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Improving the Thermal Comfort of ferrocement Classrooms by Involving the Community in the Use of Alternative Construction Technology

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Abstract

This study was planned to realize two objectives: one, to determine how to use bioclimatic strategies to solve the thermal problems in classrooms constructed of ferrocement in one school in the community in Sta. María Roalo, Oaxaca, México. The other was a social objective that dealt with the involvement of students, teachers and parents as a mechanism to help them develop through workshop activities skills needed to improve the conditions in the school. A physical diagnosis was carried out on the environmental conditions in the classrooms during different observations and with measurements taken during the 2010 summer season. The observations of the students and teachers on the comfort levels in the classrooms were collected by questionnaire. Their perceptions of what needed to be done to improve both the aesthetics and the thermal conditions in the classrooms were collected from the students and teachers in informal meetings and other questionnaires. The study established a method of bioclimatic analysis that can be used to form a basis for designing strategies to improve the environment and the comfort level of the classrooms. The study proposes a participatory methodology in which students and other users of the classrooms work together in workshops to develop the capacity to use construction techniques appropriate for the conditions found in the classrooms.

Keywords: Appropriated technology, bioclimatic strategies, ferrocement classrooms, qualitative study.

1. Introduction

It is urgent that the neediest sectors of society develop solutions to long standing problems with infrastructure especially in school and housing construction. It is also true, that this situation presents an opportunity to committed professionals to work in solidarity with people in their communities in order to help them become protagonists in finding solutions to their problems. This paper presents one way in which expertise in construction at the Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional (CIIDIR) from the Instituto Politécnico Nacional Unidad Oaxaca, México has been transferred to a community to help with problems in school construction.

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The principle underlying the project is to help the members of the community help themselves by locating the responsibility for the planning and management of the project in the village (González et al., 2011; Pérez, 2001).

It was decided to use a method that is mutually beneficial to both CIIDIR and the community. For CIIDIR the objectives are to enrich the academic programs in three areas; teaching, research and extension. For the community, especially for the students, the teachers and the parents of the school, the objectives are to become aware of the problems and their possible solutions, particularly by acquiring technical skills which are easy to learn (Garzón, 2001). It is possible that with the experience gained in this project the community will be able to identify and address other concerns in the community for example, issues related to housing, potable water and sanitation. In this case with this newly-acquired knowledge and these skills, they will be able to solve the problems of comfort in the interior of the classrooms and the school in general.

2. Localization

This study occurred in Santa María Roalo which is part of the municipality of Zaachila located in the state of Oaxaca, México. The geographical coordinates of the town are latitude 15º 47’02’, longitude 96º 55 and altitude 1500 msnm (Figure 1)

Figure 1. Project localization

3. Methodology

This research employs the same methods and is a continuation of the work carried out by Caballero et al., (2010). The earlier work was a cross sectional study employing both qualitative and quantitative techniques. The methodology of the field work was conducted in three phases: a) sensitization to the problems b) diagnosis of the thermal conditions of ferrocement classrooms, based on social and physical perceptions and c) planning strategies to solve the problems. As a result of this intervention several proposals were developed, one of which is reported in this paper.

The study (Caballero et al., 2010) was conducted at the Escuela Telesecundaria in the community of Santa Maria Roaló, Zaachila, Oaxaca, México. It examined the issues of comfort in the classrooms which were built with ferrocement technology (Figure 2). The research team, following the methods of participatory action research,(Alberich, 2002; Maffrand et al., 2002), adopted the following structure: a)participatory diagnosis, b) the development of a conceptual frame work and c) a participatory action plan to implement the solutions to the problems.

Figure 2. School built with ferrocement technology. Sta. María Roaló, Zaachila. (Photo: J. Caballero, 2010)

3.1 Diagnosis

The diagnosis comprised a quantitative study (Lertsatitthanakorn et al., 2009; Krugger and Givoni, 2004) in which the temperature of the classroom environment was measured. The diagnosis also included qualitative information (Clemes-Croome et al., 2008; Buidawi, 2007) from the students and teachers on their perceptions of the thermal conditions in the school with on-site physical observations made on four separate occasions of the activities in the classroom and of the behaviors of the users.

