Vol 6 Issue 8 May 2017

ISSN No : 2249-894X

Monthly Multidisciplinary Research Journal

Review Of Research Journal

Chief Editors

Ashok Yakkaldevi
A R Burla College, India

Ecaterina Patrascu
Spiru Haret University, Bucharest

Kamani Perera
Regional Centre For Strategic Studies, Sri Lanka

Welcome to Review Of Research

RNI MAHMUL/2011/38595 ISSN No.2249-894X

Review Of Research Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial Board readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.ror.isrj.org

REVIEW OF RESEARCH

EVALUATION OF STRUCTURAL PERFORMANCE IN CONSTRUCTIVE SOIL-CEMENT AND CELLULAR CONCRETE SYSTEMS- (BRAZIL)

Renato Acriz Menezes[1], Mesaque Silva de Oliveira[2], Marco Antonio Guerreiro Prado Filho[3], Wesley Gomes Feitosa[4], Doriedson Sousa Dias[5], Júlio Cesar de Alencar Bessa[6]

[1] Master's degree from the Federal University of Uberlândia UFU (2006), Teacher at Laureate International Universities / UNINORTE (Brazil),

[2] Master's degree from the Federal University of Amazonas - UFAM (2017), Teacher at Laureate International Universities / UNINORTE (Brazil),

[3] Master's degree from the Federal University of Pará - UFPA (2016), Teacher at NiltonLins University / UNL (Brazil),

[4] Master's degree from the Federal University of Amazonas - UFAM (2017), Teacher at Laureate International Universities / UNINORTE (Brazil),

[5] Master's student degree from the Federal University of Pará - UFPA (Currently), Civil Engineer from Laureate International Universities / UNINORTE (Brazil),

[6] Master's degree from the Federal University of Amazonas - UFAM (2015), Teacher at Laureate International Universities / UNINORTE (Brazil),

SUMMARY

The user's primary requirement with respect to the building system is to make sure that it is actually safe, that is, that it actually meets the structural safety requirements.Structural performance assessment is one of the ways to determine if the system is actually secure;Ideally, any and all construction systems should be submitted to performance evaluations, taking into account users' requirements: safety, habitability and sustainability;Only in this way, one would have the guarantee that possible problems presented during the evaluation, would not be passed on to the users, being corrected in its initial stage.In this study, the performance evaluation happened in an inverse way, where the construction system was evaluated through field tests after the housing units were completed.In this way, the behavior of these residences could be evaluated by comparing the results obtained in the field tests and the criteria established by the Draft Standards in 02.136.01.001, 02.136.01.002 and 02.136.01.004 of the Brazilian Association of Technical Standards (ABNT, 2004), which present methods for evaluating the performance of residential buildings, as well as verifying the construction systems that did not meet the established criteria, indicating their failures, thus guaranteeing their non-occurrence in future constructions.

KEY WORDS:*Performance*

Evaluation, Housing Units, Building System, Soil-Cement, Concrete Mobile.

I. INTRODUCTION

The Brazilian housing deficit is currently estimated at around 6.6 million units, exerting great pressure on the public sector, most often blamed for the problem, arising from social, economic and cultural, intrinsic to the history of the country 1.

In Brazil, the Ministry of Cities was created, which intends to bring together the resources of the various federal agencies, which are related to urban development, with the objective of investing, in a rational manner, large numbers of dwellings.The federal government shows interest in facing the problem, but it is known that the Brazilian housing deficit is very large.However, it is important to emphasize that the large Brazilian metropolises present a disorderly urban growth, causing the population to adopt inadequate solutions with dwellings in places lacking in urban infrastructure, such as: basic sanitation, transportation, security and public services (KLEIN et al, 2004).

In our country, a number of innovative solutions, in terms of construction systems, are introduced in the market to solve the Brazilian housing deficit.However, not all meet the minimum requirements for a desirable housing affordable and quality (Silva Filho et al, 2002).

The first innovative housing, funded by the now defunct National Housing Bank (BNH), now partially incorporated into the CaixaEconômica Federal (CEF), was introduced without first having to undergo a technical evaluation to predict its behavior.In fact, it was the construction of the housing complex of Itaquera in São Paulo, in the middle of the 70's, which served as a great laboratory for new technologies, being used different construction systems distributed in 31,860 housing units.The errors and correctness of this experiment, however, were only evaluated after the completed and inhabited buildings (ALMEIDA, 1984).Oliveira (1996) describes that the lack of standardization where manufacturers and builders could rely, directly influenced the quality of the product, leading in most cases to disastrous experiences, with serious damages for all agents involved in the construction process. The problems of pathologies and the high costs of maintenance and replacement are transferred to the users.Taking into account the concept of standardization, which defines the definitions, characteristics (dimensions, qualities), test methods, employment rules, etc .;Due to these difficulties, there was a great interest in normalizing the performance evaluation so that the manufacturers of these new systems could guarantee the quality of the final product.

However, the BNH at the end of its existence, in an attempt to equate the problem of the lack of Brazilian normalization and recognizing the need for new technological solutions that allowed the construction of large-scale buildings, invested in research aiming at the elaboration of criteria to evaluate the Performance of innovative construction systems (IPT, 1981).

