International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Effects on Reinforced Concrete Slabs by Environmental Loads

Aurora Martínez Loaiza, María Teresa Sánchez Medrano

Abstract: ***Throughout the development of accelerated testing procedures, the behavior of pure concrete specimens was evaluated for a comparison in the different effects that are generated between concrete specimens with resistance to the compression of 20 MPa (200 kg/cm2) regarding water/cement (w/c) 0.62, being this compressive the employee minimum value according to Mexican regulations and which is currently used in the construction of structural elements of the housing and specimens with compressive strength of 25 MPa (250 kg/cm2) with ratio water/cement (w/ c) of 0.55, considering that this resistance corresponds to the recommended minimum value according to criteria of durability in coastal areas to the same regulations. The different concrete structures early deterioration has been the cause of constant study in recent years, finding that their durability differs as specified in the Mexican regulations. Damages that occur in elements directly exposed to environmental influences, as in the case of roof slabs, are attributed, mainly, to errors and defects in the design stages or execution in the construction process and not to the effect of these charges. Visualizing the effect of conditions of moisture, temperature, and solar radiation on this type of structure requires years of direct observation. The mass loss and degradation of the exposed surface, as well as the penetration of the carbonation front, were established as measurement parameters. The significant mass loss registred was 0.374% in the specimens with an f’c of 20 MPa and a minor value of 0.046% in the specimens with an f’c of 25 MPa. Regarding the carbonatation front, a value of 10.7 mm was registered in the short edges of the trial specimens with an f´c of 20 MPa and 7.3 mm for the specimens with an f´c of 25 MPa.***

Even though the mass loss percentages were less than 1%, and considering that carbonatation triggers corrosion processes that lead to the early deterioration of reinforced concrete structures, the results obtained indicated that the increase to the compressive strength by decreasing the w/c relation, besides favoring the concrete mechanical properties, it can also increase its durability; demonstrating the necessity of designing concrete mixtures that attend the local weather conditions, and even more in the significant exposed elements such as roof slabs.

Keywords: ***Reinforced concrete, environmental loads, accelerated tests, carbonation.***

I. INTRODUCTION

Injuries caused by atmospheric agents can be direct causes that trigger pathological processes in reinforced concrete structures (Solís-Carcaño 2008, 45), although the lesions are usually attributed to errors and defects in the design or axis stages -follow in the construction processes (Barona and Sánchez 2005, 63). The constructive problems causing the aesthetic and functional deterioration affect the durability of the houses where walls and slabs are generally exposed to environmental loads, understanding these, such as changes in temperature, humidity, the pH of rainfall and the concentration of atmospheric pollutants (Solís-Carcaño. R. 2005.15), so they are considered among the most vulnerable elements in a structure. Slabs exposed to the environment, under certain conditions of heat and humidity or the presence of acid rain may decrease their useful life; the concrete may have empty spaces during the setting process (Suárez-Dominguez, EJ et al. 2020), such situation is more critical when the porosity of the concrete (in connection with its compressive strength) (Quintero 2011, 70), or the inadequate coating, facilitate the entry of moisture and penetration of chlorides to the matrix of the concrete, which, combined with carbonation processes, trigger the corrosion of the reinforcing steel (Xinhji Zhu 2016, 668); considering this phenomenon, the leading cause of deterioration of reinforced concrete structures (Ossorio 2014, 162). Within the environmental conditions, it is considered that the temperature and relative humidity are the most important physical characteristics (Mena 2005, 4); for this reason, the exposed concrete elements such as roof slabs, could be seen impacted by climatic and chemical factors primarily (Mena 2005,10).

The study area corresponding to Tampico-Madero-Altamira is surrounded by a system of lagoons, the Pánuco River, and the Gulf of Mexico. It is located in the region called the North Gulf Coastal Plain within the Mexican Republic, it has a sub-humid warm climate where rainfall is recorded between 1000 and 2000 mm per year and the temperatures oscillate in a range of 22 ° and 26 °C, with regions that exceed 26°C. Depending on the environmental humidity and the extreme temperatures it presents, it belongs to climate zone C (Mena 2005, 28) and due to its high degree of relative environmental humidity, it has been considered as one of the wettest areas in the country (Molina 1980, 177).

Revised Manuscript Received on February 28, 2020.

