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Strategies to Reduce CO_2 Emissions in Housing Building by Means of CDW

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Abstract

One of the biggest problems that human beings face is climate change and construction industry is one of the sectors causing the greatest impact, which has led him to adopt sustainable strategies. However, these have not been effective enough to reduce CO_2 emissions, since solutions are required accompanied by other alternatives. Therefore, the objective of this study is to reduce CO_2 by implementing CDW strategies under the following method: 1) analysis of CO_2 of the major raw materials consumed, 2) use of the materials at the construction site was determined, 3) waste streams generated at the construction site were identified and those that could be reuse were highlighted, 4) CDW recycling strategies to avoid the use of the major raw materials consumption are proposed, and 5) one of the strategies proposed is further analyzed. The results show that natural aggregates generate the greater amount of CO_2 due to the consumption of fuel required for their transportation. By replacing 68% of natural aggregates by recycled aggregates, CO_2 can be reduced by 53%. Finally, these results can help to promote the opening of new CDW recycling companies in Nayarit and thereby contribute to the sum of sustainability practices in housing building.

Keywords:

Climate Change;
Minimization;
Best Practices;
Construction Phase;
Construction and Demolition Waste;
Recycling;
On Site.

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1- Introduction

At present, one of the biggest environmental problems on a global scale that human beings face is climate change, a product of the high concentration of greenhouse gases (GHG) in the atmosphere. The most harmful and most important GHG in the atmosphere are mainly those of anthropogenic origin, especially CO_2 from the burning of fossil fuels and industrial processes [1].

One of the sectors causing the greatest environmental impact and contributes to global warming is the construction sector, as it consumes large amounts of materials, raw materials and energy that mostly comes from non-renewable sources [2]. In this sense, approximately 10% of the world's energy consumption is destined to the manufacture of building materials. The construction and demolition phases also contribute around 40% of solid waste generated in developed countries, while the operation phase of construction products emits around 40% of global GHG, so the construction industry is one of the sectors with the highest global energy consumption [3].

These impacts have led to the change of the construction industry of adopting sustainable construction instead traditional construction techniques [3]. This change has also been promoted by international agreements such as the Paris Agreement, established in 2015. It forces to maintain the global average temperature below 2 ºC above Pre-industrial levels and to pursue efforts to limit the increase in the temperature at 1.5 °C. Following this agreement, an increasing number of organizations are adopting carbon reduction objectives in their projects, as current scenarios such as until now project global temperature increases of 3.2 to 5.4 ° C by the year 2100, and even the fulfillment of all

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strategies determined in the Paris Agreement would imply an average heating of 2.6 to 3.1 ºC in 2100 [4]. So, if global warming is limited to the maximum critical level of +2 °C compared to Pre-industrial temperatures, substantial reductions in greenhouse gas emissions are required in the coming decades [5]. That is why the construction sector must be able to drastically reduce its CO_2 emissions with the use of new technologies, materials and innovative manufacturing processes, which lead to the efficient use of natural resources and embodied energy.

Therefore, there is a wide range of opportunities to reduce CO_2 emissions throughout the life cycle of a building, including mitigation strategies to reduce the associated emissions in construction phases [4]. In this sense, strategies and good practices based on the manufacture of sustainable and energetically efficient building materials have been determined as an alternative instead traditional materials, that can be an adequate solution for the problem of pollution and conservation of natural resources for future generations [6].

In this sense, there are many researchers who have analyzed different phases to reduce CO_2 emissions through building materials. These strategies can be grouped into: 1) materials that store coal, which are responsible for separating, transporting and permanently storing CO_2 to avoid its emission into the atmosphere [7], 2) materials with cleaner production, which are responsible for promote the use of ecological materials through innovative technologies and manufacturing processes, which involve the efficient use of natural resources, embodied energy and better waste production [8], and 3) materials made from coal residues , which consists of replacing raw materials by recycled materials, especially products resulting from the combustion of coal, for example: the use of fly ash to reduce energy consumption and CO_2 emissions [9].

Among the materials that are most used for building construction, Portland cement stands out, especially for the manufacture of concrete and represents the 90% of global CO_2 emissions [10]. In this sense, concrete is one of the most consumed materials in building construction and its production represents the 5% of global CO_2 emissions [11]. Therefore, the search for more sustainable concrete that minimizes CO_2 emissions during its transportation to the construction site is essential for the building sector to reduce its emissions. On the other hand, aggregates such as sand and gravel, are other materials that are most used in the building, because they are mainly the by-product of concrete [12].

