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As first article we present, *Environmental improvement to reduce urban vulnerability in irregular settlements*, by ACOSTA-MUÑOZ, Mauricio Diego, FLORES-LUCERO, María de Lourdes and GUEVARA-ROMERO, María Lourdes, seconded to the Benemérita Universidad Autónoma de Puebla, as next article we present, *Responsible changes in the brick industry: clay bricks and PET blocks*, by DIAZ-VEGA, María Eugenia, ZAMORA-CASTRO, Sergio Aurelio and GRAJEDA-ROSADO, Ruth María, seconded to the Universidad Veracruz, as next article we present, *Study of the physical-mechanical characteristics of concrete in a concrete-PET mixture*, by ESPINOSA-SOSA, Enrique Esteban, CRUZ-SUSTAITA, Vianey and LERMA-LEDEZMA, David, with secondment at the Universidad Politécnica de Altamira, finally, we present, *Implementation of hydraulic and sanitary engineering under the concept building information modeling, in a nine-floor intelligent building, Zapopan*, *Jalisco*, by CARO-BECERRA, Juan Luis, ROBLES-CASOLCO, Said, LUEVANOS-JACOBO, Jonathan Eduardo and VIZCAÍNO-RODRÍGUEZ, Luz Adriana, seconded to the Universidad Politécnica de la Zona Metropolitana de Guadalajara and Universidad Politécnica Metropolitana de Puebla.

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Environmental improvement to reduce urban vulnerability in irregular settlements

Mejoramiento ambiental para disminuir la vulnerabilidad urbana en asentamientos irregulares

ACOSTA-MUÑOZ, Mauricio Diego†, FLORES-LUCERO, María de Lourdes* and GUEVARA-ROMERO, María Lourdes

Benemérita Universidad Autónoma de Puebla, Puebla, México.

ID 1[sr] Author: *Mauricio Diego, Acosta-Muñoz* / **ORC ID:** 0000-0002-7352-971X, **Researcher ID Thomson:** HOF-3945-2023, **CVU CONAHCYT ID**: 1056835

ID 1[st] Co-author: *Maria de Lourdes, Flores-Lucero* / **ORC ID:** 0000-0003-3849-0060, **Researcher ID Thomson:** HOF-3441-2023, **CVU CONAHCYT ID**: 85792

ID 2[nd] Co-author: *María Lourdes, Guevara-Romero* / **ORC ID**: 0000-0001-7312-3499, **Researcher ID Thomson:** Q-5521-2017, **CVU CONAHCYT ID**: 336949

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Abstract

The peripherals illegal settlements in Puebla, have common denominator to born in a situation of urban vulnerability, it means with a lack of infrastructure and basic services and on some occasions on land not suitable for urbanization. This is the case of the Cuitláhuac neighborhood where approximately 400 inhabitants live. The neighborhood only has electricity service, his high urban vulnerability becomes worst in the rainy season with the formation of gullies, flooding sites and soil erosion, affecting the mobility of the inhabitants. Authorities ignore these problems and not always included them in urban development plans. The objective of research is to look for environmental alternatives to reduce urban vulnerability in illegal settlements. The methodology is based on action research and the main techniques were: documentary review, physical and virtual field trips, virtual meetings and semi-directed interviews. A relevant conclusion is that green infrastructure is feasible and can be implemented in the short term and that it arouses much collaborative interest from the inhabitants both for its implementation and for its maintenance.

Ilegal settlements, Urban vulnerability, Green infrastructure

Resumen

Los asentamientos irregulares de la periferia poblana, tienen el común denominador de nacer en situación de vulnerabilidad urbana, es decir, con carencias de infraestructura y servicios básicos y en algunas ocasiones sobre terrenos no aptos para urbanizar. Este es el caso de la colonia Cuitláhuac, donde habitan aproximadamente 400 habitantes. La colonia solo cuenta con el servicio electricidad por lo que su vulnerabilidad urbana es alta y se agudiza en temporada de lluvias con la formación de cárcavas, sitios de anegamiento y erosión del suelo afectando la movilidad de los habitantes. Las autoridades suelen hacer caso omiso de dichas problemáticas y difícilmente son incluidos en los planes de desarrollo urbano. El objetivo de la investigación ha sido buscar alternativas ambientales para disminuir la vulnerabilidad urbana en los asentamientos irregulares. La metodología está basada en la investigación acción y las principales técnicas utilizadas fueron: revisión documental, recorridos de campo físicos y virtuales, reuniones virtuales y entrevistas semidirigidas a actores clave. Una conclusión relevante es que la infraestructura verde es factible y puede implementarse en el corto plazo, y despierta el interés colaborativo de los habitantes tanto para su implementación como para su mantenimiento.

Asentamientos irregulares, Vulnerabilidad urbana, Infraestructura verde

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* Author's Correspondence (E-amil: maria.flores@correo.buap.com)
† Researcher contributing as first author.

Introduction

Urban peripheries have become the recipients of the growth of cities, where many times this expansion was carried out without the provision of the necessary infrastructure and services. In the municipality of Puebla, it is estimated that about 65% of the urban sprawl was generated by settlements with some type of irregularity (Flores, 2017).

Several authors (Bazant, 2004, Alguacil, 2013, Flores, 2017) have pointed out how urban peripheries tend to grow in a disorderly and functionally disjointed manner from urban centres, with strong deficiencies in facilities, services and infrastructure. They show that they are conceived from their origins in conditions of institutional, social and urban vulnerability. Vulnerability can be defined as the propensity of a society to suffer harm or to be harmed, and to encounter difficulties in recovering afterwards, so that it does not refer to the existence of an established critical situation, but rather, to the set of conditions of risk, fragility and disadvantage that would make possible the entry of that critical situation of disadvantage (Lavell, 2001).

The above characteristics are identifiable in the irregular settlement of Cuitláhuac, located in the south-west of the city of Puebla. It is situated on a terrain with irregular topography, specifically on the slope of a hill whose slope drains the rainfall through the colony to the lowest levels. Its irregular character places it outside of the institutional development plans, making it invisible to the municipal authorities, which has caused it to be currently only served by electricity. Lacking, among other things, drainage systems that allow for the proper management of rainwater, it is conducive to the formation of waterlogging and flooding sites, a problem that is exacerbated by having only dirt roads, thus affecting the mobility and accessibility of the inhabitants. Studies such as those by Flores (2017) and Patiño (2004) have observed irregular settlements in the Puebla-Tlaxcala metropolitan area, generally from the point of view of marginality, poverty and lack of services and infrastructure, and even when their situation of urban vulnerability has been pointed out, their contributions have focused mainly on reflecting on institutional aspects, on the lack of municipal action and their exclusion in planning frameworks.

However, no work was found that focused on analysing aspects related to urban improvement through environmental alternatives, particularly green infrastructure as an innovative element that contributes to the substitution of grey infrastructure for rainwater runoff management.

The work was developed under the hypothesis that, with the collaborative work of the population, aware and informed about the importance of the environmental services that nature provides, green infrastructure techniques can be designed and implemented to reduce their vulnerability. The objective is to show the main results on urban vulnerability in Cuitláhuac as well as the work carried out with the inhabitants to develop a green infrastructure project and start the work for its implementation.

The paper is composed of four sections. The first develops theoretical approaches to urban vulnerability in irregular settlements and the importance of green infrastructure with social participation to reduce it. The second section analyses and diagnoses the conditions of urban vulnerability in the Cuitláhuac colony. The third section identifies viable green infrastructure to improve urban conditions in the face of risk, as well as the participatory process for its initial implementation. In the fourth section, the discussion leads to the conclusions.

Methodology

The methodology is qualitative, based on action research, which consists of developing mutual learning processes between the different actors involved in the problems in order to analyse and mitigate them through collective learning (Flores, 2018).

Three physical field visits were carried out to diagnose urban vulnerability and risk situation. To complement the above, Geographic Information Systems were used for the spatial analysis of terrain topography and runoff dynamics using mainly available vector datasets. Two virtual meetings were also held with the board of directors and some inhabitants (due to the COVID-19 pandemic) to inform, elaborate the project and make agreements to carry out revegetation actions.