Internationally, the concept of performance had been used for some time, but its use in a more systematic way began in the 1960s and 1970s. Countries like France, England, Germany, Norway, Denmark, the United States and Canada took care to evaluate Its new constructive systems with the objective of providing a guarantee that a new and unknown product will perform satisfactorily when used in construction (OLIVEIRA, 1996).

The first modern evaluation system was established in Europe in the 1960s, the French Approval System, designed to reduce restrictions on the introduction of innovative constructions.Established by a decree of the Ministry of Construction, the system is run by the Center Scientifiqueet Technique du Bâtiment (CSTB), an organization of the Federal Government French (OLIVEIRA, 1996).

The request to obtain the French Certificate of Approval, provided only for new construction systems, must be requested by a manufacturer or builder, and the form must specifically mention the area of application and its method of use.The samples are submitted to tests and experiments in workshops, factories, laboratories or in the workplace and the evaluation is based on safety, usefulness and durability, taking into account the climatic conditions and the regulations of existing building constructions (OLIVEIRA, 1996).

In Brazil, the technological innovations were not accompanied by the mentality to evaluate the performance of the new construction systems before launching them in the market.Normally, the systems were evaluated only for their initial costs, not counting the costs of operation and not even those of maintenance and / or recovery being relegated to the background the concern with the aspects of durability and life of the buildings (ALMEIDA, 1984).

Concerned with the question of evaluating the performance of the new construction systems, CaixaEconômica Federal, considered one of the largest financial agents in housing, launched, on December 18, 2000, general guidelines for "Performance Assurance Analysis of Non-Conventional Constructions or Innovative "(KLEIN et al, 2004).

In parallel, the Institute for Technological Research (IPT) of the State of São Paulo in 1998 presented a text for discussion entitled "Minimum Performance Criteria for Ground-Level Housing of Social Interest", within the Brazilian Program for Quality and Productivity of Housing Construction PBQPCH).This program was created to stimulate and support actions in the sectors of the productive chain, installing and expanding the productivity and quality of the construction sector (SILVA FILHO et al, 2002).

In July 2004, ABNT launched the Draft Standards in 02.136.01.001, 02.136.01.002, 02.136.01.003, 02.136.01.004, 02.136.01.005, 02.136.01.005 (ABNT, 2004), whose purpose is to define the requirements and criteria Performance standards applicable to residential buildings of up to five floors, their elements and components, considering the ELU and ELU.The Draft Standard consists of the following parts: Part 1 - General Requirements;Part 2 - Structure;Part 3 - Internal Flooring;Part 4 - Facades and Internal Walls;Part 5 - Coverings;Part 6 - Hydro-sanitary systems.

In Manaus, the disorderly urban growth generated by the migration of families to the search for jobs and land, has provoked an increase in violence, unemployment and lack of housing.The environmental aspect has been directly affected, since such social problems have led families to invade certain forest regions in the vicinity of the creeks, causing both deforestation and pollution.

The use of these two construction techniques (soil-cement and cellular concrete) has aimed at the rationalization and industrialization of construction, based on the following premises: to develop affordable housing, to use new materials of great quality and with great durability;To develop technologies using simple constructive components of an industrial nature, easy to assemble and with the possibility of expanding its original plant, reducing debris, and producing a safe and pleasant dwelling for the user in theAppearance, conservation and cleaning, thermal and acoustic comfort and sealing.

The walls of the housing units constructed in soil-cement were executed in two ways: the first one with exposed bricks with cement mortar and sand, in the trace 1: 3 (figure 1.1), while the second with a plastered wall (figure 1.2) .

Figure 1.1.Wall of ground-cement rejoiced.Source: The Authors, (2017).

Figure 1.2.Wall of soil-cement towed.Source: The Authors, (2017).

The walls of the housing units in cellular concrete were also executed in two ways: the first refers to the execution of the masonry, that is, placing electrowelded steel screens on all walls before concreting (Figure 1.3). While the second form refers to the execution of the partially reinforced masonry, that is, placing the welded steel screens only in the walls encounters (figure 1.4).

Figure 1.3. Wall in reinforced cellular concrete. Source: The Authors, (2017).

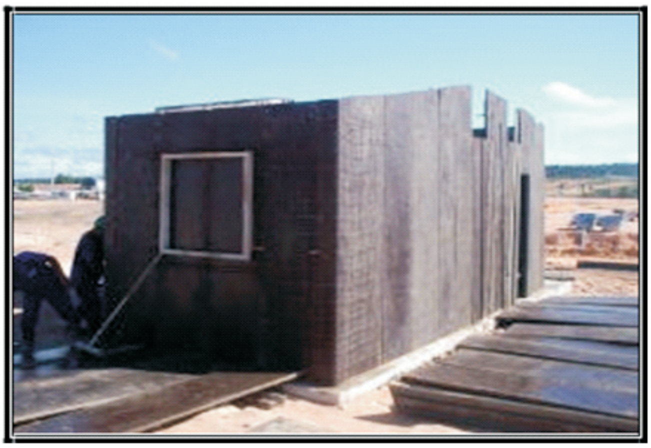

Figure 1.4. Wall in partially assembled cellular concrete. Source: The Authors, (2017).