Based on the above, there are strategies that focus on the manufacture of alternative concrete for structural use and for the preparation of prefabricated materials, either by replacing or decreasing the amounts of Portland cement, or from the reuse of CDW. On the other hand, there are other strategies to be implemented during the construction phase, which reduce CO_2 emissions, for example, the decrease in transport inside and outside the construction site, the decrease in the use of materials, etc. To reduce the transport of materials, the reuse on site of waste is essential, only in 2016 the construction sector in Europe generated 923,910,000 tons of construction and demolition waste, which represented around 36% of the total of the waste generated [13].

In this sense, the objective of the present study is to reduce CO_2 emissions and thus the impact to climate change caused by the single-family housing construction sector in the state of Nayarit, by implementing by implementing construction and / or demolition waste management strategies (CDW) in the housing construction phase. Therefore, a brief description of strategies related to CDW management is presented below.

1-1- Strategies for the Use of Alternative Concretes

Concrete that stores carbon. One of the key strategies to reduce CO_2 emissions from the energy and industrial sectors is global decarbonization, which includes the capture and storage of carbon [7]. An example of this type of technology is the manufacture of concrete from the construction and demolition waste of buildings, which at the same time can capture CO_2, this through the crushing of said waste to use them as aggregates for concrete and cure them with CO_2 actively or passively. These concretes are ideal for manufacturing concrete blocks and paving stones [14]. Another way to minimize GHG is to use steel slag as a raw material for the manufacture of building materials. The author establishes that the materials made of steel slag based on CO_2 activated, is a good alternative to store part of the CO_2 that is in the atmosphere and to replace Portland cement in the manufacture of prefabricated materials, which is an ecological solution against global warming [15].

Environmental pollutant gases can also be reduced, especially CO_2 through building materials or building elements that contain nano-compounds with photocatalytic characteristics, such as titanium dioxide (TiO_2), which is responsible for the oxidation of the pollutants present in the environment through the use of sunlight and oxygen, to react chemically with the pollutants, thus rendering them harmless for both health and the environment [16].

At present there are materials with these characteristics, for example, the photocatalytic cements, which can be used for the manufacture of mortars for wall coverings, and for manufacturing concrete blocks. There are also photocatalytic additives that are applied directly to a surface or structure [16].

Concrete that has a cleaner production. Materials that contemplate having a cleaner production for their manufacture, prove to be the appropriate philosophical, technological and technical framework to promote sustainable innovation in organizations in the construction sector, considering in particular the problem of construction and demolition waste [8]. An example of this strategies can be the manufacture of biological building materials from the use of hemp plant fiber derived from agricultural waste [6]. Hemp, which has excellent thermal insulation properties and high carbon storage potential, can be used as a building material when mixing hemp fiber with concrete [17].

A good practice to reduce CO_2 emissions in the atmosphere and energy consumption in cement manufacturing is the use of a cement manufactured with low-calcium clinker and cured by carbonation. Cement with low-calcium clinker is synthesized at a lower temperature than Portland cement. Another of the benefits of this cement is a greater compressive strength compared to Portland cement [18].

Materials manufactured from construction and demolition waste are another alternative of sustainable practices, thereby, recycling concrete is an important practice in which the construction industry must focus to carry out a sustainable future. The use of recycled aggregates in concrete has proved successful in structural applications [12].

In countries of the European Union there are regulations for the use of recycled concrete in structural applications, for example, in Spain, there is the EHE-08 Structural Concrete Instruction Standard, which includes recommendations for the use of recycled concrete, and sets that for structural application it is recommended to limit the recycled coarse aggregate content to 20% by weight over the total coarse aggregate content. Also, the present norm sets that the aggregate can be used for mass concrete and reinforced concrete, both with a strength not exceeding 40 N / mm2, excluding its use in prestressed concrete. In Italy, there is the D.M. 01/11/2017 “Minimum environmental criteria for the allocation of design services and works for new construction, renovation and maintenance and public buildings”, which sets that the concrete can contain at least 5% of recycled (dry) material on the total product weight. The bricks used for masonry and ceilings must have a recycled (dry) content of at least 10% on the weight of the product, while the ceramic elements for ceilings, floors and facades must have a recycled (dry) content of at least one 5% on the weight of the product [19].

Concrete with materials from carbon. A key to high performance in cementitious building materials depends of carbon combustion products, for example, concrete based on fly ash [20]. The author maintains that using concrete based on fly ash gives greater resistance and durability to structures such as roads, bridges, tunnels and buildings. In addition, this type of concrete provides greater permeability and greater resistance to compression than the Portland cement-based concrete.

