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Determination of the KG-CO_2 / M^2 of a hydraulic concrete pavement

Determinación de los KG- CO_2/ M^2 de un pavimento de concreto hidráulico

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Abstract

One way to pollute today is through the construction of works, according to Anink, D., Boonstra, C., and Mak, (1996) the construction sector is responsible for 50% of the natural resources used, 40% of the energy consumed (including energy in use) and 50% of the total waste generated. Several studies related to GHG contamination that occur in the life cycles of construction materials have been carried out in relation to this sector, and research has also been carried out on the pollution in KG-CO_2 / M^2, per year produced by the social interest housing in its life cyclef. The objective of this work is to investigate the CO_2 / M^2 contamination of the construction of the hydraulic concrete pavement of a fractionation in Sonora using the "Emissions Inventory" method with standard CO_2 emission factors of each material, of the and volumes total works. The result obtained with the established criteria was that 84.77 kG-CO_2 / M^2 are produced in the construction, which allows us to contribute in an area of construction that is little explored in pollution through the construction of urban roads.

Efficiency, Energy, Housing, CO_2, Materials

Resumen

Una forma de contaminar hoy es a través de la Construcción de Obras, según Anink, D., Boonstra, C., y Mak, (1996) el sector de la Construcción es responsable del 50% de los recursos naturales empleados, del 40% de la energía consumida (incluyendo la energía en uso) y del 50% del total de los residuos generados. En relación con este sector se han realizado diversos estudios elacionados con la contaminación de GEI que se producen en los iclos de vida de los materiales de construcción y también se han hecho investigación de la contaminación en KG-CO_2/ M^2, por año que producen las viviendas de interés social en su ciclo de vida. El presente trabajo tiene como objetivo investigar la contaminación de CO_2/M^2 de construcción del pavimento de concreto hidráulico de un fraccionamiento en Sonora utilizando el método de "Inventario de emisiones" con factores de emisión estandar de CO_2 de cada material, de la y los volúmenes totales de obra. El resultado obtenido con los criterios establecidos fue que en la construcción se producen 84.77 kG-CO^2/M^2, lo que nos permite contribuir en un arae de la construcción poco explorada en la contaminación a través de la construcción de vialidades urbanas.

Eficiencia, Energía, Vivienda, CO_2, Materiales

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Introduction

The beings develop their life in a physical space surrounded by other organisms and the physical and socioeconomic environment. Biotic and abiotic factors interact with each other generating a place of their own and said space is called the environment (Marino, 2009). Until not very recently, the capacity of the human being to alter the environment was limited and punctual, however in the last hundred years its capacity to alter the environment has increased significantly, reaching to endanger the entire planet (CIDEAD, 2009).

The environment has endured to a certain extent the activities of the human being with a degree of suitability, producing desired goods and products, causing emissions or discharges through air, water and land. (Encinas, 2011). Atmospheric emissions, discharges or non-visible waste, generated by industries are undoubtedly the most damaging of waste produced by human activities. Its invisibility, together with the spatial and / or temporal distances to which its worst effects can be manifested, leads to a contempt that is absolutely inadmissible when viewed from the perspective of the requirements of sustainability (Ortiz y Del Cerro, 2007).

These emissions have caused what in recent decades has been mentioned, the so-called climate change where according to (IPCC, 2014) climate change is the variation of the state of the climate, identifiable (through statistical tests) in the variations of the mean value or in the variability of its properties, which persists for long periods of time, usually decades or longer periods.

In 1988, the Intergovernmental Panel on Climate Change, known by the IPCC acronym in English, was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). purpose of monitoring this problem by analyzing the available scientific information (Berzosa, 2013). One of the objectives of the IPCC is to assess whether this climate change is caused by anthropogenic origin or natural, where the natural are the waste or emissions derived from both organic and inorganic materials and anthropogenic are all those activities that generate emissions produced by the man.

These gas emissions are called Greenhouse Gases (GHGs), where according to (Benavides and León, 2007) are the gaseous components in the atmosphere, both natural and anthropogenic, that absorb and emit radiation at certain wavelengths of the spectrum infrared radiation emitted by the surface of the earth, atmosphere and clouds.