3.1.1 Physical diagnosis comfort classrooms

Dataloggers temperature recorders (HOBOS) were used in two classrooms which presented critically high temperatures. The temperatures in the classrooms were recorded during the summer season (May and June 2010) at hourly intervals for sixty days. The aim of the measurements was to discover, analyze and evaluate the thermal behavior of these ferrocement classrooms.

3.1.2 Qualitative diagnosis

A qualitative study was conducted using a questionnaire to ascertain the knowledge and impressions which students and teachers had, of the problems in the classrooms and their possible solutions. The level of interest and the desire to participate in the project were also explored (Figure 3).


Figure3. Participatory diagnosis with students and parents. (Photos: R. Alavéz, 2010)

Specifically the questionnaires collected data on the following information: perceptions of the variations in temperature, typical activities in the classrooms, satisfaction with the comfort level inside the classroom, preferences for types of ventilation and lighting, impressions of the impact of the temperature in the classrooms on students´ health and perceptions of an ideal model classroom for students.

3.1.3 Developing a Conceptual Framework

The information obtained from physical diagnosis of the classrooms together with the information from the questionnaires completed by students and teachers, was collected, synthesized and analyzed. The results were made available to the students, teachers and parents. Following that the CIIDIR team presented alternative and strategies to resolve the problems of comfort in the classrooms.

3.1.4 Participatory Action Workshop

This strategy was proposed as a way of training members of the school community, students, parents and teachers, to be the generators of their own solutions, through the acquisition of knowledge and the interpretation of their circumstances (Enet, 2012; Mori, 2008). With that understanding, they can move to transform their reality.

The workshop developed the following agenda:

1) The adoption of a social pedagogy which allows the participants to work as partners to achieve: a) to motivate people to take individual responsibility in their community, b) to work together to identify their problems, and c) to design and implement solutions. In this case the problems were identified as difficulties with stabilizing the comfort level and with associated health problems in the classrooms.

2) The Methodology first called for the establishment of an environment in which the group could work. Second, in that environment they would have opportunities to learn from the personnel of CIIDIR both the knowledge and the processes of construction. Third, they would need time to discuss how they felt about the appropriateness of this alternative construction and whether it would meet their needs. Fourth, they would have the opportunity to practice using the methods of alternative construction and to decide if it is what they need.

3) Characteristic of the workshop as an instrument of social research, the process emphasized “learning by doing”(Arrow, 1962) during which participants carried out alternative construction methods with researchers from CIIDIR, and reflected on the activity afterwards (Figure 4).

Figure 4. Workshop Activities. (Photo: J. Caballero, 2010)

4. Results

Figure 5 shows the average temperatures recorded in one of the classrooms in the study period (The data in Figure 4 presents information from one of the *Dataloggers,* because the other *Dataloggers* failed). The thermal comfort zone for Oaxaca City, 21.5 to 26.5ºC, is presented in horizontal blue discontinued lines. 80% of the temperature readings both inside and outside the classroom are located outside of this zone. Moreover, there is little difference in thermal lag presented during school hours, from 7 am to 14 pm. This indicates that the insulating capacity of ferrocement is almost zero. Therefore the community decided to take actions to improve the thermal conditions in the classrooms.