***** Correspondence Author

Aurora Martínez Loaiza*, Facultad de Ingeniería “Arturo Narro Siller”, Universidad Autónoma de Tamaulipas, México

María Teresa Sánchez Medrano, Facultad de Arquitectura, Universidad Autónoma de Tamaulipas, México

Table 1 shows the record of the climatic conditions of humidity, temperature, and solar radiation obtained from the Meteorology surface and Energy database. Table 1. Annual average values over 22 years (July 1983-June 2005) in Tampico, Tamaulipas. Mexico.
Latitude: 22.274 Longitude: -97.864 source: Own elaboration based on Atmospheric Science Data Center https://eosweb.larc.nasa.gov

Average monthly relative humidity	74.2%
Monthly air temperature at 10m above the Earth's surface	24.5ºC
Daily solar irradiation on a horizontal surface	4.9 kWh/m2/día

Physical injuries in roof slab eaves of the dwelling shown in Figure 1 (a) are a condition of deterioration commonly observed in the area, due to its high relative humidity content, (Molina-Capel 1980, 182) as well as of efflorescence, chemical lesions resulting from the interaction between environmental factors and materials used in construction (Broto 2004, 34).

The cracks in ribs, as shown in Figure 1 (b), are caused by the corrosion associated with the humidity of the environment and the poor coating of the reinforcement that accelerates the corrosion processes of steel (Papadopoulos 2011, 3367). In Figure 1 (c), the loss of mass in the reinforcing steel that generates a decrease of the mechanical properties and the reduction of its service capacity in this structural element can be seen.

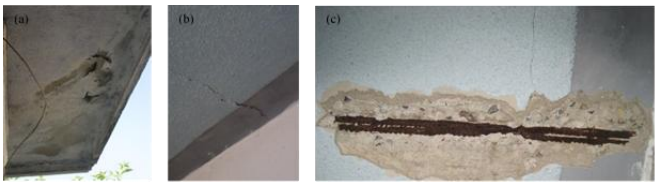

Figure 1. Physical, chemical, and mechanical injuries in reinforced concrete roof slabs. (a) Physical and chemical injuries in eaves caused by humidity in the environment. (b) Mechanical and chemical injuries associated with corrosion of reinforcing steel. (c) Loss of mass in the reinforcement steel in ribs. Source: Photograph of the authors.

High concentrations of chlorine and humidity, present in coastal or marine areas, generate more aggressive environments for the structures, causing premature deterioration that leads to corrosion (Solís-Carcaño. R. 2005, 16), as could also be verified in the walls of reinforced concrete in homes in southeastern Mexico (Solís-Carcaño 2008, 49), increasing repair and maintenance costs in both public and private works (Troconis, 2011, 102).

This implies the existence of a potential correlation between environmental loads (defined as environmental effects, such as humidity, temperature, salinity, the pH of rainfall and the concentration of air pollutants on the structural elements), and the injuries present on reinforced concrete roof slabs. Therefore, comes the need to determine the influence that weather conditions and air pollution exert on the process of deterioration of these structural elements which can lead to adequate preventive and corrective maintenance strategies, including changes in current regulations. As an alternative to studying the behavior and durability of reinforced concrete slabs, a simulation of the environmental conditions of sunlight, humidity, and dew was carried out through an accelerated artificial aging chamber that by UV fluorescent lamps reproduces the harmful effects of the sunlight alternating with condensation cycles at high temperature and dew (spray) comparable to the conditions of the outdoor environment, (Nogueira, Ribeiro, Moysés, Dias, & Dias, 2009). The accelerated aging data are comparative, without a conversion factor between the hours of exposure in the artificial aging chamber and the equivalent exposure abroad due to the vast number of variables related to its geographical location and climate, (Grossman s / f, 1).

Carbonation in concrete is the loss of pH that occurs when atmospheric carbon dioxide reacts with moisture inside the pores of the concrete and converts calcium hydroxide with a high pH to calcium carbonate, which has a more neutral pH. When CO2 increases in atmospheric air due to combustion processes, the visible carbonation of concrete accelerates, increasing the risk of deterioration.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

When the calcium, sodium, and potassium hydroxides are carbonated, the pH decreases resulting in an acidic medium, when the carbonation front crosses the thickness of the coating and reaches the area of the reinforcing steel, this decrease in pH leads to the disappearance of the passive layer of steel that protects it from corrosion. A suitable coating will keep the protection of the reinforcement longer, delaying the deterioration process (Muñoz and Mendoza 2012, 75).