The evolution of the opinion of the scientific community has gone from not being able to attribute to man any effect on the climate (IPCC, 1990) until signing that, with a greater than 90% probability, global warming is caused largely by anthropogenic emissions of greenhouse gases (GEI) (IPCC, 2014).

CO_2 is the Greenhouse Gas that has the greatest impact on the environment and one of the main causes of climate change.

Probably the intensification of the greenhouse effect, because of CO2 emissions is the greatest impact of human activities on a planetary level. It is expected that by 2100, perhaps by 2020, atmospheric CO2 will have doubled compared to the one before the industrial era.

At the current growth rate, the duplication will occur in 2,056, when 560 ppm is reached, which leads to predictions of an increase in the average temperature of the planet between 2.3 and 5.2 ° C depending on the model of general circulation used (Ortiz y Del Cerro, 2007).

The environmental impact produced by the Construction industry in the light of the Industrial Revolution is the outstanding debt that industrialized societies have to face in view of this new millennium; The truth is that the industrial revolution is a great change in the techniques used in the production of building materials, given that until then, the materials were natural, typical of the biosphere, from the immediate environment, simple manufacturing and adapted to the climatic conditions of the territory where the building was carried out (Arenas, 2008).

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The expansion of the cities and the materials with which they are built is causing a great contamination and for this the construction industry enters as one of the industries highly generating emissions and waste by the materials used that come from the earth's crust, producing 450 million tons of construction and demolition waste annually, currently the possibility of reusing and recycling this waste is very limited since only 28% is used, increasing the need to create landfills and intensify the extraction of raw materials. Construction is responsible for 50% of the natural resources used, 40% of the energy consumed and 50% of the waste generated (Symonds, Argus, Cowi and Bouwcentrum, 1999).

Research has been conducted where according to (Berzosa, 2013) in the research "Analysis of greenhouse effect emissions throughout the life cycle of the roads" where the problem of greenhouse gas emissions in the sector of greenhouse gases was analyzed the construction of Spain and, as a result, the contaminating elements or actors are the construction machinery, which is the main element (61.5 - 84.9%) followed by those emissions related to the consumption of materials (9, 5 - 32.9%).

The emissions related to the management of the natural systems constitute an appreciable percentage (3.5 - 7.1%). The transport is of little relevance in relation to the rest of the elements (0.4 - 2.2% of the total of the construction phase).

There was also an investigation where according to (Casanovas, 2009) "Sustainable construction. A strategic view "says that to be able to extrapolate the environmental impact information, from architectural projects to construction in general, it is necessary to have a series of projects that are sufficiently representative of the construction in a certain territorial area, and that be generic and be for building typologies, it suggests that the expression per square meter constructed is used, as it simplifies and makes the obtained results more easily visible and interpretable.

In the investigation "Model of quantification of CO_2 emissions produced in buildings derived from the material resources consumed in their execution" according to (Mercader, 2012) the CO_2 emissions produced in the execution of the usual building model defined as the residential block were evaluated destined to housing of official protection, derived from the manufacturing process of the material resources used in its execution.

In view of the impacts derived from climate change, the need to take measures with the aim of mitigating the possible negative effects derived (Ihobe, 2013).

The basis on which the efforts to reduce emissions must be defined, is to know the contribution of each agent in relation to greenhouse gas emissions (GHG) in order to establish the starting situation and set the objectives of reduction and evaluate the degree of success of the strategies implemented. All this involves quantifying GHG emissions and assigning emission values to the activities evaluated (Ihobe, 2013).

Currently, there are several methods to determine greenhouse gas emissions that are generated directly or indirectly from certain activities, one of the most important and widely used is that of the construction industry, with an emissions inventory, this method helps to know the amounts of CO_2 generated by the construction of a project, taking into account the emissions of the materials used, the burning of fossil fuels of the machinery used, among other factors that intervene in the work activities.

These emissions are determined with the help of standard emission factors of each material and machinery used in the work, these factors can be found in graphs or tables on the internet or and come from various sources, or from different databases made by institutions, public bodies and private ones responsible for creating the same factors.

There are other methods, one of them is the carbon footprint where it is evaluated with an approach that includes a greater scope in relation to the emission sources associated with the organization (since it analyzes the emissions from the perspective of the life cycle analysis of the evaluated concept) (Ihobe, 2013).