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Semi-directed interviews were conducted with key actors to understand their organisational situation, their relationship with public institutions and the conditions for carrying out environmental actions. A documentary review was also carried out on vulnerability in peripheral areas, green infrastructure and social participation, as well as local official instruments on irregular settlements and risk.

Vulnerability in irregular settlements, a long term constant

Urban vulnerability, according to Ochoa and Guzmán (2020), refers to three basic aspects: the environmental risk conditions (due to poor topographical conditions or conditions prone to natural disasters or located in risk areas for human activity) in which some sectors of the population are settled, which makes them insecure; poor habitability conditions, i.e. a degraded urban-architectural environment; and deficiency in the coverage of basic services and infrastructure and equipment. These differentiated characteristics of society or subsets of society predispose human settlements to suffer damage when faced with the impact of an external physical event, making their subsequent recovery difficult (Alguacil, 2013).

Irregular settlements (IA), when established spontaneously, outside of urban planning, are vulnerable because they do not have the urban conditions to settle and are often located on land that is not suitable for urbanisation. In addition, transactions are private between seller and buyer without being recorded in the land registry, which prevents them from being taxed or provided with basic services (Bazant, 2004). The criteria established by the regulatory framework for the regularisation and incorporation of this type of settlement into urban development has excluded them from the right to urbanisation, leaving them behind for an indefinite period of time (Silverio, 2020) and invisible to state institutions.

In the search for solutions to their housing needs and the provision of basic services (water, electricity, drainage and sewage), they form leaderships or form relationships with organisations that help them to manage these needs. Some political organisations take advantage of the solidarity and need of the inhabitants, turning them into objects of manipulation (Silverio, 2020) in exchange for the introduction of basic services. This condition leads to a lack of autonomy in decision-making, which recreates a form of social vulnerability which, according to Sánchez (2011), corresponds to the set of characteristics that a person or group has, which determine their capacity to anticipate, resist and recover from the impact of unforeseen events.

Green infrastructure as an environmental alternative to reduce urban vulnerability

Accelerated urbanisation processes reduce open spaces in urban centres, which leads to a series of problems such as minimal groundwater recharge, reduced infiltration and increased runoff, causing flooding, decreased biodiversity, urban heat island effect, and in general a reduction of environmental services (Peñúñuri & Hinojosa. 2017). In irregular settlements, conventional urbanisation patterns are commonly followed, giving priority to the implementation of impermeable elements such as the use of asphalt and hydraulic concrete, which reduces the infiltration capacity of rainwater and increases the risk of flooding.

Faced with this problem, the use of green infrastructure has become a viable alternative to move towards sustainable forms of city-making and address urban vulnerability. According to Benedict & McMahon (2006) it is defined as an interconnected network of natural areas and open spaces within cities that preserve the functional characteristics of natural spaces and provide a wide range of benefits to people and wildlife, within the ecological framework for environmental, social and economic health. Green infrastructure has an impact on the increase of green areas and open spaces in cities and therefore of catchment and infiltration areas, reducing stormwater runoff, preventing the overflow of grey drainage systems, flooding and the saturation of urban watercourses.

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At the same time it fulfils multiple functions, brings a wide range of socio-environmental benefits, and also according to Peñúñuri & Hinojosa (2017) these alternatives are often more economical compared to conventional measures.

The need for social participation

Peñúñuri & Hinojosa (2017), indicate that it is necessary to include citizen participation in the realisation of the different stages of design and implementation of green infrastructure, taking into account its ease of construction and implementation. Furthermore, integrating the community in such processes promotes a sense of ownership of the space, and the likelihood of perpetuating its maintenance and operation.

Considering that irregular settlements are generally organised for the demand of their basic needs and services, it highlights the possibility of taking advantage of these pre-established organisational networks to implement this type of measures. At this point, the collaborative action of universities and governmental institutions play a fundamental role in transforming thinking and putting environmental alternatives into practice, allowing progress to be made towards empowerment to solve problems. Likewise, acting on a small scale is a more apprehensible opportunity to get closer to the inhabitants, for the understanding and resolution of territorial problems through participatory action (Flores, Guevara, & Milán, 2018).

The Cuitláhuac colony

This study focused on the colonia Cuitláhuac (Figure 1), an irregular settlement established in 2010, located southwest of the city of Puebla, at a distance of 17 km from the historic centre, within the municipality and state of the same name, in Mexico. It currently has approximately 400 inhabitants (Silverio, 2020) and a surface area of approximately 17 hectares.

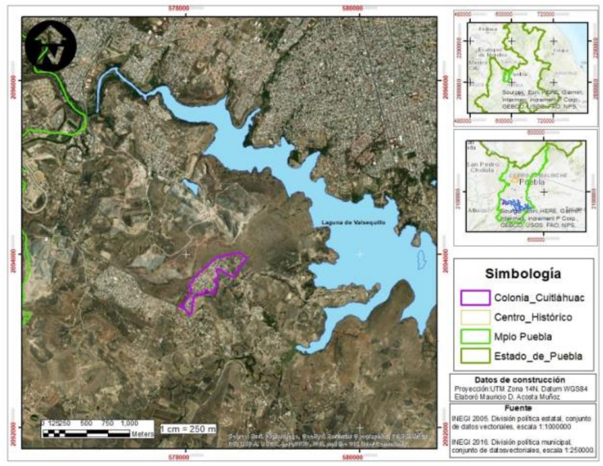

Figure 1 Location map of the colony Cuitláhuac
Source: Own elaboration based on the State and Municipal Political Division of INEGI (2010.)

In the colony Cuitláhuac, according to Silverio (2020), the economically active population amounts to 53% of the colonos, of which 36% have an average monthly income of 250 USD, 26% have an income of 150 USD, another 26% have an average income of 350 USD, while 13% have an income of less than 100 USD per month. Only 3% of the inhabitants earn 450 USD per month. Given these conditions, the inhabitants found it viable to buy cheap lots in the periphery, which had its origins in the sale of ejido land in San Andrés Azumiatla, Puebla, to the organisation Antorcha Campesina (AC), which then lotified and sold the land. It also assumed control over decision-making and actions in Cuitláhuac, where the president is appointed directly by this organisation. AC also manages the infrastructure and services for the improvement of the settlement before the local governments, violating the autonomy of the colony.

The institutional inability (and convenience) to incorporate irregular settlements into urban development programmes excludes Cuitláhuac from the provision of basic services. This situation is worsened by the limited equipment and personnel available to state institutions, which is reflected in a deficient coverage of their functions over the territory, leaving the Cuitláhuac colony outside the scope of institutional programmes.

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Currently, only 60% of the colony has electricity service, and eight years ago an attempt was made to implement a drainage system, with 50% progress, but this was not achieved. In 2014, the drilling of a well to provide drinking water to the community began; however, this work only left the registration of the deposit, without giving continuity to the phases of the establishment of a supply network, so the water service is supplied through the purchase of pipes. The streets are unpaved, and get worse during the rainy season, have a poor mobile phone signal, lack of cleaning services and no street furniture.

In Cuitláhuac, urban vulnerability due to environmental risk is also observed because it is located on the slope of a hill near the watershed that delimits the micro-watershed, where the slope of the land has a northwest-southeast direction, with rainwater coming from the upper part of the micro-watershed, which crosses Cuitláhuac and incorporates its channels into the ravines near the settlement, whose immediate destination is the Valsequillo dam.

The lack of a sewage and drainage system, and of paved streets (Figure 2), cause rainwater to form gullies, soil erosion, waterlogging affecting some houses, as some infiltrations can be observed in the walls, and difficulties in the mobility of the inhabitants due to the formation of muddy areas (Figure 2).

Figure 2 Urban conditions in Cuitláhuac
Source: Author, 2021

The vegetation in the area before the establishment of the colony corresponded to induced pastures, alternating with annual rainfed agriculture (INEGI, 2016), however, with the establishment of the colony, the use of the land was changed to constitute a human settlement, removing the already poor vegetation. This increased soil degradation problems, affecting soil functions by decreasing the availability of nutrients and organic matter, reducing the rooting depth of plants, and thus decreasing the infiltration rate and water retention capacity.