In this work, there were structural performance tests in buildings built by the construction technique of soil-cement and cellular concrete adopting the procedures set forth in the Standards Project Nos 02.136.01.001, 02.136.01.002, 02.136.01.004 (ABNT 2004) and in the text suggested by the IPT (1998).These buildings were evaluated verifying if they meet the minimum structural performance criteria established by the ABNT Standard Project and the text proposed by the IPT (1998), through impact tests (soft body and hard body) and occupation loads Suspended, sleeping net and interaction between walls and doors).

The text proposed by the IPT (1998) was used in this research to evaluate the structural performance of the housing units of soil-cement and cellular concrete through the sleep network support tests.The text indicates the requirements and criteria that should be considered in this evaluation, complementing the Draft Standard 02.136.01.004 (ABNT, 2004) which indicates the methodology to be adopted in this test.

II BIBLIOGRAPHICAL REVIEW

II.1 PERFORMANCE ASSESSMENT BUILDING CONSTRUCTION DISCRIMINATION

In this part, the concepts of performance evaluation, user requirements, exposure conditions and the requirements and performance criteria that must be addressed by the housing units of soil-cement and cellular concretes are presented. Structural performance.

II.2 GENERAL DESCRIPTION

The performance evaluation seeks to analyze the suitability to use a product or a constructive technique, designed to fulfill a function, regardless of the material solution adopted.In order to achieve this, the performance evaluation shall subject the building and / or its constituent parts to a systematic investigation, based on consistent assessment methods, capable of producing an objective interpretation of the expected behavior of the product under defined conditions of use Of Standard 02.136.01.001 - ABNT, 2004).

According to Souza (1984), housing is characterized as a defined product whose function is to satisfy user requirements, consisting of performance evaluation in predicting the potential behavior of the building when in normal use.

In order to modernize housing construction and consequently reduce costs and losses, with increasing productivity, some companies have made efforts, both in the rationalization of conventional construction processes and in the development of new processes (REIS and BASTOS, 1994).

It should be noted that as new construction systems emerge, the need to evaluate them is of fundamental importance, avoiding that future problems arising from new construction techniques are transferred to users.In this way, a basic methodology must be determined to evaluate the performance of these constructive systems, ensuring that the performance evaluation has a standard to be followed (MITIDIERI, 1998).

The basic methodology for applying the concept of performance consists of: identification of user requirements to be met, exposure conditions to the product, establishment of (qualitative) requirements and performance criteria (quantitative) to be met and definition Of evaluation methods (SOUZA, 1983).

The application of this concept contributes to guiding the development of products in the area of components and the development of projects, also contributing to the normalization of housing (Performance Standards) and paves the way for a system of quality control of new products based on certificates of (THOMAZ, 1993).

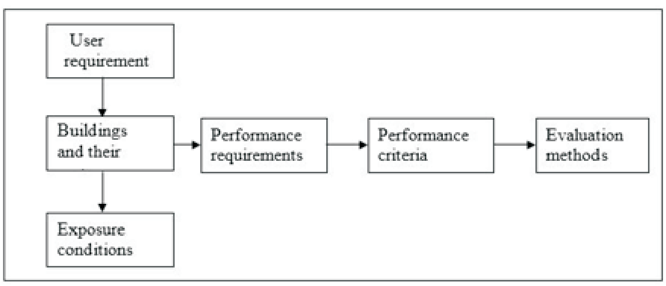

Figure 2.1.Flow chart of performance evaluation.Source: The Authors, (2017).

II.2.1 USER REQUIREMENT

The requirements of the users are understood, in the case of housing, as the level of conditions necessary for the safety and health of man, his comfort and satisfaction of his economic concerns (SOUZA, 1984).

According to Mitidieri and Souza (1994), the concept of user requirement is quite relative, it varies from country to country or even for each region within the same country, since what constitutes a requirement for a developed country may constitute only in Desire for those less developed.

Under the various actions in housing, the building and its parts must meet the applicable requirements that are listed in Standard Project 02.136.01.001 (ABNT, 2004). - Performance of residential buildings up to 5 floors - Part 1: General Requirements, According to table 2.1.

Security	- Structural safety - Safety against fire - Safety in use and operation
Habitability	- Sealing - Hygrothermal comfort - Acoustic comfort - Light comfort - Health, hygiene and air quality - Functionality and accessibility - Tactile and anthropodynamic comfort
Sustainability	- Durability - Maintainability - Environmental impact

Table 2.1.User requirements.Source: Draft Standard 02.136.01.001 (ABNT, 2004).

II.2.2 CONDITION OF EXPOSURE

The conditions of exposure to which a product is subjected can be understood as the set of actions acting on it during its useful life (IPT, 1981).

The actions may occur due to phenomena of natural origin (winds, rains, etc.), origin external to the building (external impacts) and due to the use of the building itself (overloads of use, fires, etc.).For each of the user requirements, sets of exposures should be considered.Thus, in the case of the requirement of thermal comfort, the exposure conditions will be characterized by the set of climatic variables that occurs in the summer and winter period in a given region.This set of variables is composed of air temperature, relative humidity, insolation, solar radiation, winds and precipitations (OLIVEIRA, 1996).

II.2.3REQUIREMENTS AND PERFORMANCE CRITERIA

Once the function of the dwelling is defined as that of satisfying the requirements of the user, the building, its elements and components must meet, when submitted to the conditions of exposure, certain performance requirements.These requirements will be qualitatively expressed based on the specific function that the element / component occupies in the building and in the light of human requirements (Junqueira and Geyer, 2005).