One of the biggest benefits of concrete based on fly ash is the reduction of the Embodied Global Warming Potential (GWP) measured in kg of CO_2e and thereby the replacement of cement by 30% by fly ash in the concrete manufacturing represented a 22% decrease in its GWP compared to a concrete for port use [20]. Any replacement of Portland cement with fly ash reduces the impacts associated with the extraction of raw materials. In addition, the amount of materials sent to landfills is reduced, a destination that fly ash would have if not reused. In this sense, by partially replacing the cement for ready-mixed concrete with fly ash by 30-40%, an approximate saving of 25% of GHG emissions can be achieved [21].

In this sense, replacing raw materials with recycled materials to reduce energy consumption and CO_2 emissions is the focus of contemporary research to reduce emissions related to the building construction sector. The geopolymer concrete produced with 100% of fly ash is a sustainable building material capable of replacing Portland cement [9], as well as the replacement of Portland cement by 70% by coal bottom ash plus an addition of 5% lime, is a suitable paste of high performance for use in bricks, tiles, pavers and controlled applications of low resistance [10].

1-2- Construction and Demolition Waste Management Strategies

At the construction site, waste prevention and collection are techniques that should be identified, designed and contemplated in a general construction site management protocol, which can be articulated in waste prevention and collection [22], for example:

- Waste management. Develop construction and demolition waste management plans that involve stakeholders (contractors, waste management organizations, housing developers, customers, suppliers), prioritize waste prevention and reuse, set minimum requirements for management and identify and quantify the amounts of construction and demolition waste and its treatment needs, promote innovation in recycling opportunities and regulate or standardize materials management.
- Management and prevention of waste on site. Prevent and manage waste, including monitoring of waste generation, establishing waste separation and collection strategies and updating the waste management plan at the construction site.
- Efficiency in the use of materials. Avoid wasting materials by improving their logistics, waste management planning and application of innovative storage and handling practices.

- Materials reuse. Collect materials at the construction site, avoiding the generation of waste, for example: bricks, tiles, concrete, structures, etc.
- Waste treatment and material recovery. Separate and process waste, both in mobile and stationary plants, to maximize the production of high-quality recycled aggregates.
- Other good practices for recycling CDW at the construction phase are those shown below [23]:
- Concrete Recycling. The main use of concrete waste is recycled aggregates. It is recommended that the proportion of recycled coarse aggregate does not exceed 20%. Only 100% recycled aggregate is usually used as coarse aggregate in non-structural concrete. It is also recommended that the recycled fine aggregate is not considered for the manufacture of new concrete, so it must be separated and used in other applications, such as: preparation of mortars for interior coatings and interior masonry work, among others.
- Recycling ceramic waste. Ceramic waste can be recovered and used directly, such as leftover bricks or tiles, or transformed and used as a substitute for natural raw materials, mainly as recycled aggregates. The main use of ceramic waste is: fillings and embankments, bases and subbases, manufacture of concrete and mortars.
- Recycling asphalt material. They can be used as an alternative raw material in the construction of new floors. It can also be used as granular materials, mainly in base or subbase layers or on roads.

However, it is necessary to keep in mind that it is not convenient to recycle the concrete residue on site, because for this it is necessary to perform a series of quality controls, both to aggregate and concrete. These controls increase the economic cost and the risk of not complying with the minimum resistance required by current regulations. A good and economically viable alternative is the purchase of recycled aggregates to produce concrete on site [23].

Finally, the three main groups of strategies mentioned above focused on the manufacture of construction materials, especially in the manufacture of concrete for prefabricated materials, undoubtedly, they are a good alternative solution to contribute to the reduction of emissions from CO_2 in the building sector. However, for the present study that seeks to reduce the impact on climate change at the construction phase, many of these strategies would hardly achieve a significant decrease in said impact, due to factors related to the local availability of cement substitutes, which would mean not avoiding CO_2 emissions resulting from the transport of construction materials. This entails determining strategies that allow the decrease of transport inside and outside the construction site, including the decrease in the use of construction materials. To reduce the transport and use of materials, the reuse of waste on site is essential.

2- Materials and Methods

To accomplish the objective of the present study to reducing CO_2 emissions and consequently the impact on climate change of the single-family housing construction sector in the state of Nayarit, by implementing construction and / or demolition waste management strategies (CDW) in the housing construction phase, the steps shown in Figure 1 below were considered:

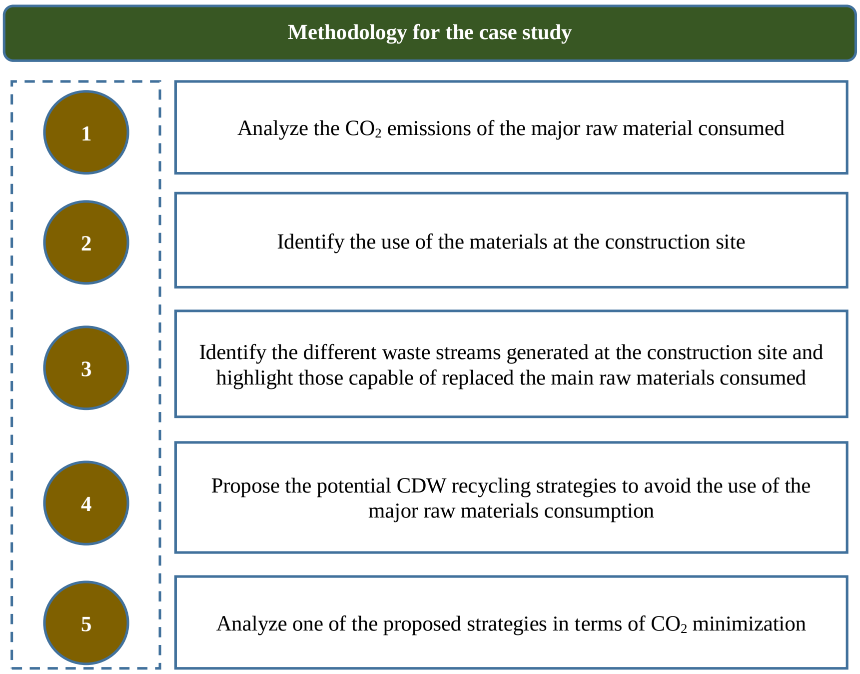

Figure 1. Research Methodology.

1. Data were taken from the analysis of CO_2 emissions of the major raw materials, which arose from the methodological proposal used in the case study "Design of organizational strategies against climate change from a sustainability approach, case: the housing building sector in Nayarit" [24]. The methodological proposal called Design of Strategies for Climate Change (DEO-CC by its acronym in Spanish) used in the case study mentioned above is based on the NOP Methodology [25].
2. The materials with the greatest environmental impact were identified and their use was determined at the construction site, considering the data that emerged from the methodological proposal established in the case study mentioned in step 1 [24].
3. The different waste streams generated at the construction site were identified, considering only those that are most generated and considering the amount of waste generated by each square meter of construction [23].
4. Two possible CDW strategies were established for application at the construction site, in order to avoid greater consumption of raw materials.
5. Finally, the possible CDW strategy that will be implemented at the construction site is analyzed, based on the analysis of two cases in terms of minimizing CO_2 by using recycled aggregates.

3- Results and Discussions

3-1- CO_2 Emissions from Materials

In the case of a study of a 54 m^2 single-family housing of social interest, the results of Table 1 show that natural aggregates are the construction materials that most contribute to the generation of CO_2 emissions resulting from their transfer to the construction site, with a total of 5,651,901. 13 $kgCO_2$, which represent the 80% of the total emissions generated [24] (Figure 2).

Table 1. CO_2 emissions from transfers of construction materials.

Materials	Quantities (kg)	Fuel consumption lt per km	Material transfer kg-lt	Emission factor $kgCO_2$/lt	Emissions $kgCO_2$
Steels	828.57	567.3	470,047.76	2.596	1,220,243.98
Binders	2,929.67	3.63	10,634.70	2.596	27,607.68
Ready mixed concrete	13,793	3.15	43,477.95	2.596	112,790.88
Ceramic materials	16,715.03	2.05	34,265.82	2.322	79,565.21
Natural aggregates	62,562	34.8	2,177,157.6	2.596	5,651,901.13
Total					**7,092.108.88**