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The main characteristic with the emission inventory method is that you can determine the emissions generated by each activity carried out, concept of work, stages of the construction process, among others, in this way you get more specific information**.** In the present investigation refers to the CO_2 generated by a stage in the construction of roads (streets) in a subdivision of Ciudad Obregon Sonora, Mexico, this to determine the quantification in Kg-CO_2 / M2 generated by the construction process. To analyze this problem it was necessary to mention that civil engineering has been developing new and more efficient methods for urbanization, due to the economic growth of the countries, the high demand for increasingly challenging construction for civil engineering but taking care benefit the environment; However, in recent decades the construction industry has increased the impact it has on the environment, this by the emission of greenhouse gases that are generated in the process of construction materials, in the construction process of the work.

These gases have contributed to climate change and all that it entails (droughts, torrential storms, variations in temperature). CO_2 in 2010 represented 76% of the total of Greenhouse Gases anthropogenic, this being the one that has the greatest impact on the environment (IPCC, 2014), which is why it is necessary to obtain quantitative information on the CO_2 generated by the construction to know the impact that the buildings are having on the environment, and thus work so that the activities on site, the materials process go hand in hand towards the same objective, and also, generate information that can help future investigations. The hypothesis is that the emission of Kg-CO_2 / M^2 for the construction of roadsides (streets) is 100 $KgCO_2$ / M^2, with a variation of + / _ 10%.

Methodology

The present investigation is considered quantitative, since the collection and analysis of data is used to answer research questions and test previously established hypotheses, it is exploratory since there are no previous works in this area of construction, it is non-experimental and cross; the first because no situation is built but existing situations are observed, not intentionally provoked by the researcher (Hernández, 2003) and transversal, because the variables are described and their incidence and interrelation analyzed.

To carry out this project was attended by a student and professors researchers of Civil Engineering of the Technological Institute of Sonora, making the relevant calculations to obtain results, materials and equipment used, the Opus Software for obtaining of the quantities of work with which they worked on this project and the excel electronic sheet, for the calculation of the CO_2 generated by the construction, interpretation of results.

The sources of information were previous works related to the project, such as theses, articles, scientific journals, electronic bibliography in general and the HueCO_2 database to obtain emission factors. It was also necessary to make a preliminary compilation of information, which determined the emission factors to be used for the calculation of the inventory. Dell OPUS program, the concepts and quantities of work, units, materials, machinery and equipment used in the work were obtained, an east calculation was determined with the HueCO_2 database, the results of CO_2 generated by each of the concepts were obtained of work and were parameterized in Kg-CO_2/M^2.
Procedure:

1. Initial investigation: Previous collection of information, this refers to the subject of study. In this case, it was decided to look for previous research already carried out, related to the CO2 generated by the constructions.

2. Determination of factors: The emission factors to be used for calculating the emissions inventory in the established project were determined.

3. Design of the spreadsheet and transcription of data from OPUS to Excel: A budget was acquired in the OPUS program, for the design of a format with the Excel tool, of the budget to be calculated where some variables can be shown, such as the concept of work, units, materials used for the concept of work, equipment used for work concepts and as well as the quantities of work.

4. Placement of the emission factors: Once the factors are placed, the results of CO2 generated by each construction concept are obtained.

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5. Results of Kg / CO_2: The construction Kg-CO_2 / M^2 were obtained, from the emission factors file of the HueCO_2 database, this summing the total emissions of each stage in the construction and proceeded to make graphs and interpret information obtained.

Results

The data obtained in the study are presented in tables

1	Fittings	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
1.01	Stroke and leveling of fittings	.1541	2888.5	445.22
1.02	Manufacture of L-type lining	30.5149	2524.5	77034.98
1.03	Manufacture of type I lining	44.1531	364	16071.73
1.04	Backing of concrete lining	1.1201	2888.5	3235.3
1.05	Backing of concrete lining	36.4384	85	3097.26

Table 1 Emissions generated in the garrison stage
Source: Own Elaboration

Table 1 shows the emissions generated in the garrisons stage for each construction concept where the total is 99,884.60 Kg-CO_2.