The requirements and criteria are understood as qualitative and quantitative conditions, respectively, to which a given product must meet when subjected to the conditions of exposure, in order to satisfy the requirements of the user.They are interpreted as levels of safety, habitability and durability, that the product must meet when submitted to actions (MITIDIERI and SOUZA, 1994).

For example, in the case of structural safety, the requirements are laid down in order to ensure that the housing elements do not reach the ultimate limit state, corresponding to ruin by rupture, excessive deformation or instability and the state of use. Unacceptable cracks that are detrimental to the use or durability of the part and deformations that exceed acceptable limits for the use of the structure (THOMAZ, 1993).

The experience that the IPT has accumulated in the evaluation of innovative constructive systems has shown that there should be eliminatory and qualifying criteria.The eliminatory ones would be the criteria related to the safety, habitability and durability, whereas the classificatory ones are those that would add quality to the system as better acoustic comfort, hygrothermal, etc. (ANTAC, 2003).

II.2.4 EVALUATION METHODS

Defining the requirements and criteria to be met by the housing, its elements and components, standardized methods of evaluation are necessary to verify if these products meet the requirements and criteria set (SOUZA, 1984).

According to the basic needs of safety, health, hygiene and economy, minimum levels of performance ("Level M") are established for the different elements and parts of the construction, which must be met.Considering the different possibilities of aggregation of quality products, which implies even different cost / benefit ratios, for performance exceeding the minimum requirements, intermediate ("I") and higher ("S") levels are established respectively.In the case of public funding agents or housing developers, and the developers in general, it will be necessary to define the desired level of performance in each case without any indication, it is understood that the "M" level is agreed upon - (ABNT - project 02.136.01.001, 2004).Silva Filho et al. (2002) points out that the evaluation methods can be established from tests and measurements, calculations and technical judgments.Two types of tests and measures are highlighted: measures of measurable properties of components and building elements (thermal conductance, loss of sound transmission, resistance to fire, mechanical resistance, etc.) and tests and measurements where Exposure in a simplified and standardized way (accelerated aging of painting systems, tests of watertightness of façades, simulations of wall crashes, etc.).

The calculation is a theoretical model of the behavior of the building or element, and is adopted analytically, based on certain properties of the constituent materials and components, as well as the exposure conditions.Thus, this method of evaluation seeks to quantify by means of estimates, taking into account the characteristics of the materials of the housing units as well as the medium in which the building is inserted, if such buildings meet the established requirements and criteria.

For example: The calculation of the evacuation time of the users of the housing in case of fire, from the analysis of the architectural design;Calculation of the structural safety level of the building when subjected to wind loads.

The technical judgment is based on expert knowledge based on experience of similar cases and conditions already known and enforced through use of design analysis and product prototype inspections in factories.

III. STRUCTURAL PERFORMANCE ASSESSMENT

The structural performance of the dwelling should be evaluated in two aspects: safety (ultimate limit state) and use, which considers deformation of the elements, cracking and other faults that compromise watertightness and durability (KLEIN et al. , 2002).

In addition to the permanent actions, we must analyze the accidents that may act in housing and other mechanical efforts, resulting from the use of the building, such as impact, suspended eccentric loads and requests transmitted through the doors.The ABNT Standard Project 02.136.01.004 (2004) describes that the evaluation of structural performance of ground dwellings is performed according to the criteria of ultimate limit state, limit state of use, support capacity of suspended parts, resistance to soft body impact , Hard body impact resistance, actions transmitted by internal and external doors and sleep network support.

In this work the structural performance of the buildings under study was evaluated through the verification of the limit state of use, tests of support capacity of suspended parts, resistance to impact of soft and hard body, actions transmitted by the interaction between walls and doors and support of hammock.

The first criterion, the ultimate limit state, is the stability and structural strength of the buildings, as opposed to the demands of simultaneous combination of permanent loads and loads due to wind.In order to evaluate under this criterion, the load tests imposed on the structure (wall compression test) and the wind action test (ABNT - project 02.136.01.002, 2004) must be carried out.

The second criterion, limit state of use, must guarantee the durability and normal use of the structure, limiting the formation of cracks, the magnitude of deformations and the occurrence of localized faults that could damage the levels of performance foreseen by the structure itself and for The other elements and components that make up the building, including hydro-sanitary facilities and other building systems (ABNT - project

02.136.01.002, 2004).

Therefore, in the practical part of this work, the criterion of the ultimate limit state was not evaluated, since it was not possible to perform the wall compression test, since the housing units were already completed, and therefore, with their proper working loads Cover and the proper weight of masonry).

The performance of the tests to evaluate the structural performance of the constructions built on masonry of cement-based and mortar-plastered masonry and on masonry in reinforced and partly reinforced cellular concrete were carried out in at least three housing units for each type of masonry on the walls Shown in Figure 2.2 as follows: Wall P4 was assessed by the soft-body impact strength test;The P4 wall was evaluated by the hard body impact resistance test;The wall P7 was evaluated against the behavior under the action of loads from suspended parts;The P6 wall was evaluated against the behavior under the action of loads coming from the sleeping net;The Po1 port was evaluated through the interaction between walls and doors.

