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Reuse Of Construction and Demolished Waste as Aggregates in Concrete: A Review

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Abstract:-
This paper presents reviews of the authors for the use of construction and demolished waste of building in concrete as recycled coarse aggregates. It is observed that from many years ago that the peoples of rural areas shifted from villages/small towns to developed city centers. Due to this huge number of migration of peoples creates problems accommodations and their basic needs. For the solution of accommodation and other problems demolish old structures and construction will shift from horizontal to vertical space such as: high rise building. However, demolition of old structures creates many issues and for the solution those issues on and only the better option of reused of Construction & Demolition waste as in green concrete. The views of the several authors and construction industry are the utilization by consuming it in new concrete in various ways. Replacement of fine aggregates, coarse aggregates and even cement has been attempted. Green concrete is produced by replacing natural coarse aggregates in 50% dosage with coarse aggregates obtained from demolished old concrete which was suggested by the several authors. Use of recycled in concrete has not much effect on the basic properties (specific gravity, water absorption, unit weight and density) of Recycled coarse aggregates comparison with natural coarse aggregates. Therefore, the use of this waste in new concrete not only helps in reducing the waste management issues but also help protecting the environment greatly.

Keywords: Old structures, Green Concrete, Demolishing and Construction Waste, Recycled Coarse Aggregates, Waste management.,

1. Introduction

It is observed since last few decades that people migrated from villages, towns and small cities to developed cities. This migration of people in large quantum caused problem of accommodation and associated facilities in those developed cities. Providing accommodation to these migrants in limited available space led to the many problems. On the other hand, unavailability of space for new construction particularly in developed cities of globe forced the construction industry to shift from horizontal development to vertical development by demolishing the old structures. This technique has solved the problem to great extent but posed

the problem of effective management of huge quantum of the construction and demolition waste (C&D) generated as a result of demolishing of old structures [1, 2, 3]. Lack of space for dumping this waste forced the industry to take it too far distances resulting in increase in overall cost of the project. Dumping the same near city centers not only raise the aesthetic issue but also adds up to environmental problems due to chemical reaction of organic impurities attached to the waste and its decay. Proper management and particularly onsite use of this material thus became the major area of interest of the scholars.

The use of this waste material in landfills remained intact for considerable time. The scholars and industry added its utilization by consuming it in new concrete in various ways. Replacement of fine aggregates, coarse aggregates and even cement has been attempted.

Large portion of concrete body is occupied by the coarse aggregates, thus, utilization of this waste as coarse aggregates consumes large volumes of it. However, it is believed that the resulting concrete will be different in properties and behavior than normal concrete with all-natural aggregates. Like normal concrete structures, infrastructure made with this concrete also has to face several natural and accidental effects during service life and should be strong enough to resist the same.

It is noted that good quantum of work related to the evaluation of properties of recyclable aggregates has been addressed internationally. Also, the properties of concrete made with this type of aggregates but the scatter in results requires more work for the same and about other parameters is still required. In Pakistan at present this type of aggregates are seldom used. The waste normally goes to the landfills resulting in waste management issues and threat to environment. Whereas, if the same is utilized in new concrete will not only reduce the above-mentioned problem but also results in economy of the projects.

This research study provides ideas regarding the reuse materials of the demolished structures in new concrete. By the using of this technique may reduce the cost of the project, reduce environmental impact by dumping of the demolished materials nearby city.

Organization of the paper is based on the sections of Introduction, Literature Review, Potential use of the C&D waste, Potential Reuse of the concrete aggregates, Properties of the concrete, Conclusion and References.

2. Literature Review

Since past few decades, the massive generation of construction and demolition waste (C&D) has increased and threatening the public environment and humanity worldwide. A large amount of research has been devoted to the (C&D) waste from difference perspectives [10]. Demolition of old structures is increasing on daily basis for the construction of new and high-rise building to meet the basic needs and to improve the life style at modern pace. From the demolition of old structures construction wastes are generated in the shape of ceramics, crushed bricks, crushed concrete block, fine recycled aggregates, fiber composites, steel fibers, plastic plates, fly ash, blast furnace slag, silica fume and biomass/volcanic ashes, polymers, bentonite, FRPs, glass, rubber, foundry sand etc.

The use of old demolished concrete as coarse aggregates in new concrete has been studied by several scholars around the world [1, 2, 12-13]. But there is wide scatter in the published results about the subject matter. This shows that there is still need of more work in the field, not only to study its behavior but also to improve confidence and set landmark for the future researchers of the field. This chapter presents the review of relevant available state-of-art on the topic.