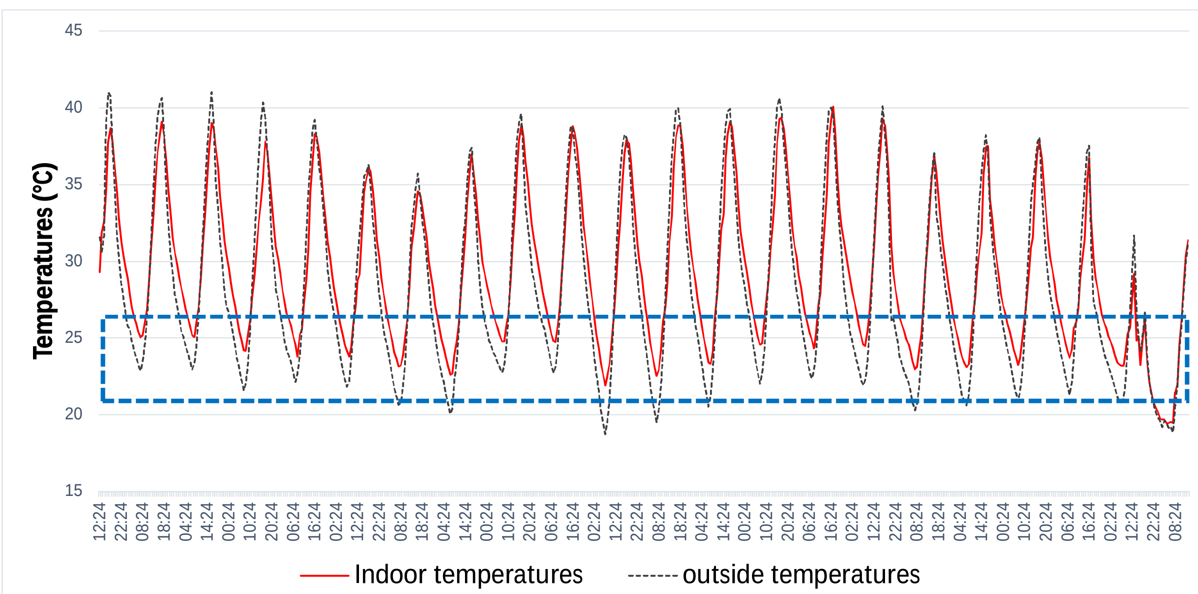

Figure 5. Temperatures in lecture halls during the summer

4.1 Bioclimatic Strategies

Figure 6 denotes some design strategies than can be used during the Oaxaca City summer season to provide comfortable classroom conditions: cross-ventilation, the use of vegetation which will release oxygen and by shading, help to avoid solar radiation during the highest radiation hours.

Figure 6. Vegetation outside of classrooms to provide fresh air. (Photo: R. Alavéz)

Another design strategy is to use thermal insulation on the roof and ferrocement walls, this can be done by building a second roof (Figure 7) using local materials and urban solid waste (recycled plastic bottles and cardboard).

Figure 7. Bioclimatic strategies-second roof on classrooms. (Photo: R. Alavéz)

4.2 Results of the questionnaire

An analysis of the questionnaires completed by 38 students yields the following information: The average age of the students who completed the questionnaire is 14.4 years. The student group consisted of 56.3% male and 43.8% female. The majority of the students said that the principal activities in the classroom during school hours are to study (69.8%), to write (25%) and to read (6.3%).

The results of the section of the questionnaire dealing with the students' perceptions of ventilation, temperature and associated health problems are reported below (Tables 1 y 2).

Table 1. Perception of temperature and ventilation in classrooms

Variables	Categories	Frequency (n)	Percentages (%)
Temperature perception			
Common fan use	Yes	27	84.4
	No	5	15.6
	Total	32	100
Perception of air flow without the fan	Not at all acceptable	18	56.3
	Slightly acceptable	6	18.8
	Moderately acceptable	4	12.5
	Very acceptable	2	6.3
	Just right/completely acceptable	2	6.3
	Total	32	100
Perception of the temperature in the classrooms without the fan.	Very cold	1	3.1
	Slightly warm	1	3.1
	Warm	13	40.6
	Very warm	17	53.1
	Total	32	100.0
General perception of temperature in classrooms.	Acceptable	4	12.5
	No acceptable	28	87.5
	Total	32	100.0
Inside classroom ventilation			
Satisfied with air flow.	Yes	5	15.6
	No	27	84.4
	Total	32	100
Satisfied with Indoor environment.	Yes	20	62.5
	No	12	37.5
	Total	32	100
Suggestions for strategies to improve the environment.	Bigger fans, insolation	31	96.9
	No suggestions	1	3.1
	Total	32	100.0

Table 2. Health problems from the environmental classrooms conditions

Variables	Categories	Frequency (n)	Percentages (%)
Severe respiratory infections	Yes	6	18.8
	No	26	81.3
	Total	32	100
Claustrophobia	Yes	6	18.8
	No	26	81.3
	Total	32	100
Suffocation	Yes	2	6.3
	No	30	93.8
	Total	32	100
Eye problems	Yes	5	15.6
	No	27	84.4
	Total	32	100
Dehydration	Yes	12	37.5
	No	20	62.5
	Total	32	100
Allergies	Yes	3	9.4
	No	29	90.6
	Total	32	100
Sleepiness	Yes	10	31.3
	No	22	68.8
	Total	32	100
Headache	Yes	7	21.9
	No	25	78.1
	Total	32	100

The results show that the majority of the students surveyed (94%) said that they suffered some physical reactions to the environment in the classrooms, the most common being sensations of dehydration and sleepiness. The students indicated their tastes and preferences from the point of view of the esthetics of the building. They wanted any changes in the school to reflect their responses in Table 3.