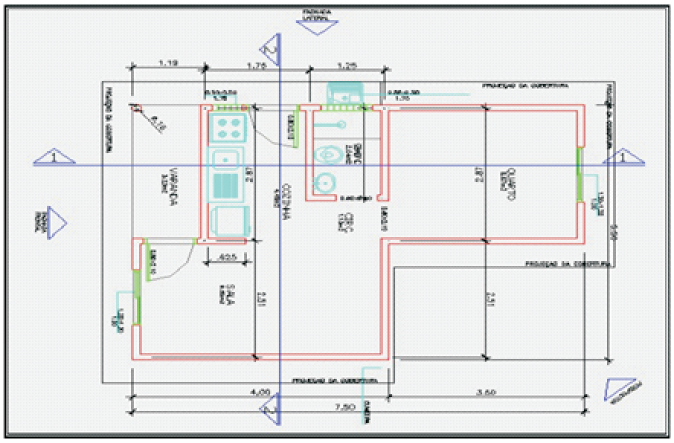

Figure 2.2.Ground floor of a standard housing unit.Source: The Authors, (2017).

The walls of the housing units of soil-cement and cellular concrete, chosen to carry out the tests and the reason for the choice of each wall, are presented below:

The P4 wall was evaluated by the soft-body impact test, because it is the second most critical wall because of its length, but the difference in the most critical wall, P2, is only 50 cm (Figure 2.2).It was not possible to perform the test on the wall with the longest length (P2), considered the most critical, since the houses were built close to each other with a distance of 2,50 m, making it impossible to perform the test;As in the soft body assay, the P4 wall was chosen to be evaluated by the hard body assay, because it is the only wall along with the P3 that presents distance between the houses that does not hamper the assay;The wall P7 was chosen to be evaluated against the behavior under the action of loads coming from suspended parts, due to the fact that it belongs to the kitchen area where cabinets, shelves and the like are usually installed;The P6 wall was evaluated against the behavior under the action of loads coming from the sleeping net, because this wall is positioned the network owner, although this also occurs in P4;The Po1 door was evaluated by the interaction between walls and doors, because it is the facade door, receiving directly the wind action without any obstacle, since the kitchen door does not receive such action directly.

III.1 STRUCTURAL PERFORMANCE REQUIREMENTS – STATES OF USE (ESL)

The performance of the structure, and of the other elements of the construction bound to it, should not be hampered by excessive displacement or excessive cracking, considering the permanent actions and use.Deformations, cracks and any faults should not impede the free functioning of elements and components of the building, such as doors and windows, facilities, etc.Under these conditions, the probability of occurrence of cracks and unacceptable damages should be minimal, in the order of 0.1% (considering the characteristic actions with a 95% significance level) - (Draft Standard 02.136.01.002 - ABNT, 2004).

III.2 PERFORMANCE CRITERIA AND LEVEL – LIMITED USE STATUS (ELS)

Under the action of vertical loads, temperature, wind, differential settling of foundations or any other requests that can act on the construction, the structural components - (Draft Standard 02.136.01.002 - ABNT, 2004): Must not present displacements higher than those indicated In Table 2.2;

Reason for imitation	Elements	Shift. Limit	Type of displacement
Visual / psychological insecurity.	Pillars, walls, beams and slabs (visible components).	L/250 or H/300	Final displacement including creep (full load).
Detachments, fissures in Fences or finishes, Faults in the operation of frames and installations.	Frames, installations, fences and rigid finishes (floors, linings and etc).	L/800	Portion of the arrow that occurred after installation of the load corresponding to the element under analysis (wall, floor, etc.).
	Lightweight partitions, flexible finishes (floors, linings and etc).	L/600	
Detachments, fissures in Fences	Rigid walls and / or finishes	L/500 or H/500*	Horizontal or vertical distortion caused by variations in temperature or wind action, angular distortion due to foundation settling (total displacement).

* For 2 type of request, the maximum horizontal displacement at the top of the building should be limited to Htotal / 500 or 3 cm, respecting the lower of the two limits:
L - wall length
H - Wall height

Fonte: Projeto de Norma 02.136.01.02 (ABNT, 2004).

Table 2.2.Displacements limits for permanent loads and accidental loads in general.Source: Draft Standard 02.136.01.02 (ABNT, 2004).

They must not present cracks with openings that are larger than the limits indicated in specific norms (NBR) 6118 (ABNT, 2003), NBR 9062 (ABNT, 2001), or opening of more than 0,4 mm in any situation, Always prevailing the lowest limited value;

They must not present chipping, localized fractures, plastifications or any other damages that will damage the performance of the other elements of the construction;They must not present detachments or cracks in walls, floors, covering elements, ceilings and finishes in general, tolerating cracks and detachments not visible to the naked eye by an observer positioned 1m from the surface of the element under analysis, in a visual cone With an angle equal to or less than 60 °, under illumination equal to or greater than 250 lux.

Permanent, accidental loads due to wind and specific deformations must be considered.The value of the calculation request is given by expression (2.1).

Request: Sd =? G Sgk +? Q Sqk +? W Swk +? And Sek (2.1)

In the more general cases, in the analysis of the deformations can be considered only the permanent and accidental actions (overloads) characteristics, being taken for?g the value 1 and?qvalue 0.7, then the new value calculation request is given by the expression (2.2).

Sd = Sgk + 0.7 Sqk (2.2)

The limit displacements for the permanent loads and accidental loads in general are presented in Table 2.2.