2	Earthworks	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
2.01	Clean stroke and leveling	.1541	20177	3110.0545
2.02	Excavation in box in 2 layers of 20 cms	.7478	400	299.1392
2.03	Subgrade treatment to 90% of proctor test	.5237	23915	12523.2674
2.04	Stuffing compacted in layers of 15 cm	1.4776	5978.75	8834.0294
2.05	Construction of hydraulic base	1.6545	3587.25	5935.1332
2.06	Irrigation impregnation with asphalt fm-1	5.7741	20177	116504.9741
2.07	Decapitation, lifting and leveling of well of visit	305.9380	12	3671.2564
2.08	Demolition and rehabilitation of valve box type 2	814.3355	1	814.3355
2.09	Demolition and rehabilitation of valve box type 12	1234.9749	2	2469.9498

Table 2 Emissions generated in the earthworks stage
Source: Own Elaboration

En la tabla 2 se pueden observar las emisiones generadas en la etapa de terracería por cada concepto de obra donde el total es 154,162.13Kg-CO_2.

3	Pavement structure	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
3.01	Surface sweeping by mechanical means	.3526	20177	7114.7935
3.02	Construction of hydraulic concrete pavement	53.0891	20177	1071179.758
3.03	Slab-garrison board	.0011	2888.5	3.0797
3.04	Junta de loa-poso	.0011	730	.7783
3.05	Supply and placement of curb	42.1312	12	505.5749

Table 3 Emisiones generadas en la etapa de estructura
Source: Own Elaboration

Table 3 shows the emissions generated in the pavement structure stage for each work concept where the total is 1,078,803.98 Kg-CO_2.

4	Cleaning and signaling	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
4.01	Cleaning the work area with machinery	.2960	20177	5973.19908
4.02	Supply and installation of sv-poste	9.8	89.8275	880.3095
4.03	Supply and placement of die	12.4080	6	74.4479
4.04	Demolition of bench for die making	3.8730	2	7.7460

Table 4 Emissions generated in the pavement structure stage
Source: Own Elaboration

Table 4 shows the emissions generated in the pavement structure stage where the total was 6,935.70 Kg-CO_2.

5	Filling in lots	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
5.01	Filling in compacted batches	.3776	7059	2664.6672
5.02	Stuffing in compacted streets	.3776	2960	1117.7751

Table 5 Emisiones generadas en la etapa de relleno en lotes
Source: Own Elaboration

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Table 5 shows the emissions generated in the filling stage in lots for each work concept where the total is 3,783.44 Kg-CO_2.

Database HueCO2		
Emission by area	84.7762	Kg-CO_2/M^2
Total in Kg-CO_2 of the work.	1343569.8741	Kg-CO_2

Table 6 Total emissions generated in Kg-CO_2 y Kg-CO_2/M^2
Source: Own Elaboration

Database In table 6 you can see the total amounts in Kg-CO2 Kg-CO_2/M^2.

Discussion of results

Discussion of results 84.77 Kg-CO_2/M^2.
Significant variations can be observed with respect to each stage of the construction process, table 2 resulted in the largest quantities of CO_2 generated with 15.4162.13 Kg-CO_2 due to the use of earthmoving machinery, according to mini ecosystems (2008), since the burning of fossil fuels is one of the main pollutants and generators of CO_2.

The hypothesis put forward was 100 Kg-CO_2 / M^2. with a tolerance of plus or minus 10%, which gives a range of values of 90-110 Kg-CO_2 / M^2., So the results are very close to the obtained

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Conclusions

The objective of this investigation was to determine the quantification of emissions in Kg CO_2 / M^2 generated by a stage in the construction of a hydraulic concrete pavement in a subdivision of Ciudad Obregón Sonora, Mexico, making use of standard emission factors obtained from different sources , the data base $HueCO_2$ and the amounts of work of the project to be studied, all based on the necessary data collection and the use of the quantities of work and the emission factors that with the help of an Excel format designed to obtain automatically the CO_2 results generated by each work concept.

The emissions proposed in the hypothesis were 100 Kg-CO_2 / M^2, and using an area of 15.848.44 m2 of pavement, the results obtained were 84.78 Kg-CO_2 / M^2, a value very close to the range established in the hypothesis of 90-110 Kg-CO_2/M^2

These results could be improved by using some software with included databases for the calculation since it would help to have a better management of emissions.

It is recommended to continue carrying out studies that allow the parameterization of these values in order to estimate the pollution values generated by the construction of urban infrastructure without having to repeat the way in which this research was developed.

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