Article

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Asphalt mixes with recycled construction and demolition materials for pavement repair

Mezclas asfálticas con materiales reciclados de construcción y demolición para la reparación de pavimentos

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Abstract

The objective of this research was to demonstrate that it is possible to develop an asphalt mix material for construction and demolition, which could be used in pavement repair or patching. The study was mainly to collect the recyclable waste in stone aggregates chosen by crushing using to prepare an asphalt mixture, which was subjected to several laboratory and field tests to determine its mechanical behavior. The results were within the accepted norm ranges. Lastly, an analysis of the costs per cubic meter of recycled shows revealing a 14% savings compared to a traditional direct cost mix.

Asphalt, Durability, Mix, Recycling, Waste

Resumen

El objetivo de esta investigación fue demostrar que es posible desarrollar un material de mezcla asfáltica para la construcción y la demolición, que podría utilizarse en la reparación o el parcheo de pavimentos. El estudio consistió principalmente en recoger los residuos reciclables en agregados pétreos elegidos por trituración utilizando para preparar una mezcla asfáltica, que fue sometida a varias pruebas de laboratorio y de campo para determinar su comportamiento mecánico. Los resultados estuvieron dentro de los rangos normativos aceptados. Por último, un análisis de los costes por metro cúbico de reciclado revela un ahorro del 14% en comparación con una mezcla tradicional de coste directo.

Asfalto, Durabilidad, Mezcla, Reciclaje, Residuos

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Introduction

The repair of roads in our environment is carried out based on flexible pavements with asphalt emulsions and aggregates derived from natural rock extracted from nearby quarries, the pavements are subjected to environmental agents such as temperature, humidity and precipitation that reduce their durability which extends the frequency of repairs that must be carried out to maintain operating standards.

The use of recycled materials can contribute significantly to the reduction of the environmental impact in this type of works, it avoids the depletion of raw materials since it reduces the extraction activity of primary materials by substituting a percentage of the borrowed material that usually comes from quarries, and reduces the volume of waste occupied in landfills, consequently, the advance in this technique contributes significantly to reducing the environmental impact.

In the present investigation, recycled construction materials were used to design a mixture, trying to achieve an exact determination of the properties of the asphalt cement in order to characterize the material and thus be able to predict the response and the possible failures that may occur.

It was shown that recycled aggregates have their own physical properties and characteristics that improve performance, ensure results and prolong the useful life of mineral materials in public works.

For the use of this material in the repair of pavements for highways and urban roads to be possible, it is necessary to use chemical additives that, when added to the asphalt, increase its resistance and delay its aging.

Background

Research on the use of recycled aggregates in construction has focused more on lines of bituminous mixtures and concrete made from recycled material.

In Germany, 60 million tons of recycled aggregates are currently produced, of which more than 40 million are used for the maintenance and construction of bases and sub-bases for highways and urban roads.

Starting in 1993, the RG Min-STB 93 Directive facilitated the growth of the recycling sector in Germany and made it possible to demonstrate that recycled aggregates are very competitive in the markets for granular materials intended for the construction of foundations and sub-bases. roads.

A pioneering example in Spain in terms of on-site recycling is the plant set up by Dragados in Barajas, which began operating in February 2000. The plant has made it possible to take advantage of stone materials from the demolition of concrete and asphalt slabs at the airport. This experience is not applicable to works in which the recycled material must come from a construction and demolition waste treatment plant, in which the waste can have different origins, and strict controls must be applied to the quality of the resulting recycled material.

Other experiences in the use of recycled aggregates can be found in the construction of the Green Cycling Ring of the Community of Madrid and in the Green Corridor of Parque de las Cañadas (Cádiz).

Additionally, it has been found that the rheological characteristics of the asphalt binder in the mixture also have a significant influence on the visco-plastic behavior of these materials. In the mechanistic design of pavements, the vertical forces that the subgrade layer supports are controlled, in order to avoid the formation of traces on the surface. However, no design methodology controls the permanent deformations produced by the visco-plastic behavior of asphalt mixtures.

Problem statement

Construction waste is a pollutant that infertilizes the soil, constituting a problem for the environment, in addition to the lack of new alternatives for its recycling, such as its use in the repair of asphalt pavements.