Reducing risk with green infrastructure and social participation

A project was carried out with soil restoration measures and green infrastructure to limit water erosion, favour the infiltration of the tributaries, improve the characteristics of the soil and thereby reduce the problems caused by sudden floods caused by intermittent runoff. This is based on the establishment of living barriers and revegetation of the margins where rainwater runoff crosses the colony.

The living barriers consist of plantings of species in rows, arranged in such a way that they do not allow the free passage of runoff and sediments (CONAFORT, 2018), allowing the retention of silt and water infiltration, with the aim of collecting, spreading and reducing the speed and energy of the affluent, as well as its expenditure. This favours water infiltration and the development of native vegetation, favouring the restoration of degraded areas in semi-arid zones, on shallow, stony or compacted soils, characteristic of Cuitláhuac.

The revegetation of the runoff margins consisted of the establishment of plant species, preferably native and low maintenance, in order to establish an interconnected network of green areas, in order to restore the composition of the soil and thereby preserve the functional characteristics of natural spaces, providing benefits to people and wildlife.

The proposal was developed so that the inhabitants could implement it without depending on the authorities and was presented for improvement and strategies for its implementation. It was enthusiastically accepted and approved.

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In order to implement the living barriers and revegetation, we took advantage of the internal organisation of the colony, which carries out Sunday work to improve its streets, generally promoted by the organisation Antorcha Campesina. The first stage of the work consisted of placing live barriers between the streets Valle de Anáhuac and Av. Mexica, as this is one of the places where one of the rainwater runoffs crosses the colony. The actions consisted of planting 18 plants of the maguey espadín species (*Agave angustifolia*) and 10 of the maguey lechuguilla species (*Agave maximiliana*) (Figure 3).

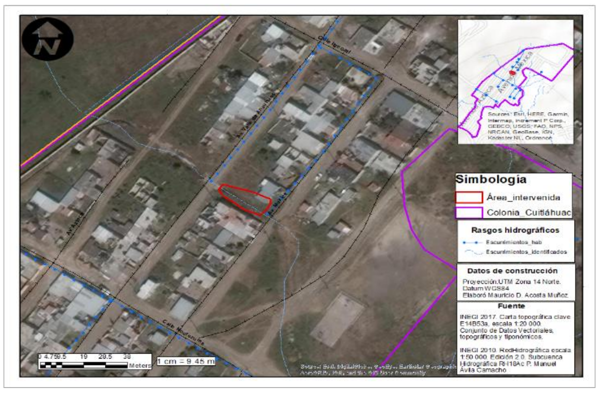

Figure 3 Area intervened for the implementation of living barriers
Source: Own elaboration based on topographic chart and hydrographic network RH18Ac from INEGI (2017 and 2010.)

The planting day was attended by around 35 people, with similar proportions of men and women, ranging in age from 20 to 59 years, but some children also attended. They brought their own tools such as shovels, picks and machetes (Figure 4).

Figure 4 Inhabitants of Cuitláhuac participating in the implementation of living barriers
Source: Author, 2021

The plants were arranged in such a way that they were perpendicular to the direction in which the river normally flows, taking advantage of the fact that, during the planting day, the runoff was dry, given its intermittent nature.

During the planting day, the active and enthusiastic participation of the settlers was observed. These actions aroused interest in addressing the lack of drainage infrastructure through the implementation of nature-based alternatives that they themselves can implement, such as green infrastructure, as a measure to help reduce the problems observed in the formation of waterlogging and mudflats within the colony. A second day was held to revegetate the banks of the same runoff as the first day, but on this occasion, 50 m upstream. Eighty blue agave plants (Tequiliana Webes var. azul) between 20 and 40 cm in height were planted.

About 35 people attended this day, approximately 20 women and 10 men and about 5 children. Prior to the planting of the agaves, a brief technical explanation was given on the benefits of the vegetation and how to plant it. The planting was carried out on the margins parallel to the site where the runoff flows, starting from the perimeter fence of the colony to favour infiltration, reduce the mass flow through the site and prevent the plants from being carried away by the current (Figure 5).

Figure 5 Conditions of the intervention site, where the runoff margins were cleaned and revegetated
Source: Author, 2022

The work days awakened interest in the care and maintenance of the intervened space, as they became aware of the benefits that this action will have on the management, infiltration and reduction of rainwater.

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In subsequent days, organised and directed by the settlers themselves, a growing interest in the care and maintenance of the plants was observed. In addition, they planted more plants in the area, in order to give continuity to the work of revegetation of the runoff margins.

Some of the inhabitants commented that they were pleased to participate in this type of activity, as it is an alternative to reduce their vulnerability due to the lack of infrastructure. Likewise, being part of these actions encourages the appropriation of their spaces.

Discussion

Most of the irregular settlements in metropolitan areas such as Puebla have only electricity and water services and it can take up to 20 or 30 years to have other basic services; however, they do not consider the provision of public space, sanitation systems and much less, infrastructure and services that help mitigate the different natural risks that may exist (Flores, 2017). The lack of basic urban infrastructure in the colonia Cuitláhuac is evidence of how these types of settlements are, from their origins, subject to different conditions of urban vulnerability, which is exacerbated by their social vulnerability and their illegal land ownership. Cuitláhuac has only had electricity for twelve years and the rest of the services have not been provided to date.

In addition to the above, it is environmentally vulnerable, and the irregular topography on which it is located plays a central role, as it makes urbanisation difficult and gives way to problems related to flooding and inundation, with adverse effects on the population in their daily lives. In terms of flooding, we cannot forget that climate change becomes a threat that exacerbates this vulnerability since, according to (Conde et al. 2021), climate change scenarios for the city of Puebla for the middle and end of this century point to an increase in temperatures and extreme precipitation patterns.

In this situation, the development of strategies that enable communities to manage their vulnerability and risk is fundamental. Da Cunha and Thomas (2017) point to the need to make them more syntropic in order to move from a state of vulnerability to one of adaptation to the environment.

In this sense, the use of green infrastructure and collective action are fundamental allies to provide solutions that are easy to implement and less costly than traditional grey infrastructure. Furthermore, according to (Vázquez, 2015) it has significant contributions to both mitigation and adaptation to climate change.

The process of revegetation and implementation of living barriers initiated in the Cuitláhuac demonstrates that actions can, according to Peñúñuri & Hinojosa (2017) start with small and simple applications, with multifunctional effects, taking into account that this type of infrastructure brings a wide range of social, environmental and economic benefits. On a small scale, the use of this type of engineering increases the capacity of spaces to offer basic services, without forgetting the improvement of the natural landscape. In addition, the participation of the inhabitants is paramount, as integrating the community promotes a sense of ownership of the space, guaranteeing the functioning of this infrastructure in the long term.

The technical university work and the participation of the inhabitants of the irregular settlements contribute to the community becoming active and taking ownership of the space, contributing to the sustainability of the green infrastructure. As Borja (2019) says, active citizenship is the hope, from the neighbourhoods and from the cities, through, among other things, popular initiatives based on a dialogue between professionals and citizens that makes it possible to advance in the possibility of building a practical ethics.

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Conclusions

Given the vulnerabilities found in Cuitláhuac, the use of green infrastructure proved to be an important ally in reducing urban vulnerability, as it can be implemented in the short term and at a lower cost. This type of infrastructure could be implemented without government intervention, using the pre-established organisational structures in the colonia.

The university plays a fundamental role in the dissemination of knowledge and application techniques, as it is a trustworthy institution and facilitates links with the inhabitants, who are open and available for collaborative work. From the initial accompaniment of the university with the inhabitants, environmental actions were continued in an autonomous manner by the settlers, that is to say, collective work to reduce risk was perpetuated. This was based on an incipient awareness of their situation of vulnerability and risk.

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Responsible changes in the brick industry: clay bricks and PET blocks

Cambios responsables en la industria ladrillera: ladrillos de arcilla y bloques de PET

DIAZ-VEGA, María Eugenia†, ZAMORA-CASTRO, Sergio Aurelio and GRAJEDA-ROSADO, Ruth María*

Universidad Veracruz, Facultad de Ingeniería de la construcción y el Hábitat, Veracruz, Veracruz, México.