2.1 Construction and Demolished (C&D) Waste and Its Management

The waste generated as a result of demolishing of old structures or as a result of construction of the structures is generally known as construction and demolishing waste. Since past few decades the quantum of this waste is one of the largest streams produced globally [12]. Waste generates from the demolishing of old structures are categorized in following way.

1. Aluminum siding
2. Architectural antiques
3. Asphalt
4. Brick/Masonry blocks
5. Concrete blocks
6. Gas pipe/Metal pipe
7. Porcelain plumbing fixtures
8. PVC pipe
9. Steel: structural or rebar
10. Wallboard/Drywall(gypsum)
11. Doors and windows wood
12. Glass

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13. Marble/tile pieces

Minimization of construction and demolished waste of structures requires special attention to C&D waste management. Following are the key points for the adoption of managing C&D waste [10 & 18].

1. C&D waste should be dumped/reduced at source as far as possible.
2. Reuse or refurbishment before reuse should be adopted to reduce C&D waste
3. Recycling of waste may be opted.
4. If recycling to secondary material is not required or feasible then the energy of the waste may be utilized as renewable energy.
5. If all above options are not feasible then last resort is to dump the waste in landfill but it should be done in controlled manner to make best possible use of the land.

Construction and demolished waste are managed in steps / ways which reduce, reuse, recycle, burn and dump in landfill as shown in Figure 1, again these steps also divided into sub-sections. Construction waste management moved increasingly towards the first of these steps, as per the framework proposed by European Union [11] and is reproduced as under.

1. The proximity principle
2. Regional self-sufficiency
3. The precautionary principle
4. The polluter pays
5. Best practicable environmental option.