Justification

One of the main problems in the world is environmental pollution. The need to recycle construction waste does not only concern the largest countries or the most industrialized communities, but also a global demand.

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Many countries, ranging from the most developed to developing countries like ours, could experience the saving of natural resources and preservation of the environment using these recycling techniques. Therefore, it is necessary to inculcate this recycling culture in addition to that of preserving the environment, a culture that could have economic advantages that would favor the development of our peoples, since there are no initiatives that allow short-term solutions, such as the case of asphalt mixtures with construction and demolition materials.

Construction waste is a pollutant that infertilizes the soil, constituting a problem for the environment, in addition to the lack of new alternatives for its recycling. Hence the importance of incorporating recycling techniques that allow us to reduce environmental pollution due to construction waste and that will reduce the amount of bench materials used, in addition to lowering costs and obtaining the resistance required by standard in the construction of pavements.

Objectives

General Objective

Obtain an asphalt mixture with recycled construction and demolition waste for its application in the repair or patching of pavements, thus contributing to the non-contamination of soils and the preservation of the environment.

Recheck bibliographic information

Determine the characteristics of recycled materials and their suitability for use in asphalt mixtures.

Determine and evaluate resistance through tests

Check the evolution of the behaviour of each mixture made, comparing it with that of traditional asphalt Contribute to the reduction of contamination by construction waste.

Prepare the asphalt mixture with construction and demolition waste for its subsequent comparison and evaluation of behaviour with traditional asphalt.

Disseminate the results, through scientific fairs, triptychs, diptychs, etc.

Hypothesis

With the addition of recycled construction and demolition materials in asphalt mixtures, it is a matter of obtaining a material with better resistance, low cost and characteristics similar to conventional ones, to be used in the repair or patching of pavements. In this way we contribute to recycling and non-contamination by this type of waste.

Materials and method

Materials

The materials used are:

- Asphalt Emulsion.
- Crushed concrete.
- The Crushed rill.
- Sieve.
- Foundry vessels.
- mixing paddle.
- Burner.
- Fuel (LPG).

Other materials

- Kerosene (for curing).
- Chemical additives.

Methodology

The study will proceed as follows.

It will be developed in 5 stages:

In the first stage, the collection of the materials was carried out, where mainly concrete rubble, blocks, and bricks were obtained, once the samples were collected, they were crushed, this process was carried out for each material to obtain the aggregates separately. Next, they were mixed proportionally, homogenizing the samples and drying them. Finally, a representative sample was taken by quartering and the characterization of the petrous material was carried out.

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In the second stage, various tests were carried out to obtain the physical characteristics of the aggregates.

The tests carried out were:

Loose dry volumetric weight to obtain the weight of solid particles per unit volume, expressed in kg per cubic meter.

Particle size analysis to classify the material particles by size, passing it through a succession of meshes, obtaining the weight of the particles retained as a percentage of the total sample.

Relative density, obtained as the ratio of the density to the absolute, including its voids

Absorption percentage, to determine the amount of water absorbed by the stone material previously saturated with water at a temperature between 15º and 25ºC for 24 hours.

Equivalent of sand, whose purpose was to determine in the fraction that passes the mesh number 4.75 under established test conditions, the volumetric proportion of particles of size greater than that of clay, with respect to the volume of fine particles of size like that of clay.

In the third stage, the mixture was made with the different types of rubble.

Subsequently, the asphalt mixture was subjected to an unconfined compression test to assess the maximum fatigue that a specimen made with standardized test dimensions and conditions would withstand.

In the fourth stage, the specimens were classified according to the granulometry used. As a fifth and last stage, a comparative analysis of costs was carried out at unit price of both mixtures, the traditional one and those obtained from materials recirculates considering the concepts of removal, loading, and unloading, supplies, hauling, accommodation, compaction of materials, etc.

The direct cost was integrated into items, namely: a) materials, b) labor, c) equipment and minor tools, and d) basics of the asphalt mixture.

Results and Discussion

Strength and stability tests (casting)

2 ½ in. cylindrical test pieces. tall and 4 in. in diameter to determine the optimum content of asphalt cement. Two types of asphalt cement were used, one conventional and the one modified with 5% polyethylene.