ID 1st Author: *Maria Eugenia, Diaz-Vega* / **ORC ID:** 0000-0002-7582-6267, **CVU CONAHCYT ID:** 351110

ID 1st Co-author: *Sergio Aurelio, Zamora-Castro* / **ORC ID:** 0000-0002-5237-6320, **Researcher ID Thomson:** G-7614-2019, **CVU CONAHCYT ID:** 104980

ID 2nd Co-author: *Ruth María, Grajeda-Rosado* / **ORC ID:** 0000-0001-9961-3541, **Researcher ID Thomson:** HTR-6109-2023, **CVU CONAHCYT ID:** 802541

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Abstract

The brick industry needs carbonization processes to produce its products. This has resulted in it becoming one of the actors that generate the most polluting emissions and impacts climate change quickly. Therefore, the industry must take action in favor of sustainable options. The following work carries out a comparative work of conventional bricks and blocks made with PET to explore their effectiveness.

Bricks, Clay, Contaminants, PET

Resumen

La industria ladrillera necesita de los procesos de carbonización para la producción de sus productos. Esto ha resultado en que se convierta en uno de los actores que más emisiones contaminantes genera e impacte en el cambio climático rápidamente. Por lo que es de prima importancia que la industria accione a favor de opciones sustentables. El siguiente trabajo realiza un trabajo comparativo de ladrillos convencionales y bloques hechos con PET con el objetivo de explorar la efectividad del uso de estos.

Ladrillos, Arcilla, Contaminantes, PET

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† Researcher contributing as first author.
* Author's Correspondence (E-mail: lgrajeda@uv.mx)

Introduction

Urban planning has been overtaken by the crisis spread by climate change. Cities have become vulnerable to the damaging natural disasters that are striking with increasing frequency. This directly affects buildings and infrastructure which, in most cases, are not yet prepared for such disturbances.

In 2006, it was estimated that the construction industry was responsible for 30% of the world's solid waste and has been actively involved in the emission of greenhouse gases (UN, Environment program, 2021). It is worth mentioning that, despite a substantial increase in investments to reduce energy consumption in this sector, CO2 emissions increased in 2021.

Furthermore, the brick industry, located in the core of the construction industry, is responsible for a large part of the emissions of polluting gases that accelerate the consequences of the greenhouse effect and have direct repercussions on cardiorespiratory diseases. In 2020 alone, annual global production was 1,500 billion bricks (Berumen-Rodríguez, Pérez-Vázquez, Díaz-Barriga, Márquez-Mireles, & Flores-Ramírez, 2021).

The manufacture of conventional bricks requires excessive energy use and some of the polluting gases are carbon monoxide (CO), volatile organic compounds (VOC), nitrogen dioxide (NO2), sulphur dioxide (SO2), heavy metals, carbon dioxide (CO2), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), dioxins, among others (Berumen-Rodríguez, Pérez-Vázquez, Díaz-Barriga, Márquez-Mireles, & Flores-Ramírez, 2021).

The following work will take conventional bricks, such as clay bricks, as the object of study and compare them with bricks made from PET (polyethylene terephthalate) plastic. The objective will be to compare and explore the existing renewable options, in order to make the construction industry, more specifically the brick industry, a space in which sustainability and resilience to the effects of global warming are taken into account.

Methodology

The following research is a mixed approach, as it aims to carry out a comparative analysis from both qualitative and quantitative approaches. A search for university research, official articles and experimental studies was carried out. These were found in databases such as Google Scholar and Redalyc, as well as in the websites of governmental institutions and non-governmental organizations.

Information was limited to conventional brick manufacturing processes, basic characteristics and socio-environmental repercussions. Similarly, literature was sought on the production of bricks with PET plastic and its characteristics. With this in mind, the comparative method was used in order to draw strong conclusions about the efficiency in both cases.

Results

Manufacturing processes

In the case of the conventional brick, the raw material required for its production is essentially clay, sand and water. The mixture is prepared to a plastic ceramic mass, poured into moulds to obtain the raw brick and left to dry. The pre-dried brick is then taken to the firing kilns, where the chemical changes take place (Pontifica Universidad Católica del Perú, 2019).

In the kiln, the combustion process must be based on the adaptability of temperature control and the effect of each fuel on the material to be heated. Among the most commonly used fuels are wood, charcoal, coal, mineral coal, natural gas, propane, fuel oil, among others (Figueroa Parra & Martinez Delgado, 2000). Although firing processes may vary depending on the fuel, specific brick materials and the kiln design itself, combustion processes are one of the main air pollution processes.

For the manufacture of a PET block, it is important to first determine that it is an optimal raw material for the production of the block. As it has high thermal and mechanical strength, good creep coefficient and high chemical resistance, it is considered as a good substitute for traditional elements (Campos, Gómez, Montero, Pantoja, & Pasco, 2020).

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For example, the study by Maaze and Shrivastava (2023) shows how fly ash geopolymers are a sustainable substitute for raw clay brick; another material is plastic powder, supplanting the 7.5% mass of clay, which is reported to make bricks that are lightweight, with greater durability to water absorption and volumetric stability (Idrees, Akbar, Saeed, Gull, & Eldin, 2023). It is important to mention that, of the 770 tonnes per day of solid waste, 7.7% is plastic, of which only about 30% is collected for reuse (UN Environment programme, 2021).

Although only a small percentage of the waste chain is reused, 21 tonnes are still available for reuse. PET elements are cut out and used for the mixing of the blocks. Sometimes it is melted before being added to the mix, but in this case the plastic loses some of its properties. Once poured into the mould, it is left to cool for a few hours or a day until it hardens (Maure, Candanedo, Madrid, Bolobosky, & Marín, 2018).

Brick properties

The processed bricks themselves should be homogeneous and compact, they should be well fired and sufficiently porous without any excess (Barranzuela Lescano, 2014). Also, clay bricks have the capacity to withstand compression. They have properties such as hardness, shrinkage and sonority. According to the regulations of the Mexican Ministry of Communication and Transport (SCT, 2022) they must be suitable for severe climates with frost and high rainfall. One advantage of clay bricks is that, as they are available in different types, the selection can be varied among those available on the market.

In the case of PET blocks, the choice is equally optimal if the above characteristics are considered. This is due to the fact that they comply with resistance and impermeability. The PET partition can reach five times more resistance than traditional brick, 14% thermal efficiency and good moisture resistance (González-Velandia, Sánchez-Bernal, Pita-Castañeda, & Pérez-Navar, 2019; Viveros-López & Gonzalez-Léon, 2018). Another characteristic of polyethylene terephthalate blocks is that they are lighter than traditional bricks, making them easier to handle, and they show better water absorption performance at 4% (Wahane, Dwivedi, & Bajaj, 2023).

The analysis offered by El-Metwally et al. (2023) concludes that the larger the grain size, the higher the compressive strength and the lower the thermal conductivity, regardless of the type of plastic used; in addition, most studies consider a maximum of 5% clay mass substitution for load-bearing constructions, increasing if it is for non-load-bearing walls (Wahane, Dwivedi, & Bajaj, 2023); Another interesting observation is the consideration of including plastic fibres in the mortar to improve thermo-mechanical properties, tensile strength and thermal insulation, as well as the reduction of micro-cracks.

Generally, the addition of an additive to conventional bricks has been more concerned with improving physical or chemical properties on an almost selective basis. For example, additives against freezing and thawing or to accelerate setting time. That is, according to the variability and needs of the batch (Di Marco Morales & León Tellez, 2017). However, if we follow the logic of resilience in the construction sector, it is imperative to take advantage of the resources available for the manufacture of bricks and blocks.

Socio-environmental impact

The construction industry is undoubtedly one of the main generators of solid waste and emitters of polluting gases. Brick making as mentioned above is inevitably functional with carbonisation methods. According to the UN Environment Programme in its 2022 report, there is no prognosis to ensure a decrease in CO2 emissions by 2050 in the building sector. However, the use of one of the most common wastes brings only long-term benefits (UN, Environment programme, 2022).