Table 3. Ideal classroom preferences

Variables	Categories	Frequency	Percentages
Exterior walls classroom color preferences	Clear/Bright	28	87.4
	Dark	2	6.3
	Not answered	2	6.3
	Total	32	100
Preferred environment outside of classroom	Planters	21	65.6
	Trees	5	15.6
	Water mirrors	5	15.6
	Total	31	96.9
	Not answered	1	3.1

Results showed that teenagers prefer square shapes and bright colors for their "ideal classrooms". These features are similar to traditional schools built in many Oaxaca regions. This trend is due mainly to the preference that they have regarding the physical space of the classrooms, especially as they relate to their experiences both real and imagined (Silva, 2008). Preferences for the outside environment of the "ideal classroom" followed the directions established by Alvarez (2011), who believes that preferences in regard to physical space are linked to nature and necessity. These young students live in a rural setting with abundant vegetation and as a consequence their responses are shown in drawings of an ideal outdoor space, replete with planters, trees, bushes and ornamentation (Figure 8).

Figure 8. Detailing a model of an ideal classroom by the students. (Photos: J. Caballero, 2010)

4.3 Workshop

The development of the workshop enabled the community participants to acquire basic skills in organization and cooperation. It enabled the researchers from CIIDIR to modify their approach when working in order to link the construction technology with the needs of the communities. There was ample time and space during the workshop for reflection and an exchange of information on the experiences of the participants. The workshop was designed to include each of the stakeholder groups, in particular the students, teachers and people in the community. Because of its inclusiveness it was possible for all the participants to learn about and understand the expectations and aspirations of the other participants and to plan ways to realize their aspirations (Figure 9).

Figure 9. Construction of planters using plastic bottles. (Photo: J. Caballero, 2010)

One of the technologies dealt with in the workshop consisted of building a type of modular panel that they constructed with mesh and mortar-cement (Caballero, 2013). Then they filled the panels with recycled materials (PET and cardboard). Using these panels they were able to build walls and roofs with an easy-to-learn technique in which both women and men were able to participate after a minimum of training (Figure 10).

Figure10. Women and men filling the panel with recycled material. (Photos: J. Caballero, 2010)

The technology was adapted to fit the local resources- human, material, cultural and economic. The modular construction systems use components which required the use of recycled material and a minimal amount of readily available conventional material. The techniques of construction are easy to learn and allow for the ownership of the construction by the people of a community with few qualifications and little training. In addition because the system of construction is simple it does not require the use of sophisticated equipment or tools for implementation. During the workshop theoretical session, participants were informed on technical and economic benefits of the building technology (sandwich panel). Then CIIDIR team proceeded to organize working groups to build sandwich panels supervising their activities. Learned the construction technique participants were able to build insulating walls. This strategy has the purpose of helping the classrooms inside comfort (Figure 11).

Figure 11. Construction technique implemented on classroom walls to isolate them. (Photo: J. Caballero, 2010)

5. Conclusions

In this study during the workshop the researchers from Instituto Politécnico Nacional- CIIDIR and the school community of Santa Maria Roalo, Oaxaca, México, joined together to learn how to plan for any project undertaken to improve their quality of life. Then they learned simple construction techniques by building components for housing and schools. The experience gained in the workshop is applicable and adaptable to conditions in similar communities in the various regions of the state. Following this project, the demand for the use of alternative materials and methods in the building of schools and houses will play a fundamental role in disseminating the technologies to other communities.

The collaboration and knowledge of appropriate building technologies and methods of organization should permit the students, teachers and parents to solve future problems of school improvement. Participatory approach will be an important strategy to bring actions based on proposals obtained from the bioclimatic study to improve classrooms comfort. CIIDIR researchers will continue with technical assistance and training workshops with students, teachers and community participation. In conclusion researchers have asocial responsibility to the community and it can be best fulfilled through the dissemination and application of alternative technologies in construction to improve the quality of life of people in the larger Oaxaca communities.

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