And using the optimal content of asphalt cement, which for both cases was 8%, and two test conditions were carried out, dry and under humid conditions. Additionally, a second experiment was carried out within the GA open granulometry to know the behaviour of a mixture rich in asphalt, which would provide the pavement with much greater durability.

In all cases, the specimens were tested in dry and under humid conditions, to simulate the possible damage that water can cause in the mixtures, these conditions were given by means of an immersion treatment in water for 4 hours at a temperature of 600C, after this period the specimens were allowed to return to room temperature and then tested in the same way as the dry specimens.

These tests were carried out to determine if the aggregates with which the design was made meet the specifications required for the conformation of the asphalt mixture under study. A total of 16 specimens were analysed, 10 in the resistance test of the mixture (2 for each sample) and 6 in the loss of stability by immersion (2 for each one).

The table shows how the studies were classified.

Pruebas	Muestras de material seleccionado	
	Reciclada	Tradicional
Peso volumétrico seco suelto kg/m3	1183	1235
Análisis granulométrico, % que pasa		
Malla No. 4	42	45
Malla No. 40	12	16
Malla No. 200	8	10
Densidad, gr/cm3	2.14	2.09
Absorcion, %	13.5	11.9
Equivalente de arena, %	35	43

Table 1 Studies made to the add oil

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In the table above, the volumetric weight and granulometry data of the recycled samples were slightly lower than the traditional ones, but higher in all the other tests, without this meaning that it was not within the ranges accepted by the official regulations. It is noted that the increase in average absorption can be attributed to the high void ratio implicit in the material obtained from the recycled concrete blocks. Likewise, the 40% limit of the specifications is evident by virtue of the heterogeneity of the components used. In the same way, the tests carried out on the asphalt mixture that can be seen in table 2, yielded acceptable results in the tests carried out. However, sample A was discarded because it did not homogeneously cover the petrous material under study, consequently choosing sample b for the development of the mixtures to be studied.

Pruebas	Muestra A	Muestra B
A 50ºC	16	15
Contenido de residuo mezcla asfáltica %	57.4	61.6
Asentamiento a 5 dias, %	1.2	2.6
Retenimiento en la malla No. 0.850, %	0.14	0.04
Penetracion a 25ºC	93	55

Table 2 Results from evidence to the asphalt emulsions

Likewise, table 3 shows the results of the tests carried out on the mixture of petrous material

Pruebas	Muestra de material seleccionado	
	Reciclada	Tradicional
Peso volumétrico seco suelto, kg/m3	1195	1247
Humedad optima de la muestra, %	12	10
Cubrimiento, %	95	97
Manejabilidad	Buena	Buena
Adhesividad	Buena	Buena
Compresion sin confinar, kg/cm2	7.2	7.3
Perdida de estabilidad	40.2	30.7

Table 3 Results of tests on mixtures of petrous material

Finally, the cost analysis is detailed in the table.

Partida	Mezcla normal	Mezcla reciclada
Materiales	95	76.77
Basicos	320	280.35
Total costo directo	415	357.12

Table 4 Comparison of costs per cubic meter of asphalt mixtures

With these values, it is possible to estimate that the use of the recycled mixture allows a saving of 14% at direct cost compared to the cost of materials and in the basic costs of the asphalt mixture.

Conclusions

It is shown that the physical characteristics of recycled stone aggregates are very similar to traditional aggregates.

The product obtained from the recycling of construction and demolition waste meets the requirements for an asphalt.

There are no significant differences in the mechanical behavior of the recycled stone material with respect to the traditional one.

The behaviour of the potholes made with both samples was very similar and they did not show deformations or considerable detachment.

Overall, the recycled mix costs 14% less than the traditional mix at direct cost.

It is recommended to subsequently validate the research by adding the additives to the asphalt (wet method). Asphalt mixtures modified with recycled materials show a decrease in stability by 10 to 13% with respect to the conventional mixture in the optimal percentage of asphalt and additive.

This type of blend shows a tendency to improve unit weight properties. The best behaviour of asphalt mixtures is obtained when the asphalt is improved with chemical additives.

In the optimal percentage of this mix, the unit weight is similar, the percentage of voids is higher, and the stability is 0.76 times lower than that of the conventional mix.

Modified asphalt mixtures with recycled materials and chemical additives have the same behaviour as conventional ones, especially in stiffness, resistance to deformation and unit weight.

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