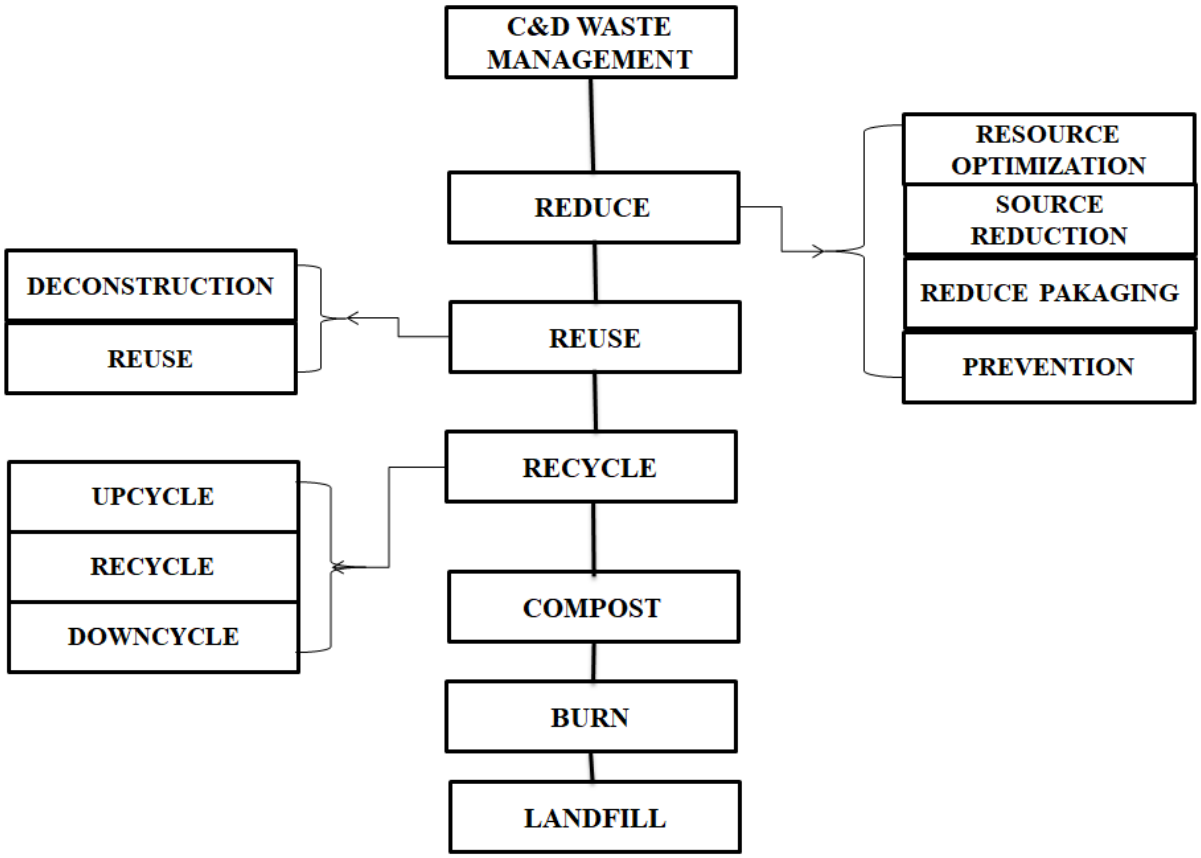

Figure 1: Construction and demolition waste management steps [12].

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3. Potential Reuse of C&D Waste

History of construction industries shows that construction wastes generated from demolishing of old buildings, mostly goes to landfill but with passage of time it became problem due to lack of available space in developed cities around the world. One of the better options for dealing this waste is by utilizing it in the new construction. Among the various components of the waste few can be utilized in the flooring and making of low traffic roads, foot-paths, walk-way, back-filling etc. As stated earlier large volumes of this construction & demolition concrete waste can be utilized if attempted to use as coarse aggregate in new concrete. Several attempts have been done by different researchers to evaluate the properties and performance of old concrete as partial replacement of the natural coarse aggregates [1, 10, 18, 22-24], but still huge vacuum and scatter in the results can be observed and need more research. Therefore, the use of recycled concrete aggregates in buildings is still limited to only few attempts, where as it has been successfully applied in roads, walkways, backfilling in structural foundation.

3.1 Green Concrete

Production of concrete involves different steps having several impacts on environment. Like production of cement results in carbon dioxide emission from cement industry which affects the environment severally. Therefore, the concrete which reduces adverse impacts on the environment or is eco-friendly is termed as green concrete. It is major area of research for scholars, researchers and industry personals since past few decades [3, 20, 21].

Few of the overall benefits of green concrete are less carbon dioxide emission, increased use of waste products, less environmental pollution, increased sustainable environment, less maintenance and repair, better performance, workability and place ability [3, 17, 20, 21].

3.1.1 Ordinary concrete

Ordinary concrete is widely being used all over the world. It is a mixture of Cement, Sand (fine aggregates) and coarse aggregates with required water cement ratio. This type of concrete is used for footing, RC beam, columns and slab in building construction.

3.1.2 Recycled concrete

This type of concrete is produced by utilizing waste of demolished structures in the shape of aggregates and even cement with suitable replacement. In demolished structural waste different type of wastes are generated such as concrete blocks, Rubber, Glass, etc as shown in Figure 2. Use of demolished waste in new concrete is known as Recycled concrete and from this type of concrete reduced the environmental impact of utilizing of natural ingredients and also save them.

Figure 2: Demolished wastes of structural elements

4. Potential Reuse of Concrete Aggregates

It is a precautionary technique aimed at minimizing the waste generated from the source before it becomes a physical problem. Recycling procedure of demolition of old concrete. From demolition of structures construction/structural wastes are generated in the shape of blocks of concrete and other materials. Recycling process starts with manual separation of type of waste i.e. old concrete, bricks, steel fibers, ceramics, glass polymers and others. Recycling of the waste is then used to produce the required size and shape aggregates. Large blocks of old concrete are reduced to required size of aggregates. For small scale projects the recycling process is carried out manually. However, proper utilization and economy require automatic careful processing to achieve economical and durable aggregates. Recycling of the waste has become a separate field of interest and research, where, valuable outcome is being produced by researcher by best possible utilization of

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the demolishing waste. Screening for cracked and deteriorated particles followed by gradation is done. Properties of the aggregates are evaluated before proportioning the same in new concrete in required dosage. Properties and behavior of resulting concrete is also required to be studied to ensure performance and serviceability of the structures during service life.

Shifting of peoples from their home town to big cities for their better future and advanced facilities require accommodation and associated facilities in these big cities. To meet the demand, old structures are being demolished and new ones are being constructed. Demolition of those structures creates problem of waste and dumping of same. For the solution of all these issues reuse of it in new construction is better option, the same is also proposed by Oad and Memon [1] among several other scholars [6 -10, & 18]. The authors used waste recycled concrete blocks to produce recycled coarse aggregates to be in concrete replacing NCA in 5% to 50% with increment of 10%. 54 specimens of NCA and 324 specimens of RCA were prepared using w/c ratio in the range of 0.45 - 0.60. Equal number of specimens was cured for 7, 14 and 28 days. Basic properties and compressive strength of the specimen were evaluated and found in good agreement with control specimen with tolerable reduction in the strength.