A common practice to measure the carbonation front is to spray a 1% phenolphthalein solution in ethyl alcohol, as a pH indicator, on the freshly cut face of a concrete specimen (Galan 2011, 26). When the concrete is carbonated, that is to say, that its pH is lower than eight due to the acidification that produces the CO2 of the environment, the concrete surface will not present color change, otherwise, for the original pH values of the concrete, will acquire a bright pink color.

According to Ycaza, 2011, the color change that occurs can be explained through the following chemical equations:

- From neutral to the primary medium: colorless → Pink
  $H_2Phenolphthalein + 2OH^- \leftrightarrow$
- $Phenolphthalein^{2-} + 2H_2O$

- From basic to very basic: Pink → colorless
- $Fenolftaleina^{2-} + OH^- \leftrightarrow Fenolftaleina(OH)^{3-}$
- From basic medium to neutral or acidic medium: Pink → Colorless
- $Phenolphthalein^{2-} + 2H^+ \leftrightarrow H_2Phenolphthalein$

As the pH of the concrete decreases due to the carbonation activated by the environment, a loss of basicity occurs in the concrete. In order to predict and reduce the degree of carbonation of concrete through the identification of the most appropriate parameters for a mixture, methods have been developed in which nomograms are used for the design of mixtures.

In experiments carried out, it was determined that the water/cement ratio had a more significant influence on the carbonation rate, establishing that at a higher water/cement ratio, there was an increase in the depth of the carbonation front, (Helene and Castro 2009, 35). It is also convenient to use evaluation techniques, mainly non-invasive that characterize this process for its subsequent correlation and resistance change (Suárez-Domínguez et al.

2015, 24) and even other critical subsequent properties (Suárez-Domínguez, EJ et al. 2014, 38).

II. EXPERIMENTAL PART:

Two types of concrete mixtures were designed, the first type with compressive strength f'c of 20 MPa (200 kg / cm2) traditionally used in the construction of slabs in homes and the second type with the value of compressive strength minimum recommended if the criteria of durability in coastal areas corresponding to a f'c of 25 MPa (250 kg / cm2) are applied. Table 2 shows the proportions and characteristics of the materials used.

Table II. The proportion of concrete mixtures used in the EAA test

Proportions of concrete mixtures% (P / P)		
Used materials	f´c = 20 MPa	f´c = 25 MPa
Portland Cement Compound (CPC) CEMEX	15.2	17.2
Water	8.8	9.4
Abra gravel of 19 mm maximum size and specific weight 2.7	42.2	40.2
River sand of the Pujal bank with specific weight 2.61	33.8	33.2

In each type of concrete produced, the compressive strength in cylinders 150 mm in diameter and 300 mm high was determined, and the rupture module was calculated in beams 600 mm long, 150 mm wide, and 150 mm high tested to bending. For the accelerated aging test, 36 specimens (tablets) with average dimensions of 75 mm thick, 10 mm wide, and 150 mm long obtained from the cutting of concrete beams used in bending tests were used. For the cutting, a universal disk cutting machine brand Controls model 55-C0210 / BZ was used. 18 tablets with f´c = 20 MPa and 18 tablets with f´c = 25 MPa were placed in a QUV / spray model accelerated aging test chamber, distributed in such way that the end panels where less UV rays are received remain free, according to manufacturer recommendations. Figure 2 shows the arrangement of specimens in one of the four sections that the camera has.

Figure 2 Placing specimens in the EEA chamber. Source: Photograph of the authors

For the exposure of the tablets, the ASTM G 154 cycle was attended, which includes the stages shown in Table 3. The specimens were tested for 180 hours in which a total of 15 cycles were completed that included the three stages described. For each type of concrete tested, 5 control tablets were reserved.

Table III. ASTM G154 G cycle specifications. Source: Q Lab 2017

Lamp Type. UVA-340 (Equip: QUV/Spray) *N/A: Not applicable				
Stage	Function	Irradiance (W/m2)	Temperature (ºC)	Weather (hh:mm)
1	UV	1.55	60	8:00
2	Spray	N/A	N/A	0:15
3	Condensation	N/A	50	3:45
4	Final stage: repeat Stage1			

Constant mass values were recorded in each specimen before and after the accelerated test with a sensitivity of ± 0.1 g.

Microscopic photographs (500) x were taken from specimens of both types of concrete tested in an accelerated aging chamber and control specimens in order to observe contrasts on the surface of exposed and unexposed concrete. The penetration of the carbonation front was determined, for this, the tested tablets were sectioned in the accelerated aging chamber and the control ones, immediately a solution of 1% phenolphthalein in alcohol was applied to them on the freshly cut and free cross-section of powder of each specimen.