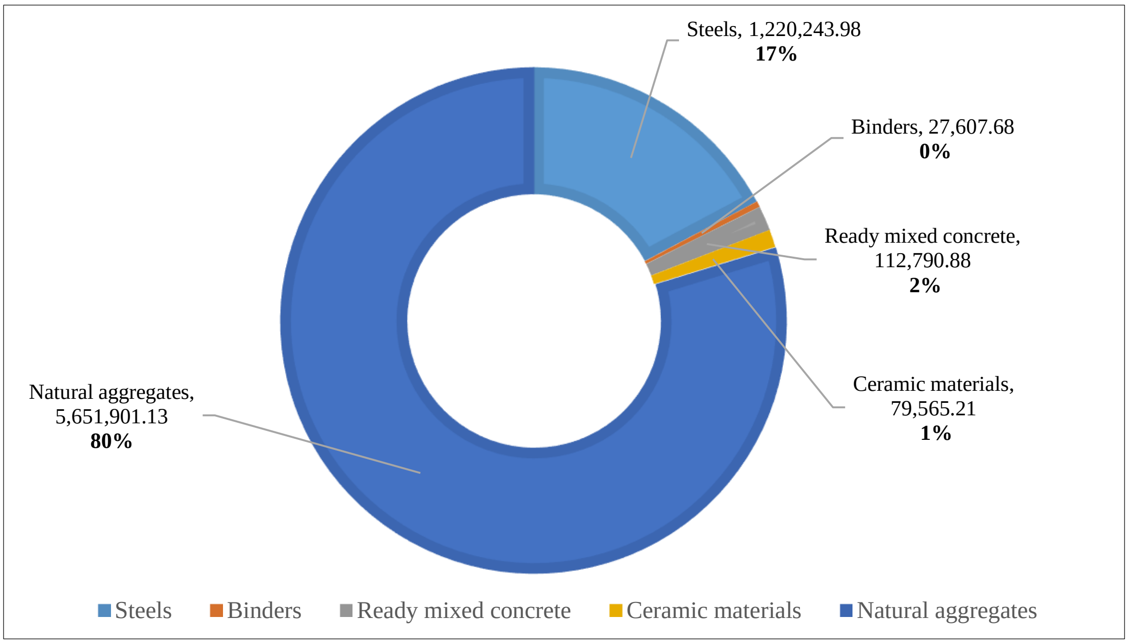

Figure 2. CO_2 emissions from transfers of construction materials ($kgCO_2$).

3-2- Materials with the Greatest Environmental Impact and Their Use at the Construction Site

Based on the determination of the CO_2 emissions analysis of construction materials, aggregates (sand and gravel) are the ones that generate the highest emissions due to the transfer to the construction site. Therefore, strategies related to good practices at the construction site will focus on the reuse of waste on site in order to reduce the transport of arid natural aggregates from their manufacture to the construction site.

In this sense, considering the aggregates as the materials with the greatest impact, next, Table 2 shows the list of the different uses and quantities of these materials in the construction process of the type housing considered in the case of study [24].

Table 2. CO_2 emissions from transfers of construction materials.

Natural aggregates	Quantities (m^3)	Material use
Sand for flattening walls	11.63	Manufacture of mortars for flattened exterior walls, masonry, flattened walls and interior ceilings.
Sand for concrete	3.71	Manufacture of concrete made on site for structural usage (columns, foundations, etc.). Manufacture of concrete for exterior and interior floors.
Sand for bonding brick and masonry	11.25	Manufacture of mortars for bonding bricks.
¾" crushed gravel	9.59	Manufacture of concrete made on site for structural usage (columns, foundations, etc.).
1 ½" screened gravel	0.47	Manufacture of concrete made on site for exterior and interior floors.
¼" crushed gravel	1.28	Manufacture of concrete made on site for structural usage (columns, foundations, etc.).
Total	**37.93 m^3 = 62, 562 kg**	

3-3- Construction and Demolition Waste (CDW) at the Construction Site

In the building sector, the average composition of the CDW shows that 52% of the waste is concrete and 27% is brick, it also has that for one square meter of construction, 123.29 kg or 0.19 m^3 of CDW are generated [23]. Then, the amount of CDW generated in this case study and considering a total of 54 m^2 of construction is equal to 10.26 m^3, of which 5.33 m^3 are concrete waste and 2.77 m^3 are brick waste (Figure 3).