If the demand for PET blocks were to increase, collection organisations would look for ways to increase their reach in the search for waste. In this way they would be suppliers of a raw material that could be substantial in the brick industry. In Mexico alone, this industry generates 52,315 jobs (Berumen-Rodríguez, Pérez-Vázquez, Díaz-Barriga, Márquez-Mireles, & Flores-Ramírez, 2021).

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Conclusions

The costs of inaction in the face of climate change will be reflected in reduced construction activity and could result in sub-optimal living and working spaces. The damage caused by natural disasters over the last 20 years has resulted in the loss of $2 trillion dollars according to the World Bank (Word Green Building Council, 2022). Starting to produce materials and products that are efficient for construction but also responsible for natural changes will create the necessary basis for trust in trade.

Although it is not the only robust solution to the problem the world is facing, it is one of the fronts to be addressed for resilience in building and housing development. Moreover, PET blocks have so far demonstrated that they can be of better quality for practical purposes. While there is still a long way to go to meet the commercial demand for building materials, PET blocks are an option that in the long term can lead to more sustainable practices in the construction industry.

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Study of the physical-mechanical characteristics of concrete in a concrete-PET mixture

Estudio de las características físico-mecánicas del concreto en una mezcla de concreto-PET

ESPINOSA-SOSA, Enrique Esteban†*, CRUZ-SUSTAITA, Vianey and LERMA-LEDEZMA, David

Universidad Politécnica de Altamira.

ID 1st Author: *Enrique Esteban, Espinosa-Sosa* / **ORC ID:** 0009-0002-3100-4226

ID 1st Co-author: *Vianey, Cruz-Sustaita* / **ORC ID:** 0000-0001-6753-7441

ID 2nd Co-author: *David, Lerma-Ledezma* / **ORC ID:** 0000-0001-8137-3308, **CVU CONAHCYT ID:** 899202

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Abstract

In the field of construction materials, concrete is today one of the most accepted mixtures of materials by the community. Cement is one of the most used products in the world, although large cities are already full of large buildings, cement is still requested in large works. One of the materials widely used as primary packaging are the thermoplastic polymers of the so-called PET (Polyethylene Terephthalate). These materials are currently very polluting mainly in oceans, seas and rivers. The properties of polymers could be exploited to reinforce the properties of concrete and at the same time reuse the polymer to reduce its contamination on the planet. For this research project the experimental methodology was applied consisting of establishing combinations of concrete-PET materials in different ratio. The results obtained from the different mixtures that were prepared from the Flexural Effort tests, it is observed that both in the mixture containing 0.5% PET and in the one containing 1.0%, the results of Flexural Effort are higher compared with the pure mixture.

Cement, Polymer, Flexion

Resumen

En el ámbito de los materiales para la construcción, el concreto resulta hoy por hoy una de las mezclas de materiales más aceptadas por la comunidad. El cemento es uno de los productos más utilizado en el mundo, a pesar que las grandes ciudades ya están llenas de grandes construcciones, el cemento sigue siendo solicitado en las grandes obras. Uno de los materiales ampliamente utilizado como envase primario son los polímeros termoplásticos de los llamados PET (Polyethylene Terephthalate). Estos materiales, actualmente son muy contaminantes principalmente en océanos, mares y ríos. Las propiedades de los polímeros podrían ser aprovechados para reforzar las propiedades de los concretos y al mismo tiempo reutilizar el polímero para disminuir su contaminación en el planeta. Para este proyecto de investigación se aplicó la metodología experimental consistiendo en establecer combinaciones de los materiales de concreto-PET en diferentes proporciones. Los resultados obtenidos de las diferentes mezclas que se elaboraron de las pruebas de Esfuerzo de flexión, se observa que tanto en la mezcla que contiene 0.5% de PET como en la que contiene 1.0%, los resultados de Esfuerzo a la flexión son más altos comparado con la mezcla pura.

Cemento, Polímero, Flexión

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* Author's Correspondence (E-mail: e57espinosa@hotmail.com)
† Researcher contributing as first author.

Introduction

In the field of construction materials, concrete is today one of the most accepted mixtures of materials by the community. Its physical-mechanical properties, the way of preparation, handling and transport, give it more advantages over other materials. In Mexico, due to its geographical condition, it is built using concrete as a highly resistant and load-bearing material.

Cement is one of the most widely used products in the world, despite the fact that large cities are already full of large constructions, cement continues to be requested in large works. According to the latest statistics provided by Index Mundi, in its report Hydraulic Cement: World Production, By Country. This report records a production of 2.31 billion tons of cement.

Hence the importance of studying and improving the properties of materials, in this case concrete or mortar in particular. Additives have been developed that help or contribute to improve the properties of cement such as setting, resistance, etc.

One of the materials widely used as primary packaging are thermoplastic polymers called PET (Polyethylene Terephthalate). These materials are currently very polluting, mainly in oceans, seas and rivers. In Mexico, 800,000 tons of PET are generated per year and only 15% is recycled, according to the president of the Special Commission for Sustainable Development of the Chamber of Deputies, legislator René Fujiwara Montelongo.

The properties of the polymers could be used to reinforce or increase the properties of concrete, which is why a way could be found to relate these materials to obtain a better quality concrete and at the same time reuse the polymer to reduce its contamination. in the planet.

Methodology

For this research project, the experimental methodology was applied, consisting of establishing various combinations of concrete-PET materials in different percentages and taking a concrete sample as a reference without containing any amount of PET.

- Mixtures are made in a 1:2 cement/sand ratio with a 0.625 water/cement ratio, using Portland CPC-30R cement without PET dosing.

- Mixtures are made in a 1:2 cement/sand ratio with a 0.625 water/cement ratio, using Portland CPC-30R cement with PET dosage: Cement/sand/water and 0.5% PET graduated by mesh No. 4.

- Mixtures are made in a 1:2 cement/sand ratio with a 0.625 water/cement ratio, using Portland CPC-30R cement with PET dosage: Cement/sand/water and 1.0% PET graduated by mesh No. 4.

- Mixtures are made in a 1:2 cement/sand ratio with a 0.625 water/cement ratio, using Portland CPC-30R cement with PET dosage: Cement/sand/water and 1.5% PET graduated by mesh No. 4.

- Mixtures are made in a 1:2 cement/sand ratio with a 0.625 water/cement ratio, using Portland CPC-30R cement with PET dosage: Cement/sand/water and 2.0% PET graduated by mesh No. 4.

Physical-mechanical tests of all the mixtures are carried out, highlighting the property of Effort to bending.

Results

As can be seen in table No. 1, the results obtained from the different mixtures that were elaborated and the data of the results of the bending stress tests are shown. These results were also graphed as shown in graph No. 1 for a better analysis of the information.

It is observed that both in the mixture containing 0.5% PET and in the one containing 1.0%, the flexural stress results are higher at 7 and 28 days compared to the pure mixture, that is, without PET content. On the other hand, it is observed that the mixtures containing 1.0 and 1.5% PET have the lowest values at 14 and 28 days compared to those of the pure sample. In graph No. 1 it is possible to appreciate the aforementioned values as in the case of the mixtures of 0.5 and 1.0% above the values of the pure mixture.

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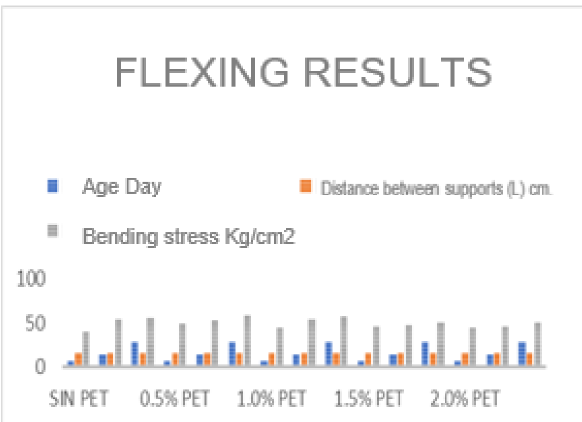
Mixes	Age Day	Load (P) Kg	Distance between supports (L) cm.	Flexibility effort Kg/cm^2
No PET	7	330.5	15	39.6
	14	455.7	15	54.7
	28	465.0	15	55.8
0.5% PET	7	404	15	48.5
	14	444	15	53.27
	28	490.5	15	58.86
1.0% PET	7	369.5	15	44.34
	14	453.5	15	54.42
	28	476.5	15	57.18
1.5% PET	7	379	15	45.48
	14	397	15	47.64
	28	420	15	50.40
2.0% PET	7	367.5	15	44.10
	14	383.5	15	46.02
	28	421	15	50.52

Table 1 Flexibility results table
Source: Own wlaboration

These results allow us to make some conclusions and to continue working on the research project.



