determination of the required concrete properties – availability of environmentally fitting place for work.
- Shelter Cluster group is regarded as the managing body for the sector of intervention in housing, and it is responsible for formulating framework for recycling operations.

- Recycling operations include: damage registration – rubble examination – risks termination – rubble transportation – rubble categorization – rubble crushing – rubble processing and reusing in construction
- Achieved the Environment preservation
- Recycling projects had economic feasibility.

## 6. Recommendations

- It's essential that an organized framework for rubble recycling operations and its use in infrastructure be formulated.
- Issuing regulations for managing and reusing the rubble in Gaza Strip, particularly for dealing with dangerous materials and pollution.
- Stressing cooperation between institutions concerned such as Ministry of Public Works, municipalities and international institutions for working in recycling.
- Accumulating strategies based on constant experience in dealing with rubble and destroyed buildings debris resulted from the wars the Gaza Strip has experienced.
- Objectives must be predetermined and must include economic aspiration, community and environment need. And basically, sustainability objectives must be sated (present and future objectives).
- Identifying required qualities for the concrete and providing eco-friendly place for work must be available.
- Preparing plans for rubble recycling process based on experience in dealing with the rubble resulting from previous wars.
- Recycling may achieve stated objectives through gapping the shortage of construction materials that are not available on the market, providing new job opportunities, employing companies and preserving environment.

The Study Limitations:

Place-based limitations: Palestine – the Gaza Strip

Time-based limitations: 2019

Subject limitations: evaluation of recycling and using rubble in infrastructure according to local and international institutions specialized in this field.





Target sample of the study: directors and CEOs overseeing rubble recycling projects.



## References

- Al Hadath Newspaper (2014). How will Gaza get rid of the tons of rubble left by the 50-day aggression? Accessed on 11th January 2019: <https://www.alhadath.ps/article/3882/>.
- Alghuraiz, Y. S. M. (2011). Volumetric changes and durability of structural concrete with recycled aggregates: Gaza strip as a case study.
- Basel Convention. (2013). Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Accessed on 12th January 2019: <http://www.basel.int>.
- Bakri Thamir. (2011). Strategic Dimensions of Recycling in Promoting the Green Marketing Philosophy “A Review of Selected Experiences from Different Companies and Countries.” *Takrit Journal of Administrative and Economic Sciences* 7 (23),
- Behera, M., Bhattacharyya, S. K., Minocha, A. K., Deoliya, R., & Maiti, S. (2014). Recycled aggregate from C&D waste & its use in concrete—A breakthrough towards sustainability in construction sector: A review. *Construction and building materials*, 68, 501-516.
- Butler, L., West, J. S., & Tighe, S. L. (2012). Effect of recycled concrete aggregate properties on mixture proportions of structural concrete. *Transportation Research Record*, 2290(1), 105-114.
- El Kharouby, A. (2011). Post-war rubble removal and potential use of recycled construction rubble in Gaza Governorates. *The Islamic University Journal*, 19(1), 179-212.
- Li, X. (2008). Recycling and reuse of waste concrete in China: Part I. Material behaviour of recycled aggregate concrete. *Resources, Conservation and recycling*, 53(1-2), 36-44.
- Musalam Alaa. Al-Agha Muhammad. El-Ashgar Nizam. (2019). Risk Management during Crises and Disasters: Umm Al-Nasr Village in the Northern Gaza Strip (Unpublished Master), Islamic University, Gaza.
- Palestinian Central Bureau of Statistics.(2019). About 13 million Palestinians in the Historical Palestine and Diaspora. Accessed on 12th January 2019: <http://www.pcbs.gov.ps/post.aspx?lang=en&ItemID=3503>.



Qaraman, A. (2019) The Activity of HYPR surfactant as Superplasticizer on the properties of concrete mixes. *Israa University Journal Of Applied Science (IUJAS)*, 3, 88 -101

Sabai, M. M., Cox, M. G. D. M., Mato, R. R., Egmond, E. L. C., & Lichtenberg, J. J. N. (2013). Concrete block production from construction and demolition waste in Tanzania. *Resources, Conservation and Recycling*, 72, 9-19

Shukla.s, Hina ,Z, Varuvel. D. (2008)Assessing informal waste recycling in Kanpur City, India, *Management of Environmental Quality An International Journal* 19(5):597-612

Tomader Mmqubbl. (2014). Study of the mechanical properties of recycled aggregate concrete (unpublished Master Thesis). Damascus University, Syria.