PH values greater than 8 show a bright pink color while the carbonated areas do not register a change in color; according to this, the carbonation depth in millimeters was measured.

A. Results and Discussion

For each type of mixture, the percentage of mass variation of five control specimens and five specimens tested in the aging chamber (EAA) in the ASTM G154 cycle described above was obtained. As expected, no variation in mass was found in control specimens. Table 4 shows the average values of the mass variation and the standard deviation in the specimens tested in the aging chamber, finding that a significant difference in these changes is not visualized. The samples tested did not show significant surface degradation.

Table IV. Average percentages of mass variation and standard deviation of specimens tested for 180 hours in the aging chamber in the ASTM G154 G cycle.

f'c in MPa	Mass variation in%	Standard deviation
20	-0.20	0.0027
25	0.02	0.0009

Figure 3 shows the microscopic concrete surfaces obtained from the samples. Regarding the effects of accelerated aging, no differences were detected between specimens before and after the test, except for erosions that were not significant since the percentages in mass loss were less than 1%.

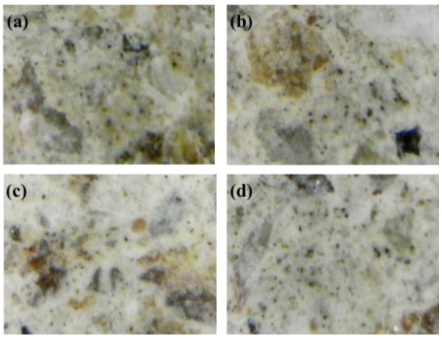

Figure 3. The visual appearance of concrete surfaces under the 500x microscope. (a) Tablet f'c = 200 kg / cm2 with 180 hours in EAA. (b) Tablet f'c = 200 kg / cm2 of control. (c) Tablet f'c = 250 kg / cm2 with 180 hours in EAA (d) Tablet f'c = 250 kg / cm2 control. Source: Photograph of the authors.

In the results of the carbonation test on tablets with f´c of 20 MPa, only one control specimen of those tested recorded progress on the carbonation front with an average value of 2.5 mm. In the case of the control tablets with f´c of 25 MPa, three presented an advance of less than 0.1 mm in the carbonation front, and the average value obtained in the remaining ones was 2 mm.

This may be due to the fact that in cases where there is no significant advance in the carbonation front, aggregates were found that inhibited the permeability of the liquid with phenolphthalein in them.

Table 5 shows the average CO2 penetration values obtained in each of the specimens with f´c of 20 MPa tested in the aging chamber. An increase can be visualized as the number of series increases with a maximum difference of increase of 25%. In all cases, carbonation is visualized along with the tested tablets.

Table 6 shows the average CO2 penetration values obtained in each of the specimens with f´c of 25 MPa tested in the aging chamber. In this case, values were also obtained that increased as the analyzed series were studied, finding no significant differences in the average of the TQ-25-2 and TQ-25-3, however, it is essential to note that the maximum and minimum values do change, showing a stabilization and uniformity in the TQ-25-2 which means that it has a homogeneous carbonation front.

Table 5 Carbonation test with 1% phenolphthalein dew in tablets tested in EAA with f'c of 20 MPa.

f´c **20 MPa**	CO2 penetration in mm		
Series	Maximum	Minimum	Average
TQ-20-1	5.5	0.5	3.00
TQ-20-2	6.0	2.0	4.00
TQ-20-3	8.0	1.0	4.50
TQ-20-4	8.6	2.0	5.30
TQ-20-5	7.7	3.0	5.35

Table 6 Carbonation test with 1% phenolphthalein dew in tablets tested in EAA with f'c of 20 MPa.

f´c **25 MPa**	**Penetration de CO2 in mm**		
Series	Maximum	Minimum	Average
TQ-25-1	5.0	2.0	3.50
TQ-25-2	4.0	4.0	4.00
TQ-25-3	6.0	2.0	4.00
TQ-25-4	6.5	4.0	5.25
TQ-25-5	9.0	5.0	7.00

Figure 4 shows the surfaces sprayed with phenolphthalein, where the control specimens for each type of concrete show the bright pink color, and the tablets tested in the artificial aging chamber show progress in the carbonation front. The changes in hue due to carbonation and uniform carbonation sections in most cases, are greatly appreciated. In other cases, such as the one presented in Figure 4c, it may be noted that some tablets showed complete carbonation throughout the cross section, although on the surface, they presented carbonation uniformity. This may be due to the porosity changes that are possible during the setting of concrete samples (Suárez-Domínguez, E.J. et al. 2020) that can modify the passage of liquids through the solid medium.