Graphic 1 Flexion results
Source: (own elaboration)

Conclusions

After analyzing the results obtained, it is concluded that:

1. It is possible to add the PET polymer to the concrete without affecting its physical-mechanical properties.

2. In the case of the Flexural Effort, the Concrete-PET combination of 0.5-1.0%, the values are higher than the values of normal concrete.

These results open up the possibility of continuing to search for the most appropriate combination and working on other variables such as:

- Modify the particle size of the PET Explore in the thermal part the behavior of the mixture at different temperature values.

- Continue varying the PET-concrete ratio until reaching the optimal ratio.

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Implementation of hydraulic and sanitary engineering under the concept building information modeling, in a nine-floor intelligent building, Zapopan, Jalisco

Implementación de ingeniería hidráulica y sanitaria bajo el concepto de modelado de información para la construcción BIM, en un edificio inteligente de nueve niveles, Zapopan, Jalisco

CARO-BECERRA, Juan Luis†*´, ROBLES-CASOLCO, Said´´, LUEVANOS-JACOBO, Jonathan Eduardo´ and VIZCAÍNO-RODRÍGUEZ, Luz Adriana´

´ Universidad Politécnica de la Zona Metropolitana de Guadalajara, Jalisco, México.
´´Universidad Politécnica Metropolitana de Puebla, Puebla, México.

ID 1st Author: *Juan Luis, Caro-Becerra* / **ORC ID**: 0000-0002-3884-2188, **Researcher ID Thomson**: K-2859-2018, **arXiv Author ID:** juanluis74

ID 1st Co-author: *Jonathan Eduardo, Luevanos-Jacobo* / **ORC ID**: 0009-0008-2882-1800

ID 2nd Co-author: *Said, Robles-Casolco* / **ORC ID:** 0000-0003-1217-7682, **CVU CONAHCYT**: 122409

ID 3rd Co-author: *Luz Adriana, Vizcaino-Rodríguez* / **ORC ID:** 0000-0001-8301-6160, **Researcher ID Thomson:** T-1324-2018, **CVU CONAHCYT ID**: 175164

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Abstract

Building Information Modeling (BIM) is the way to work in a coordinated manner among the actors involved in the construction project. This modeling includes all phases of the project: Design, Execution and Maintenance, providing real time information on the building modeling. BIM focuses on empowering and facilitating the understanding of the work program of all the actor in the construction process: Engineers, Architects, Owners, Product Manufactures, Subcontractors, etc., ordering and coordinating the information in each phase of the project, in order to make decisions, avoiding the minimum mistakes or unexpected calculations. The goal of this project is the modeling of the engineering hydraulic and sanitary, for an intelligent building of 9 floors, using REVIT software, the results obtained were the sizing of the pluvial water retention tank and the determination of available pressures (high and low pressure). It is concluded that the use of BIM tools allowed to display 3D, evaluating a logical sequence despite the complexity of its use.

Building Information Modeling, Design, Execution, Project

Resumen

El Modelado de Información para la Construcción (BIM) es la forma de trabajar de manera coordinada entre todos los actores que intervienen en el proyecto constructivo. Dicha modelación comprende todas las fases del proyecto: Diseño, Ejecución y Mantenimiento, aportando información en tiempo real sobre el modelado del edificio. BIM se enfoca en potencializar y facilitar el entendimiento del programa de obra de todos los actores del proceso constructivo: Ingenieros, Arquitectos, Propietarios, Fabricantes de Productos, Subcontratistas, etc., ordenando y coordinando la información en cada fase del proyecto, con el objeto de tomar decisiones, evitando el mínimo de errores o cálculos inesperados. El objetivo de este proyecto es la modelación de la ingeniería: hidráulica y sanitaria, para un edificio inteligente de 9 pisos utilizando el software REVIT, los resultados obtenidos fueron el dimensionamiento tanque de retención de aguas pluviales y la determinación de presiones disponibles (alta y baja presión). Se concluye que el uso de las herramientas BIM permitió desplegar vistas en 3D, evaluando una secuencia lógica a pesar de la complejidad de su uso.

Modelado de información para la construcción, Diseño, Ejecución, Proyecto

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* Author's Correspondence (E-mail: juan.caro@eacademicos.udg.mx)
† Researcher contributing as first author.

Introduction

In the construction and building industry it is still common to carry out projects with traditional processes, although they tend to be very effective, they are not effective and efficient, usually presenting delays in delivery times, cost over runs and sometimes even project abandonment (Arcudia, *et al*., 2005).

The BIM methodology is revolutionizing the 4th Industrial Revolution and takes more and more a great importance in the field of civil engineering (Campos, 2019) thanks to the excellent results obtained with this tool, there are reflected in the minimum mistakes that are made, this methodology is able to identify and give solutions to design that are not visible with Auto-CAD tools, but if they are visible at the time of project execution.

One of the benefits of BIM is that it can be applied to any construction project, whether it is a building, roadway, dam, mining or environment project, to name just a few. Our case study focuses this methodology in the design and construction of hydraulic, sanitary and pluvial installations of the project called Toren 54.

In this work an analysis of hydraulic and sanitary engineering feasibilities is made, in order to show that BIM modeling together with REVIT software tools are compatible to be used in this and other projects related to hydraulic installations.

The goal is to create a project engineering for vertical housing, implementing the BIM (Building Information Modeling) methodology as well as processing the modeling information with Revit tool. The execution of BIM consists of the modeling of geometric elements duly parameterized, with the determination of making a series of layers of information, designed with a coordinated documentation for analysis and control information that carries each phases of the project in construction (Sánchez, 2017).

Justification

Currently, the vast majority of architectural projects in Mexico are developed with CAD (Computer Assistant Design) technology and other software that facilitate tools of design, this work methodology has been transcendent in recent years in construction, however most of the projects present inconsistences, cost overruns in the terms and contracts (Ocampo, 2015).

The solution that technological development is offering to all these problems the BIM (Building Information Modeling) methodology, which offers a control of the information generated, for example: designs and technical studies, construction and management, to name just a few some. In addition, BIM modelling allows simultaneous work between contractors, designers and administrators in a virtual way *(ibid).*

Applying this methodology in the Toren 54 intelligent social interest building project, it will be possible to observe how all the layers of information are integrated in the same model, in the other words, there is control over the critical points that would be generated with the traditional work progress program model.

Background

The origins of BIM modeling date back to the second half of the 20th century, but its first real applications in construction appear at the beginning of the 21st century. In the early days of computing, the first designs based on objects, parameters and a database related to a model appeared, for all this it was necessary graphic interfaces in order to interact with the project under construction (Rodríguez, 2015).

Today in countries such as the United States or Spain the use of BIM has had a great boom in both public and private sector projects reaffirming that BIM modeling has become a paradigm shift in all stages of the work (design, construction and operation) (Mojica & Valencia, 2012).

The implementation of BIM in each phase of the project allows the exchange of information and thus obtain prototypes in an efficient manner, where the performance and operability of the building can be observed (*ibid*).

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Theoretical framework

The BIM Methodology integrates technologies and processes with the purpose of modeling the information in an orderly manner, necessary for the development of an architectural, engineering and construction project, in addition to functioning as a database where information can be stored and shared, types of materials to be used, as well as their different construction systems (Farfán & Chavil, 2016).

The database that was generated and will be built in the Toren 54 project will be a guide for future stage in terms of: energy efficiency simulation, work progress program, to name a few. The benefits that BIM offers is that it models three-dimensional objects that allow automatic editing, in addition to this, the construction of the project is made from materials that have different, physical, chemical, mechanical and manufacturing characteristics (Jobim *et al.,* 2017).