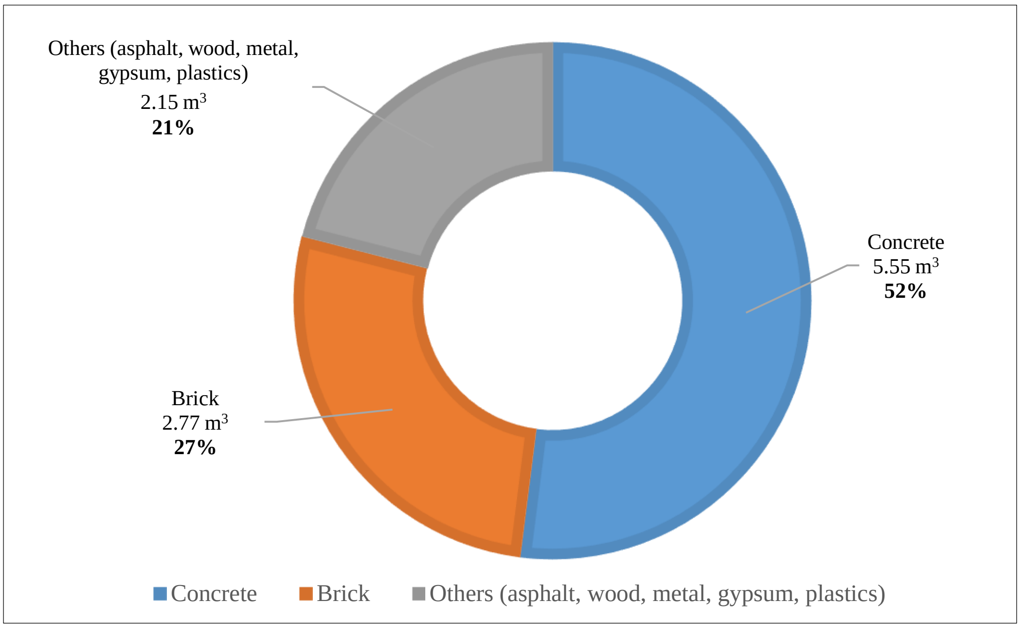

Figure 3. CDW generated at the construction site.

3-4- CDW Strategy Proposal at the Construction Site

As already mentioned in the previous section, the categories with the highest percentage of waste are concrete and masonry (bricks) [23], so both categories were only considered to establish waste reuse as a strategy, and thus be able to replace some of the natural aggregates that are necessary for the construction of the housing type. Next, in Table 3 the two categories of waste selected for the present case study are shown, as well as a possible application for reuse at the construction site (Figure 4).

Table 3. **CDW reuse practices at the construction site.**

Waste category used	Reuse practices for possible implementation
Concrete	Finishes for flat roofs with gravel.
Masonry (brick)	Manufacture of lightweight concrete made on site for roof slab filling to give slope.

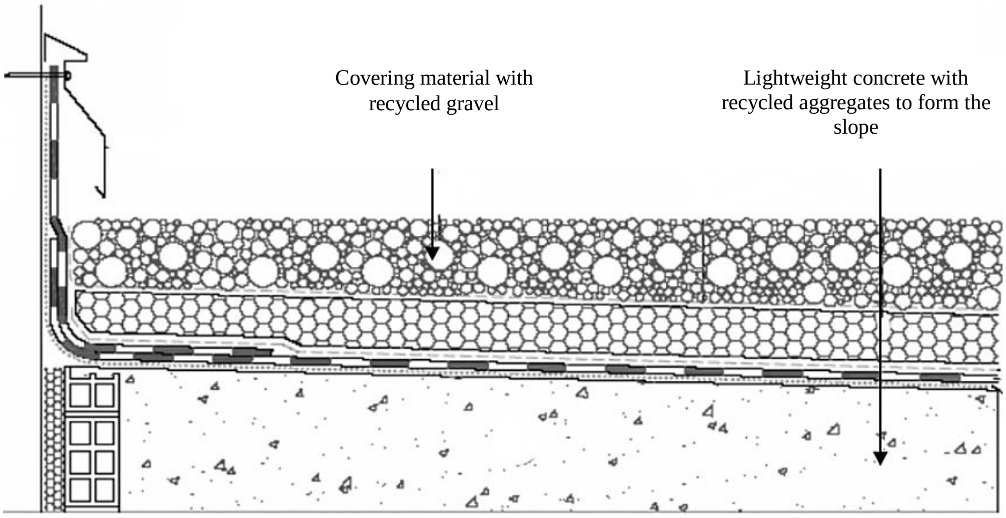

Figure 4. **CDW generated at the construction site.**

3-5- Analysis of the CDW Strategy Proposal

For the present case study and based on the practices for waste reuse mentioned above in Table 3 and Figure 4, two proposals are presented to reduce the use of natural aggregates by replacing recycled aggregates, in accordance with the Standard of Instruction of Structural Concrete EHE-08 of Spain: for structural concrete, it is allowed to replace up to 20% of coarse aggregate with recycled aggregates for the case of structural concrete, for the case of non-structural concrete it is possible to replace up to 100% of coarse aggregate by recycled aggregates (Table 4).

Table 4. **Proposed amounts for aggregate recycling at the construction site.**

Use of aggregates: manufacture of concrete and mortar on site	Case study (quantities in m^3)	Application case 1: Recycled aggregates (quantities in m^3)	Application case 2: Recycled aggregates plus the substitution of 20% natural aggregate to manufacture structural concrete (quantities in m^3)
Sand for flattening walls	11.63	11.63	11.63
Sand for concrete	3.71		0.74
Sand for bonding brick and masonry	11.25	11.25	11.25
¾” crushed gravel	9.59		1.92
1 ½” screened gravel	0.47		0.09
¼” crushed gravel	1.28		0.25
Total, recycled		**22.88**	**25.88**
Total, natural aggregate	**37.93 (62,562 kg)**	**15.05 (24,833 kg)**	**12.05 (19, 889kg)**

For both cases of application, it is proposed to replace natural aggregate with recycled aggregate. For case of application 1, it is proposed to replace a total of 22.88 m^3 and for case of application 2, a total of 25. 88 m^3.