Figure 4 Test to determine the carbonation front with phenolphthalein. (a) Tablet f´c = 200 kg / cm2 of Control. (b) Tablet f´c = 250 kg / cm2 of Control. (c) Tablet f´c = 200 kg / cm2 with 180 hours in EAA. (d) Tablet f´c = 250 kg / cm2 with 180 hours in EAA. Source: Photograph of the authors.

Regarding the carbonation potential, it could be observed that in all the tablets exposed in the accelerated aging chamber for both types of concrete there was a decrease in pH, the capillary interconnection existing in the pores of the concrete, as well as changes in humidity and high temperatures may be factors that decrease the resistance to penetration of the carbonation front.

B. *Conclusions:*

The results show that the increase in compressive strength in addition to favoring the mechanical properties of the concrete can also increase its durability, the behavior in the specimens tested with f´c of 25 MPa was superior when not presenting mass loss compared to the specimens tested with f´c of 20 MPa whose percentage was 0.20%. Although the values obtained are shallow, these losses are related to the collapse or detachment of concrete particles in areas where air bubbles are trapped and to be located near the exposed surface gave rise to an effect similar to a micro erosion process as well as the effect of the volumetric changes caused by the alternating cycles of humidity, dew, condensation, solar radiation, and high temperatures.

The exposed concrete samples decreased the pH value of the liquid present in them; in contrast, the control tablets of both concrete when presenting the bright pink color throughout their surface indicated pH values greater than 8, thus showing that the penetration of the carbonation front was zero. Since carbonation is a trigger for corrosion processes in accordance with what has been demonstrated in various studies, it is, therefore, necessary to meet the climatic conditions in the design of concrete mixtures and even more so in the most exposed structural elements such as slabs of the rooftop. Accelerated tests are an alternative that allow us to visualize in a shorter time the effects on concrete structures exposed to environmental loads, in future work, studies will be carried out to determine possible changes in mechanical compression properties after accelerated tests and a more detailed inspection of exposed surfaces using high-tech measuring equipment.

Gratefulness:

To Facultad de Arquitectura, Diseño y Urbanismo Materials Laboratory of the Universidad Autónoma de Tamaulipas, to the Universidad Politécnica de Altamira Materials Laboratory and the CONACyT Project: National Problems PN2017-5975.