III.3 STRUCTURAL PERFORMANCE REQUIREMENTS FOR ACTION OF SOFT AND HARD BODY IMPACTS

External and internal walls, with structural or sealing function, must withstand the soft-bodied and hard-bodied impacts that they may suffer during the life of the building.They translate into impact energy to be applied to external and internal walls with and without structural function.The impacts with higher energies refer to the last limit state, being those of use those with lower energies.

The impacts correspond to accidental shocks generated by the building's own use or to shocks caused by intentional or unintentional intrusion attempts. Thus, the impacts are considered both outside and inside the building, differing walls with and without structural function as well as façade walls and the inner walls - (02.136.01.004 Draft Standard - ABNT, 2004).

III.4 CRITERIA AND PERFORMANCE LEVELS FOR RESISTANCE TO SOFT-BODIED IMPACT

Under the action of soft body impact, the internal walls and facades must not: instability or rupture (impacts safety) to the corresponding impact energies shown in Table 2.3.

Component	Impacts	Energy Soft-body impact (J)	performance criteria	Performance-level
Walls with function (Walls of single-storey houses).	External impacts (external access to the public)	960	No occurrence of ruin	I
		720		
		480	No crashes occur	
		360		
		240	No occurrence of Failures; Limitations displacements of Horizontal; d_{hi} = H/250 d_{hr} = H/1250	
		180	Faults do not de occur.	
		120		
		720	No occurrence of ruin	M
		480		
		360		
		240	No occurrence of Failures; Limitations Horizontal; No occurrence of d_{hi} = H/250 d_{hr} = H/1250	
		180	No crashes de occur.	
		120		

Note: When the inner covering of the multilayer facade wall is not integral to the wall structure, nor considered as a bracing component, the criteria set forth in standard NBR 11681, considering only internal impacts and internal lining, may be adopted E = 60 J for non-occurrence of faults and E = 120 J for non-occurrence of localized ruptures, provided there is no compromise to safety and watertightness, and the coating materials used are easy to replace by the user, that is, they are available in the market.

H - wall height, dhi - immediate horizontal displacement and dhr - residual horizontal displacement. Source: Draft Standard 02.136.01.001 (ABNT, 2004).

Table 2.3. soft body impacts for external walls (facades) of one storey homes with structural function. Source: Standard Project 02.136.01.001 (ABNT, 2004).

Suffer cracks, spalling, delamination or other failure (using impacts) which could jeopardize the state of use still observing the limits instantaneous and residual displacements (d hiedhr) indicated in Table 2.2;

Damage to components, systems and finishes coupled to the wall, according to the impact energies shown in Table 2.3.

III.5 CRITERIA AND PERFORMANCE LEVELS FOR RESISTANCE TO HARD-BODIED IMPACT

Under the action of hard body impacts, internal facades and walls must not:

Suffer cracks, spalling, delamination or other damage (use of impacts), observing the limits of dents still depths shown in Table 2.4;

Traspassamento or rupture under the action of the hard body impact given in Table 2.4.

Component	Impacts	Energy Hard body impact (J)	Performance criteria	Performance Level
Walls with or without structural function; Parapets or guardrails.	External impacts (external access to the public)	3,75	Faults do not occur;	M
		20	Non-occurrence of rupture	
		3,75	Faults do not occur; Depth mossa? = 2,0 mm	I
		20	Non-occurrence of rupture.	

Note: For rails or guardrails only large hard body impacts (E = 20 J (external) and E = 10 J (internal)) are recommended.

Source: Draft Standard 02.136.01.001 (ABNT, 2004).

Table 2.4. Hard Body Impact for external walls. Source: Standard Project 02.136.01.001 (ABNT, 2004)

III.6 REQUIREMENT FOR STRUCTURAL PERFORMANCE ARISING OUT REQUEST LOADS FROM SUSPENDED PARTS

The facades and interior walls, with or without structural function, must resist the attachment of suspended parts (cabinets, shelves, sinks etc.) planned for the project, respecting the recommendations and use limitations set by the manufacturer - (ABNT - Project 02 136. 01 004 2004).

III.7 CRITERIA AND PERFORMANCE LEVELS FOR SUSPENDED PARTS REQUEST LOADS

The facades and inner walls of the housing, with or without structural function, under the action of loads applied eccentrically with respect to the wall face and loads applied faceando wall surface, depending on the type of part to be fixed can not crack, unacceptable displacements (d hiedhr), chipping or other types of failures. Table 2.5 indicates only the service charges applied by hand-standard French.

Drop-Down Simulator	Load Performance	Performance Criterion	Performance Level
Standard French hand	0.8 kN, applied at points A and B, with 0.4 kN at each point.	No occurrence of failures; Displacement limitation Horizontal; d_{hr} = H/2500	M
	1.0 kN, applied at points A and B, with 0.5 kN at each point.	No occurrence of failures; Displacement limitation Horizontal; d_{hr} = H/2500	I
	1.2 kN, applied at points A and B, with 0.6 kN at each point.	No occurrence of failures; Displacement limitation Horizontal; d_{hr} = H/2500	S

Source: Draft Standard02.136.01.001 (ABNT, 2004).

Table 2.5. Service charges, criteria and levels of performance for suspended parts applied by default French hand. Project Standard 02.136.01.001 (ABNT, 2004).