Table 5 shows the CO_2 emissions generated for case 1. Table 6 shows the CO_2 emissions generated for case 2.

Table 5. Analysis of CO_2 emissions from material transfers (Case 1).

Materials	Quantities (kg)	Fuel consumption lt per km	Material transfer kg-lt	Emission factor $kgCO_2/lt$	Emissions $kgCO_2$
Steels	828.57	567.3	470,047.76	2.596	1,220,243.98
Binders	2,929.67	3.63	10,634.70	2.596	27,607.68
Ready mixed concrete	13,793	3.15	43,477.95	2.596	112,790.88
Ceramic materials	16,715.03	2.05	34,265.82	2.322	79,565.21
Natural aggregates	24,833	34.8	864,188.4	2.596	2,243,433.08
Total					**3,683,640.83**

Table 6. Analysis of CO_2 emissions from material transfers (Case 2).

Materials	Quantities (kg)	Fuel consumption lt per km	Material transfer kg-lt	Emission factor $kgCO_2/lt$	Emissions $kgCO_2$
Steels	828.57	567.3	470,047.76	2.596	1,220,243.98
Binders	2,929.67	3.63	10,634.70	2.596	27,607.68
Ready mixed concrete	13,793	3.15	43,477.95	2.596	112,790.88
Ceramic materials	16,715.03	2.05	34,265.82	2.322	79,565.21
Natural aggregates	19,899	34.8	692,485.20	2.596	1,797,691.58
Total					**3,315,422.12**

Reusing CDW especially those of concrete and masonry to obtain recycled aggregates, implies the use of equipment and machinery to carry out a mechanical crushing process from impact crushers, which also leads to the generation of CO_2 emissions from the energy consumption.

Therefore, considering a crushing of construction and / or demolition waste machine on site, with mechanical means, as well as considering only the energy consumption that it requires for work on site, Table 7 shows CO_2 emissions generated.

Table 7. Analysis of CO_2 emissions of equipment and machinery (waste crusher).

Equipment and machinery	Energy consumption kW/h	Energy consumption TJ	CO_2 Emission factor kg/TJ	Emissions $kgCO_2$
Hammer crusher for construction and demolition waste of a non-stony nature, with the capacity to handle 10 to 25 m^3/h, with feeding belt, manually transportable.	37	0.0001332	56,100	7.4725
Total				**7.4725**

Considering an average capacity of 18 m3 / h for the treatment of waste by the equipment and machinery, 9.49 $kgCO_2$ is generated for case1 (Table 8) and 10.74 $kgCO_2$ for case 2 (Table 9).

Table 8. CO_2 emissions of equipment and machinery for the recycling of CDW (Case 1).

Equipment and machinery	$kgCO_2$ emissions per each 18 m^3	Recycled aggregates (m^3)	Generated emissions $kgCO_2$
Hammer crusher for construction and demolition waste of a non-stony nature, with the capacity to handle 10 to 25 m^3/h, with feeding belt, manually transportable.	7.4725	22.88	9.49

Table 9. CO_2 emissions of equipment and machinery for the recycling of CDW (Case 2).

Equipment and machinery	$kgCO_2$ emissions per each 18 m^3	Recycled aggregates (m^3)	Generated emissions $kgCO_2$
Hammer crusher for construction and demolition waste of a non-stony nature, with the capacity to handle 10 to 25 m^3/h, with feeding belt, manually transportable.	7.4725	25.88	10.74

Finally, Figure 5 shows a comparison of the emissions of the different scenarios for each case study, where the decrease in CO_2 emissions is clearly observed by implementing strategies related to CDW. In case 1, emissions can be reduced by up to 48% and for case 2, up to 54%.