BIM Modeling in European and Latin American Countries

The United States has implemented the BIM philosophy in public and private sector projects, proving that BIM has become a methodology in the different layers of the work (design, execution and operation).

On the other hand, the United Kingdom worked on a much more ambitious project in the implementation of the BIM methodology, which consists that from 2016 all public works projects will be executed with BIM.

Nevertheless, in Latin America the Building Information Modeling (BIM), there is little clarity about it, factors such as resistance to change, lack of training to obtain seek in BIM, notwithstanding the benefits provided by the implementation of BIM in construction projects (Ocampo, Hurtado, 2015).

Methods and materials

The virtual modeling was done throught the Revit 2019 computer program starting the analysis and design with the constructive architectural building plan of the Toren 54 in CAF format, this plan only contained architectural information which was verified with field visits that allowed to corroborate actual measurements and dimensions, in addition to defining the types of materials, storage tanks, grids, pumping and fire systems, as well as the structural design to avoid as little an possible the obstruction of plumbing and hydraulic installations.

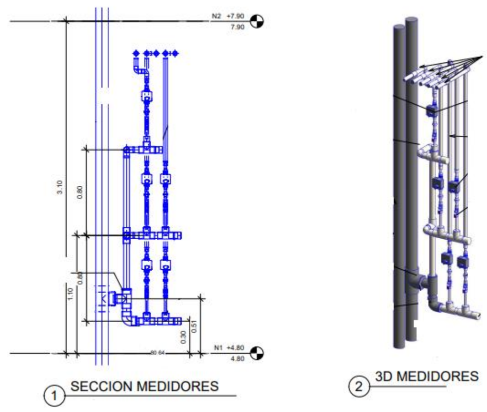

Figure 1 Meter lines
Source: Díaz Candelario, 2022

Hydraulic and sanitary installations in a house is related to "plumbing" works and is defined as the art of installations pipes, accessories and other pumping devices and equipment to carry and discharge water supply (Enriquez, 2000).

From this definition it is established what is a plumbing system that includes: distribution pipes for waters supply, fittings and traps, ventilation pipes, sanitary and rainwater drainage, including devices and connections inside the building with the exterior.

The hydraulic installation is a set of pipes and connections of different diameters and materials, with the purpose of supplying and distribution water inside the construction (Pérez, 2005).

This installation will supply water to all points and places of the Toren 54 architectural project that require it, so that it reaches both in quantity and adequate pressure to all levels and equipment of the apartments such as: furniture, sinks and drains.

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Our project to be executed is located on Guadalupe Avenue and Pintores Street, in the municipality of Zapopan, Jalisco. The paradigm shifts to be followed is to promote vertical housing in a sustainable and ecological context, catching rainwater and storing it in retention tank according to the design capacities, as well as a cistern proposed and designed for a capacity of 60 m³.

Drinking water supply systems in buildings

All housing developments to be planned in Guadalajara city must have an Integral System for the supply of drinking water, which must satisfactorily serve its inhabitants, as well as the various existing and/or planned municipal and industrial uses, with an efficient service and adequate domestic supply, for its various urban facilities and the areas intended for commercial, industrial and service use (SIAPA, 2000).

The most common systems used to supply water to a building can be classified as follows:

- Direct supply systems.

- Combined and pressure supply systems.

Direct supply system

In order to supply cold water directly to every piece of furniture in the building, it is necessary that the building is of low height and that the municipal network has sufficient pressure, so that it reaches the furniture of highest levels, which in our project the maximum 117 ft, this will be achieved with the necessary pressure from the household tap, as well as maximum efficiency available in the equipment and pumping sumps.

To be sure that the water reaches the highest levels and that the equipment works efficiently, it is necessary to measure the gauge pressure at the highest point of the building or open the check valve and that the water column freely reaches a height of 6.56 feet column water.

Combined supply systems

A combined system is designed when the pressure of the network is not enough to reach apartment, therefore there is the possibility of building cisterns or storage tanks in the lowest part of the building (basements).

Once the design and location of the cistern or storage tank of the Toren 54 project proposed, which are located in the basement by means of an auxiliary system, water is elevated to the maximum height level, to be distributed by pumping to all levels and furniture in a particular or general way, depending on the type of installation and/or service.

Pressure supply system

The pressure supply system is more complex and depends on the characteristics of the building, type of service, volume water required, pressures, simultaneity of services, number of levels, number of furniture, characteristics of the latter, etc. They can be solved by means of hydro pneumatic equipment.

Figure 2 Cross section of the Toren 54 project
Source: Díaz Candelario, 2022

Sanitary installation

The sanitary installation can be defined as a system from which wastewater from building is discharged to the most appropriate place such as septic tanks and/or the municipal network. The objective is to safely dispose of the wastewater in a way that meets the requirements of the corresponding standards and regulations of the place where it is being installed.

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The specifications can be consulted in the descriptive memories of the project, as well as the calculation memories, of course these must comply with the corresponding standards and regulations of each region of the country, which in our case are based on the Building Regulations and the Complementary Technical Standards for Hydraulic Installation (NTCIH) of Mexico City (DGCOH, 2010).

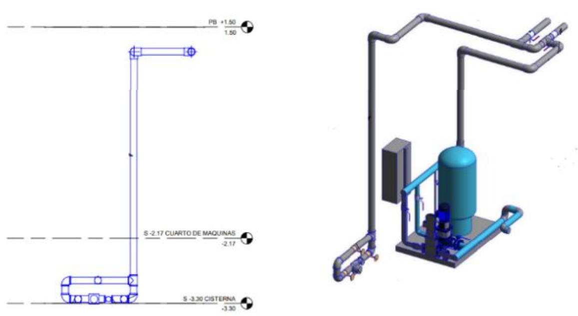

Figure 3 Pressure regulator seen in 2D y 3D, designed under BIM-REVIT modeling
Source: Díaz Candelario, 2022

Characteristics that a sanitary installation must comply with

The design that a sanitary installation depends on the flow rate and discharge pressure of each furniture. In order to have a good performance in an installation it is necessary to comply with certain requirements.

a) Types of materials

The sanitary rooms must have waterproof and non-slip floors and walls.

b) Pipelines

The diameters of the drainage pipes must not be less than 1¼ in, nor less than the drainage mouth of each piece of furniture, and they must be installed with a minimum slope of 2‰. The pipes that carry wastewater to the outside of a property must be at least 8” diameter.

The sewers must have registers greater than 4” between each one and change of address of each sewer. The sewer is the horizontal conduit into which the rainwater downspouts flow, so smooth pipes should be used, as well as a minimum slope of 2‰ as indicated in the previous paragraph.

For great buildings, the same diameter of the pipe that as the sewer is adopted, in addition, the service connection may or may not have a general siphon, this will depend on those being applied for the design of the plumbing installation, so the records must be from 15 * 24 in for depths up to 1 yd., 20 * 28 in for depths more than 2 yd.

Sewage and rainwater downspouts

The downspouts will be made of smooth materials, supported on a masonry pillar and fastened to a wall at separations @ 2 yd. by means of clamps.

The downspouts will be as straight as possible with their respective speed reducer @ 5 yd. by means of clamps. The joins with the branches and the horizontal sewer must be made with 45° angles. For reasons of economy, the number of sewage downspouts should be as small as possible, so it is advisable to overlap bathrooms, sinks and other sanitary services on successive floors so that they can be served by the same downspout.

Results

Applying the BIM methodology to the Toren 54 intelligent and sustainable building project and measuring the proposed objectives results in a virtual model containing information corresponding to the design of hydraulic, sanitary and rainwater installations. The methodology employed and used trough the REVIT software represents information a 3D model in floor and elevation plans as shown in figures 1, 2 and 3.

The hydraulic installations model was projected by modeling the nine levels, as well as verifying on site the ducts, position of high and low pressure piping, hydrants panels, records, etc. as shown in figures 4, 5 y 6.

Drinking water supply

For the calculation of the potable water supply, the different types of buildings indicated in the project data should be considered being the average amount necessary for a person to cover his or her basic daily needs.