REFERENCES

1. Barona, E., and Sánchez F. (2005). Pathological processes in social housing. The man and machine No. 24. January-June 2005. Recovered from: http://ingenieria.uao.edu.co/hombreymaquina/revistas/24%202005-1/articulo%205%20HyM%2024.pdf
   Broto, C. (2004). Broto Encyclopedia of Construction Pathologies. Spain.
2. Castro-Borges, P., Torres-Acosta, A., Balancán-Zapata, M., and López-González, A. (2012). Damage analysis due to the interaction of environmental and structural loads in a marine substructure. Construction Magazine, 11 (3), 88-98.
3. Civilgeeks.com Engineering and construction. The phenolphthalein test - comfortable and useful, Ycaza Xavier [Online] <URL: https://civilgeeks.com/2011/09/27/la-prueba-de-fenolftaleina-%E2%80%93-facil-y -util />.
4. Galán García Isabel (2011). Carbonation of concrete: a combination of CO2 with the hydrated phases of the cement and pH change front. (Doctoral thesis). The Complutense University of Madrid. ISBN: 978-84-695-0996-8.
5. Grossman, D. (s / f). Technical Bulletin LU 0833 Correlation, Questions, and Answers. Obtained from Q-Lab Corporation: www.q-lab.com
6. Helene, P., and. Castro-Borges, P. (2009). A novel method to predict concrete carbonation. Concrete and cement Research and development, 1 (1), 25-35.
7. Mena-Ferrer, M. (2005) Durability of concrete structures in Mexico: Forecasts and recommendations. IMCYC. ISBN 968-464-149-4. Editorial production: Ing. Raúl Huerta Martínez.
8. Molina-Capel, J. (1980). The relative humidity in the United Mexican States. Dialnet, 175-190.
9. Muñoz-Salinas, F., and Mendoza-Escobedo, C.J. (2012). Durability in reinforced concrete structures from the perspective of the Spanish standard for concrete structures. Concrete and cement. Research and Development, 4 (1), 63-86, July-December 2012.
10. Nogueira, P., Ribeiro, J. C., Moysés, M. R., Dias, A. C., & Dias, S. C. (2009). Effect of accelerated artificial aging on the compressive strength of composite resins. Obtained from the Venezuelan Dental Act: https://www.actaodontologica.com/ediciones/2009/1/art-6/
11. Ossorio, A. &. (2014). Prediction of the useful life of reinforced concrete structures through the use of a chloride diffusion model. Journal of the Faculty of Engineering, Universidad de Antioquía, (72), September, 161-172.
12. Papadopoulos, M. P. (2011). Corrosion of exposed rebars, associated mechanical degradation, and correlation with accelerated corrosion tests. Construction and Building Materials 25, 3367-3374.
13. Quintero-Ortíz, L., Herrera, J., Corzo, L., & García, J. (2011). The relationship between compressive strength and porosity of concrete evaluated from ultrasonic parameters. ION Magazine, 24 (1), 69-76.
14. Suárez-Domínguez, E. J., Aranda-Jiménez, Y. G., Pérez, A. P., & Izquierdo-Kulich, E. I. (2015). Determination of temperature and time profiles in a heat transfer process on land. Cuban Journal of Engineering, 6(1),23-28
15. Suárez-Domínguez, E. J., Aranda-Jiménez, Y. G. & Izquierdo-Kulich, E. I. (2014). Temporary compression resistance model for poured land. epsilon, (23), 33-42.
16. Solís-Carcaño, R. G. (2008). Damage assessment due to environmental aggression in a reinforced concrete housing. Engineering Magazine of the University of Costa Rica, Vol. 18 45-55.
17. Solís-Carcaño. R., M. E.-B. (2005). Durability in the structure of concrete housing in coastal area. Engineering Academic Magazine of the Faculty of Engineering of the Autonomous University of Yucatán, Vol. 9 No. 1 13-18.
18. Suárez-Domínguez, E. J., Pérez-Rivao, A., Sánchez-Medrano, M. T., Pérez-Sánchez, J. F., & Izquierdo-Kulich, E. (2020). Mesoscopic model for the surface fractal dimension estimation of solid-solid and gas-solid dispersed systems. Surfaces and Interfaces, 18, 100407.
19. Troconis, et. to the. (2011). Impact of the tropical environment on the durability of reinforced concrete structures. Magazine of the University of Zulia 3a. epoch. Agro Sciences, Engineering, and Technology, Year 2 No.2 100-154.
20. Wenjun Zhu, R. F. (2016). Influence of long-term chloride diffusion in concrete and the resulting corrosion of reinforcement on the serviceability of RC beams. Cement and Concrete Composites, 144-152.
21. Xingji Zhu, Goangseup Zi, Wonwoo Lee, Soye Kim, Jungsik Kong. (2016). "Probabilistic analysis of reinforcement corrosion due to the combined action of carbonation and chloride ingress in concrete." Construction and Building Materials, 667–680.

AUTHORS PROFILE

Aurora Martínez Loaiza, Architecture Ph.D. Teacher-Researcher from the Autonomous University of Tamaulipas, México. Teacher-researcher of the Faculty of Engineering "Arturo Narro Siller" of Tamaulipas, Mexico. She obtained the university award in 2019 for Research of Excellence by the UAT. She develops research in the area of technology in traditional materials by improving existing materials.

She has several publications in of housing materials technology area. She contributed in the elaboration of a book's chapter about housing subjects. She teaches for the structural area of the Engineering and Architecture degree in the UAT. She has participated as contributer in national research projects such as CONACYT.

María Teresa Sánchez Medrano, Architecture Ph.D. Teacher-Researcher from the Autonomous University of Tamaulipas, México. Teacher-researcher of the Faculty of Architecture, Design and Urbanism of Tamaulipas, México. She obtained the university award in 2013 and 2017 for Research of Excellence by the UAT. She develops research in the area of technology of traditional and alternative materials by trying new proposals and improving existing materials.

She has several publications in of housing technology and alternative materials area. She belongs to the National Researchers System of CONACYT (SNI), México. She teaches for the structural area of the Architecture degree in the UAT. She participates in national research projects such as CONACYT and PRODEP.