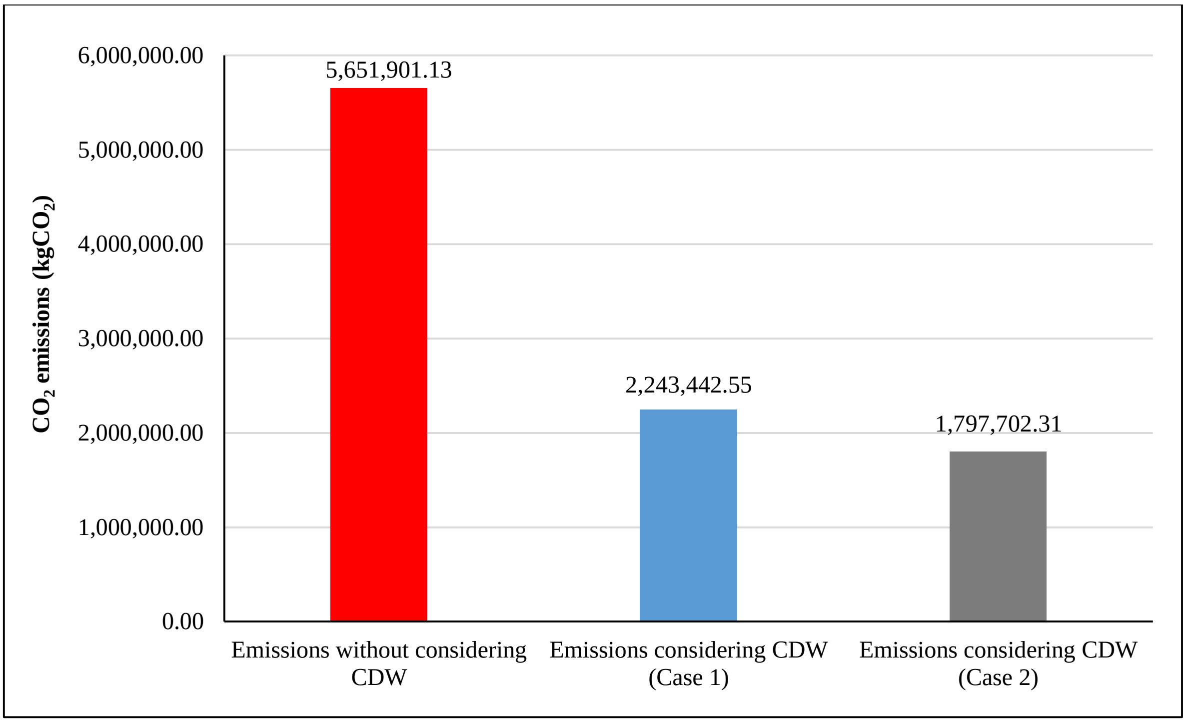

Figure 5. CO_2 emissions for implementing CDW practices at the construction site.

3-6- Discussions

Concrete and brick waste turn out to be good secondary materials to be recycled directly at the construction site, for use in finishes for flat roof with gravel and to make roof fillings to give slope.

The implementation of CDW strategies undoubtedly contributes to reducing the impact on climate change in the building sector. In the case of this study, by replacing natural aggregates with recycled aggregates by 67%, the following results were obtained:

- Considering the total emissions generated by all materials, CO_2 emissions were reduced from 7,092,108.88 $kgCO_2$ to 3,683,640.83 $kgCO_2$, which is equivalent to 48% for the case1. For case 2, they were reduced from 7,092,108.88 $kgCO_2$ to 3,315,422.12 $kgCO_2$, which is equivalent to 53%.
- Considering the total emissions generated only by natural aggregates, these were reduced from 5,651,901.13 kgCO2 to 2,243,433.08 $kgCO_2$, equivalent to a reduction of CO_2 emissions by 60% for case 1. For case 2, the emissions were reduced from 5,651,901.13 $kgCO_2$ to 1,797,691.58 $kgCO_2$, equivalent to 68%.

4- Conclusion

At the end of the present study, it can be concluded that the implementation of good CDW practices during the housing construction phase, it contributes to the housing construction sector being able to substantially reduce the CO_2 emissions resulting from the transportation of materials, especially aggregates, which leads to reducing its impact on climate change.

There are controversies about recycling the waste directly on site to reuse it in the manufacture of concrete and mortars, because it is necessary to perform a series of quality controls for the aggregate and for the concrete or mortar material, which could delay execution times on site and even increase the cost of housing, however, an alternative is the purchase of recycled aggregate from the CDW recycling plants to manufacture the concrete on site, to name an example.

In the case of the present study, buying recycled aggregates would not be the best option, because at present there are no CDW recycling plants in the Nayarit area. Therefore, the results of the present study can also contribute to promoting on the part of businessmen and the government the opening of new companies that are dedicated to the recycling of CDW in Nayarit and thus contribute to the sum of practices related to sustainability in the housing building sector. On the other hand, the present study may give rise to future research on the economic viability of considering CDW recycling plants at the construction site for housing construction in Tepic, Nayarit, where they also perform quality controls for the aggregates obtained from recycling. In this sense, the present study helps to motivate other researchers in the region to carry out studies considering the percentage replacement of other materials such as cement, whether for the manufacture of concrete or mortars made at the construction site.

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6- Conflict of Interest

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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