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In certain developments destined for residential areas with special characteristics, another enough supply may be determined as deemed appropriate by Intermunicipal Drinking Water and Sewage System (SIAPA) and with prior justification by the calculator.

The water supply for the Toren 54project is considered medium, due to a lack of hydraulic coverage by the municipality and its added value that is considered water supply marked by the SIAPA and CONAGUA of 300 lt/hab/day, it turns 4 apartments for floor plus two apartments in pent-house were projected, estimating approximately 150 people in the intelligent building of nine floors, so the average consumption of the Toren 54 building is equivalent to 16425 m³ by year and 1638 by month.

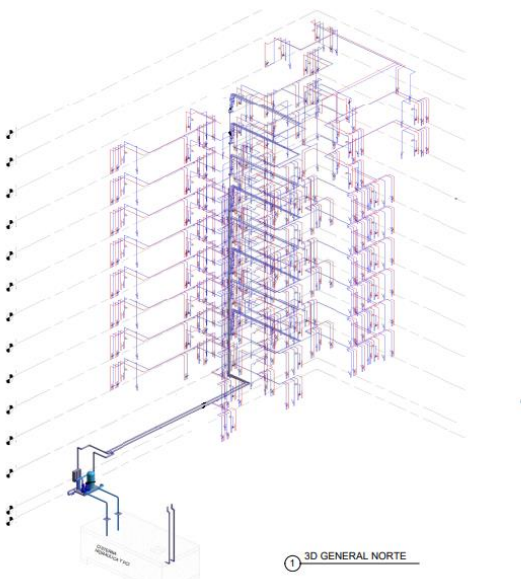

Figure 4. 3D isometric of the hydraulic installation of the Toren 54 project, displayed in BIM-REVIT
Source: Díaz Candelario, 2022

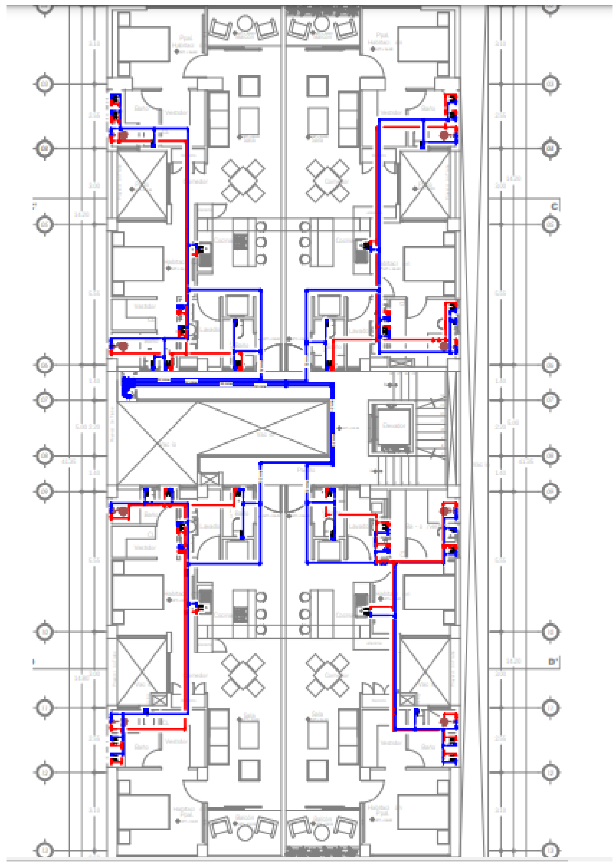

Figure 5 Architectural plan of the Toren 54 project, as well as the placement of furniture hot and cold water pipes
Source: Díaz Candelario, 2022

Design flows

The design flow is the amount of water required to meet the needs of the population in an average day of consumption. The expression that defines the average flow is as follows:

$$Qmed = \frac{Pob * Dot}{86400} \quad (1)$$

$$Qmed = \frac{150 * 300}{86400} = 0.520\ lt/seg$$

Maximum daily flow

This flow is used to calculate the daily extraction from the supply source, the pumping equipment, the conduction and the regularization and/or storage tank, it is obtained from the following expression:

$$Qmd = CVD * Qmed \quad (2)$$

$$Qmd = 1.4 * 0.520 = 0.730\ lt/seg$$

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Maximum hourly flow

This flow is required to satisfy the needs of the people on the day and at the time of maximum consumption. It is used to calculate the distribution networks and in some cases for the pipelines and is obtained from the following expression:

$$Qmh = CVH * Qmd \quad (3)$$

$$Qmh = 1.6 * 0.730 = 1.166\ lt/seg$$

Calculation of pump power

Once the maximum hourly flow has been determined, as well as the difference in level to be overcome by the pump itself, the pump power formula is applied, which is as follows:

$$P = \frac{\gamma\ Q\ Hb}{76\ \eta} \quad (4)$$

$$P = \frac{1000*1.116*38.75}{76*0.70} = 0.850 \text{ HP}$$

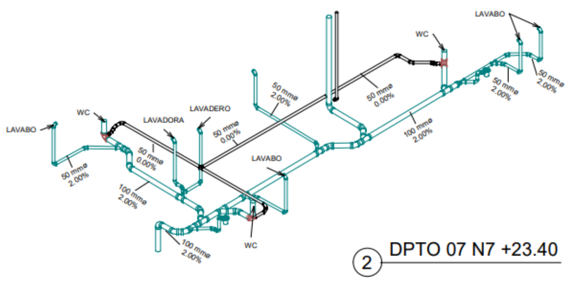

Figure 6 Isometric installation, including sinks, drains, and downspouts
Source: Díaz Candelario, 2022

Conclusions

The information is the most importance in the development of the BIM methodology, that is why it is very clear from the project planning to start collecting, organizing and analyzing quality information in order to establish the necessary guidelines for the whole modeling process and the logical development of the project.

In this way, quick access to information is achieved and there is an order in the entire work progress program that facilitates communication with the purpose of making the most of the BIM methodology and thus achieve more than a simple 3D model.

The REVIT software is not BIM, but it is part of the methodology that allows transforming the information into a virtual model, this makes it necessary that the knowledge and handing of the tool is adequate.

For our project we modeled with REVIT software, which allowed us to observe and solve mistakes in the pipes and in the design of plumbing installations, such as location of panels, valve connections, etc. Avoiding as little as possible the shock with the concrete structures (beams, footings and columns).

Being able to identify and solve these types of problems in the virtual model is what makes the BIM methodology totally innovative, since avoids altering the estimated time and costs when the work is being executed.

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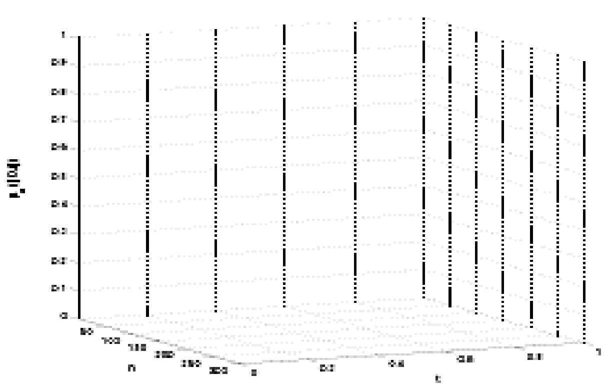

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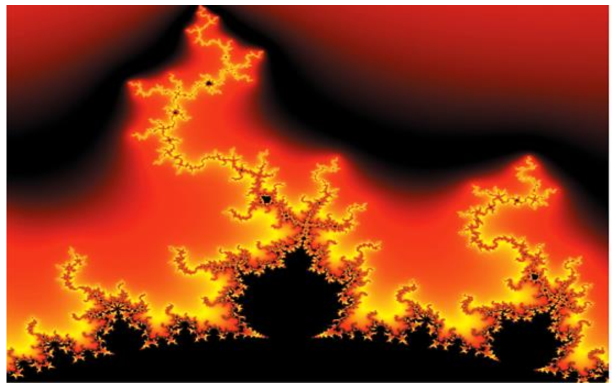

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