Kumutha and Vijai [4] used structural wastes in their research work to study the properties of recycled aggregates used in concrete with partial /full replacement of coarse and fine aggregates. Replacement of coarse aggregates with crushed concrete was used from 0% to 100% with increment of 20%. The same percentage replacement was used 0f fine aggregates with crushed bricks. They observed decreasing pattern in compressive strength, flexural strength and tensile strength except modulus of elasticity.

Malešev et al [5] used crushed waste of laboratory in new concrete with replacement of 50% and 100% for both fine and coarse aggregates. They used three types of specimens in this study and prepared 99 samples for testing the basic properties. Based on the comparison of obtained results the authors concluded satisfactory performance of recyclable concrete aggregates.

5. Properties of Concrete

There are many factors which affects the properties of concrete at fresh and hardened state. Among the factors, mix ratio, type of cement, type of fine and coarse aggregates and water are few. Few of the properties of the concrete are listed below for the purpose of flow of the reading.

1. Concrete grade
2. Concrete density
3. Workability
4. Strength (compressive, tensile and flexural)
5. Deflection
6. Cracking
7. Durability and serviceability
8. Creep
9. Shrinkage
10. Response to unconventional loading
11. Long term loading behavior

Serval scholars around the globe have made attempts to study the properties of concrete made with recycled aggregates. Among them Qasrawi and Marie [2] used demolished concrete as RCA in casting of cylinders for their research and studied the properties of recyclable concrete aggregates. Using the experimental results, the authors also coined out numerical expression for modulus of elasticity of concrete using recyclable concrete aggregates. Through the results the authors concluded that there is not much difference between the basic properties of natural and recyclable aggregates except workability and water absorption.

The authors also observed that reduction in compressive strength of concrete cylinders made with recyclable aggregates is from 5% to 25% and reduction in tensile strength is up to 14% with reference to control specimen cast with all-natural coarse aggregates. The research finding of Liu et al [14] were also similar except that they additionally studied peak strain and brittleness. They reported both the properties lower than the ordinary concrete. Silva et al [15] also utilized the similar material to study the creep behavior of the concrete and found better performance of the proposed concrete against creep. Cervantes et al [16] used recycled concrete aggregates in their research and determines the fracture and dry shrinkage properties of concrete [25].

5.1 Gradation of Aggregates

Gradation of aggregates is another aspect which ensures good strength of concrete and good serviceability of the concrete. For better performance of the concrete, aggregates should be well graded. This requires presence of all standard sizes of the aggregates in required quantity, meeting the range specified by ASTM C-128 (American Standards for Testing Methods). In well graded aggregates

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concrete space between large aggregates is filled up by smaller aggregates and thus requires less cement paste to fill the remaining gap. Whereas, use of one size of aggregates results in poorly graded aggregates concrete which requires more cement paste to fill the gap between them.

To ensure proper gradation of the aggregates, sieve analysis is used. For both natural coarse aggregates and recyclable aggregates from demolished concrete, sieve analysis is done following the standard procedure given by ASTM C-128 [19]. It is observed from the Figure 3 that the gradation of both of the recyclable and natural aggregates is within allowable limits specified by ASTM. This figure shows clearly that with negligible variation the pattern of gradation is same for both types of the aggregates.

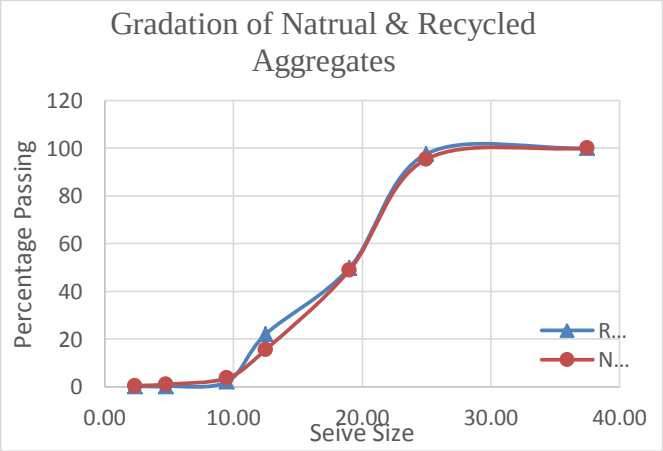

Figure 3: Sieve Analysis of Coarse Aggregates [21]