Figure 2.3 shows the points A and B where the service loads the test pieces are suspended applied.

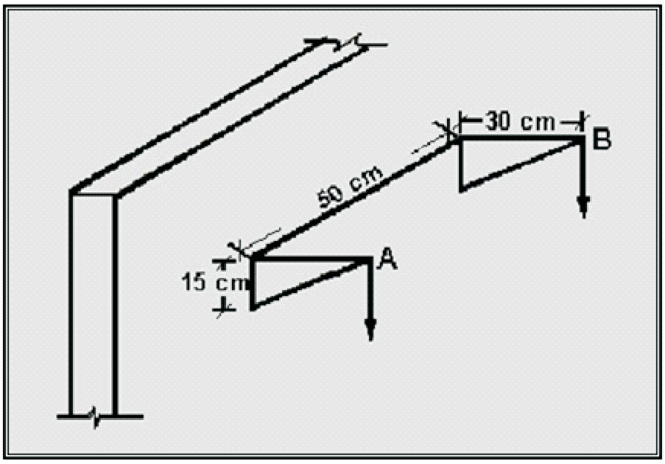

Figure 2.3. French hand- suspended diagram for testing parts. Source: Standard Project 02.136.01.004 (ABNT, 2004).

III.8 REQUIREMENT FOR STRUCTURAL PERFORMANCE INTERACTION BETTWEEN WALLS AND DOORS

The inner and outer walls of the houses, their connections and obligations, shall allow coupling ports resisting the sudden action locks the door leaves and impacts on the doors leaves - (ABNT - project 02.136.01.004, 2004).

III.9 CRITERIA AND PERFORMANCE LEVELS FOR TRANSMITTED ACTIONS FOR INTERNAL OR EXTERNAL DOORS

The outer and inner walls of the housing, with or without structural function should allow coupling ports under the following conditions: Undergoing the doors to ten abrupt closing operations, the walls must not display failures such as breakages, cracks, detachments in the meeting with the frame, the shear solidarization of the framework regions, detachments joints between wall components, etc.; Under the action of a soft body impact with energy of 240 J, applied at the geometric center of the door leaf, displacement should not occur or the frame tearing, or breakage or loss of stability of the wall. It is assumed, in the context of the contour, the occurrence of localized damage such as cracks and estilhaçamentos.

III.10 REQUIREMENTS FOR STRUCTURAL PERFORMANCE TO SLEEP NETWORK SUPPORT

The facades and interior walls, with or without structural function, they must resist the fixing of shipowners networks, planned for the project, respecting the recommendations and use limitations set by the manufacturer (IPT, 1998).

III.11 CRITERIA AND PERFORMANCE LEVELS FOT SLEEP NETWORK SUPPORT

This criterion is optional and should or may not be seen by the cultural habits of the population to which will be allocated the building system (IPT, 1998). This test was performed in this work, as in the state of Amazonas, is quite common to use hammocks, and all the houses built have network owners on their walls.

The inner and outer walls of the housing, with or without structural function, they must withstand a pullout force of 2000 N (200 kgf) applied at an angle of 60 a with the wall (02.136.01.004 Draft Standard - ABNT, 2004) . Under these conditions, should not occur:

d Hi> H / 500; d hr> M / 2500; Pullout fasteners, breaks, cracks or spalling in load transmission regions; small indentations or dents are nonetheless accepted; Any damage outside the load application area in any side of the wall.

IV. GENERAL CONSIDERATIONS

To better understand the behavior of housing units during and after the structural performance evaluation tests, performing a correct analysis in order to reach the objective conclusions, so that it will contribute to the best performance of the product is of fundamental importance to highlight the construction stages of the two systems, soil-cement and cellular concrete and describe the types of materials used for production of soil-cement and cellular concrete bricks that directly influence the quality and durability of the main building component, which is the wall. The main constructive step that must be highlighted in order to understand the performance of soil-cement and cellular concrete buildings is a form of execution of the walls and their supports ties with the foundation.

V. CONCLUSION

In general, the housing units that met all the criteria set by the standard design, with the best structural performance during field trials were the building systems of soil-cement plastered and reinforced cellular concrete. Therefore, constructive soil-cement system towed had the best structural performance, with immediate and residual horizontal displacements smaller than the reinforced cellular concrete front of the soft body impact tests, without any type of failure (item 5.3.3.2 and table 5.9, p.63).

Finally, it is emphasized that the structural performance of the foam concrete walls partially erected and soil-cement grouted, according to the construction procedures and materials shown in this study, did not meet some criteria established by standard design and is therefore recommended not using these two techniques for building affordable housing.

It should be emphasized, however, the importance of placing the steel screens electrowelded on all the walls of cellular concrete and the grout in the soil cement wall, because these two factors positively influenced the construction system of cellular concrete and soil cement respectively, causing the same atendessem all structural performance evaluation criteria established by ABNT Standard Project 2004 and IPT Manual (1998).

VII. REFERENCES

1.ALMEIDA, R. A Importância da Avaliação de Desempenho e o Controle da Qualidade. Construção São Paulo, Suplemento PINI, Sistemas Construtivos. p. 6-7. São Paulo, 1984.