5.2 Basic Properties of Coare Aggregates

Among several properties of aggregates, unit weight, density, water absorption and specific gravity are important and frequently used properties. Water demand is particularly important with reference to water demand of the concrete mix. Water-cement ratio is adjusted as per the water absorption of the aggregates. Old demolished concrete, which is main constituent of this study, is theoretically believed as more water absorbent due to its age and old mortar adhered with it. Therefore, these properties are evaluated for both natural and recyclable aggregates.

Basic properties of aggregates i.e. water absorption and specific gravity of both natural and recycled aggregates are evaluated and compared the results of authors [2, 5, 21]. Table 1 shows the results of water absorption and Specific gravity of the coarse aggregates. Table 2 shows the results of unit weight and density of the coarse aggregates.

Table 1: Unit weight and density of natural and recycled aggregates [21]

Test	Unit	NCA	RCA
Water Absorption	%	1.8	3.92
Specific Gravity		2.56	2.43

Table 2: Unit weight and density of natural and recycled aggregates [21]

Test	Unit	NAC	RAC
Unit Weight	Kg / m³	2193.70	1957.03
Density	Kg / m³	1781.24	1685.14

Water absorption of the recyclable aggregates is observed (3.92%), used in this experimental work remained on higher side than water absorption of natural aggregates (1.8%). The percent difference of water absorption NCA and RCA is recorded equal to 117%. The water absorption of recycled aggregates in comparison to Hisham and Iqbal [2] is 30% less and 11.55% less than the same reported by Mirjana et. al. [5]. Indeed, it is primarily due to the old mortar attached with the recyclable aggregates and the age of old concrete. The higher water absorption of the recyclable aggregates thus increases the water demand of the concrete mix and need to be adjusted in concrete mix design.

While analysing the specific gravity, results of both of the aggregates, shows that the specific gravity of recyclable aggregates remained on lower side of the specific gravity results of natural coarse aggregates with percentage difference equal to 6.25% [2, 5]. The basic reasoning behind the short fall of specific gravity is again same as that of water absorption. Also, density of recyclable aggregates is recoded as 84.19% of that of natural coarse aggregates used in this work. The unit weight of recyclable aggregates is also observed reduction in comparison to natural coarse aggregates and is recorded equal to 82.77% of unit weight of natural coarse aggregates [2, 5]. Deviation of basic properties of the concrete than available standards is expected to have different strength and performance of the concrete.

6. Conclusion

The above summary and discussion of the available literature regarding the present work show diversified attempts for improving concrete performance, finding alternate of one or other ingredients of concrete, use of

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recycled aggregates in new concrete. However, the scatter of results shows that still there is need of more work with respect to the use of recyclable aggregates in new concrete in general.

The waste generated as a result of demolishing of old structures or as a result of construction of the structures is generally known as construction and demolishing waste. Construction wastes generated from demolishing of old buildings, mostly goes to landfill but with passage of time it became problem due to lack of available space in developed cities around the world. One of the better options for dealing this waste is by utilizing it in the new construction.

As the literature reveals that the use of demolished construction waste in concrete as a coarse aggregates with the different percentage (0% to 100%), but the use of 50% Recycled aggregates in concrete replaced with natural aggregates has a satisfactory results in green concrete. The percent difference of water absorption NCA and RCA is recorded equal to 117%. The water absorption of recycled aggregates in comparison to Hisham and Iqbal [2] is 30% less and 11.55% less than the same reported by Mirjana et. al. [5]. Also, density of recyclable aggregates is recoded as 84.19% of that of natural coarse aggregates used in this work. The unit weight of recyclable aggregates is also observed reduction in comparison to natural coarse aggregates and is recorded equal to 82.77% of unit weight of natural coarse aggregates [2, 5].

However, this motivated the idea of the research presented in this paper. It will also prove landmark for the researchers of the field and an option to industry personals to ensure the quality of the concrete being used at site. This study gives an idea that how to use construction and demolished waste in green concrete. Use of construction waste in concrete as coarse aggregates to save the natural resources at much extent and also it reduce environmental impact. Also it save the natural resources at much extent and also it reduce environmental impact.

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