2.ASSOCIAÇÃO NACIONAL DE TECNOLOGIA DO AMBIENTE CONSTRUÍDO. Avaliação Pós Ocupação: Métodos e Técnicas Aplicados à Habitação Social. Porto Alegre: ANTAC, 2003 (COLEÇÃO HABITARE).

3.INSTITUTO DE PESQUISAS TECNOLÓGICA DO ESTADO DE SÃO PAULO. Critérios Mínimos de Desempenho para Habitações Térreas de Interesse Social. Texto para Discussão. São Paulo, 1998.

4.________________. Avaliação de Desempenho de Habitações Térreas Unifamiliares: Segurança Estrutural. Documento Preliminar, anexo do relatório 16277. 107p. São Paulo, 1981.

5.JUNQUEIRA, T. M. C.; GEYER, A. B. Avaliação de Desempenho das Edificações – Levantamento e Análises dos Critérios Mínimos Existentes. In: CONGRESSO DE PESQUISA, ENSINO E EXTENSÃO DA UFG – CONPEEX, 2., 2005, Goiânia. Anais Eletrônicos do XIII Seminário de Iniciação Científica [CD-ROM], Goiânia: UFG, 2005.

6.KLEIN, D. L.; KLEIN, G. M. B.; LIMA, R. C. A. Sistemas Construtivos Inovadores: Procedimentos de Avaliação. In: II SEMINÁRIO DE PATOLOGIA DAS EDIFICAÇÕES "NOVOS MATERIAIS E TECNOLOGIAS EMERGENTES" DA UFRGS – LEME/UFRG, 2004, Rio Grande do Sul. Anais Eletrônicos do II Seminário de Iniciação Científica [CDROM], Rio Grande do Sul: UFRGS, 2004. n.p.

7.KLEIN, D. L.; SILVA FILHO, L. C. P.; CAMPAGNOLO, J. L; GASTAL, F. P. S. L. Relatório de Ensaios de Desempenho de Protótipo do Sistema CASAFORTE MEDABIL com Painéis DIGIGRAPH. Relatório Técnico RT LEME/UFRGS no 10/2002, 49 páginas, PPGEC, UFRGS (2002).

8.MITIDIERI, C. V. Avaliação de Desempenho dos Componentes e Elementos Construtivos Inovadores Destinados a Habitações: Proposições Específicas à Avaliação do Desempenho Estrutural. Tese (Doutorado) – Escola Politécnica, Universidade de São Paulo. São Paulo, 1998.

9.MITIDIERI, C. V.; SOUZA, R. Avaliação de Desempenho de Sistemas Construtivos Destinados à Habitação Popular: Conceituação e Metodologia. São Paulo. IPT. 1994.

10.OLIVEIRA, F.L. Avaliação do Desempenho Estrutural de Sistemas Construtivos Inovadores: Estudo de Caso. Dissertação de Mestrado – Escola Politécnica, Universidade de São Paulo. São Paulo, 1996.

11.REIS, P. F.; BASTOS, P.K.X. Construções Habitacionais em Juiz de Fora: Diagnóstico Técnico. In: CONGRESSO DE ENGENHARIA CIVIL DA UNIVERSIDADE FEDERAL DE JUIZ DE FORA. V.2, p. 136-147. Juiz de Fora, 1994.
12.SILVA FILHO, L. C. P.; GRAEFF, A.; KLEIN, D. L; CAMPAGNOLO, J. L. Análise de um Sistema Construtivo Inovador Formado por Paredes de PVC com Concreto Leve. CBCIMAT 2002, Congresso Brasileiro de Engenharia e Ciências dos Materiais. Anais em CD-ROM, Natal, Brasil, 2002.
13.SOUZA, V. C. M. DE; RIPPER, T. Patologia, recuperação e reforço de estruturas de concreto. São Paulo, Editora Pini. 1998.
14.SOUZA, R. Avaliação de Desempenho Aplicada a Novos Componentes e Sistemas Construtivos para Habitação. IPT. São Paulo, 1984.
15.SOUZA, R. A contribuição do conceito de desempenho para a avaliação do edifício e suas partes: Aplicação às janelas de uso habitacional. Dissertação (Mestrado). Escola Politécnica, Universidade de São Paulo. São Paulo, 1983.
16.THOMAZ, E. Sistemas Construtivos para Habitações de Interesse Social: Proposta de Avaliação e Classificação pela Relação Custo/benefício. In: SIMPÓSIO IBEROAMERICANO SOBRE TÉCNICAS CONSTRUTIVAS INDUSTRIALIZADAS PARA NORMAS TÉCNICAS (em ordem numérica)
17.ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 6118. Projeto de Estruturas de Concreto – Procedimento. Rio de Janeiro, 2003.
18.___________. NBR 9062. Projeto e Execução de Estruturas de Concreto Pré-moldado. Rio de Janeiro, 2001.
19.___________. NBR 12646. Paredes de concreto celular espumoso moldadas no local. Especificação. Rio de Janeiro, 1990.
20.___________. Projeto 02.136.01.001. Desempenho de edifícios habitacionais de até cinco pavimentos – Parte 1: Requisitos Gerais. Rio de Janeiro, 2004.
21.___________. Projeto 02.136.01.004. Desempenho de edifícios habitacionais de até cinco pavimentos – Parte 4: Fachadas e paredes internas. Rio de Janeiro, 2004.