ROLE OF SHEAR- WALL IN CONSTRUCTION TO PREVENT THE DISASTERS DURING EARTHQUAKES

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ABSTRACT

Timber is one of the oldest and most frequently used building materials known to human. Wood in construction includes: it is an extremely versatile raw material, less energy is required to process wood into finished products, it is a renewable resource, and when maintained properly it can be a very durable building material. Today the emphasis has shifted from heavy timber construction to light frame building construction. Light-frame building construction is the most frequently used form of residential construction. In this study the importance of shear walls has been investigated for resistance to lateral loading such as earthquakes or wind. The combination of shear walls and horizontal diaphragms is often referred to as diaphragm design. So the using of shear-wall in construction to reduce the disasters and providing the durable buildings are unavoidable.

Keywords: Earthquakes, disasters, durable building, construction, shear-wall.

YAPIDAKİ PERDE DUVARIN DEPREMDE AFETİ ÖNLEMEKTEKİ ROLÜ

ÖZET

Kereste insan bilinen en eski ve en sık kullanılan yapı malzemelerinden biridir. İnşaatta ahşap içerir: o bir yenilenebilir kaynaktır, ahşap islemesi, daha az enerji istemektedir ayrıca, çok yönlü hammadde ve bakımı düzgün, çok dayanıklı yapı malzemesi olabilir. Bugün vurgu ışık çerçeve bina inşaatı ağır ahşap yapı kaymıştır. Hafif çerçeve inşaat konut inşaatı en sık kullanılan şeklidir. Bu çalışmada perde duvarların önemi özellikle, deprem veya rüzgâr gibi yanal yükleme direnç için incelenmiştir. Perde duvar ve yatay diyafram kombinasyonu genellikle diyafram tasarım olarak adlandırılır. Yani afetlerin azaltılması için inşaatta perde - duvar kullanılması ve dayanıklı binalar elde etmek için kaçınılmazdır.

Anahtar Kelimeler: Depremler, afetler, sağlam bina, yapı, perde duvar.

1. INTRODUCTION

Only during the last decades the idea that old and ancient buildings could be restored and reused became appealing for the market. In fact, the present policy is not only to preserve but also to make buildings and the whole historic part of the cities alive, functioning and appealing to the inhabitants and to the tourists. It is the unique atmosphere of narrow streets and historic squares that provides a meaning to the cultural heritage of city centers, which must be the everyday reality for the local population European countries have developed throughout the years a valuable experience and knowledge in the field of conservation and restoration. In recent years, large investments have been concentrated in this field, leading to impressive developments in the areas of inspection, non-destructive testing, monitoring and structural analysis of historical constructions. These developments, and the recent guidelines for future reuse and conservation projects, allow for safer, economical and more adequate remedial measures.

The analysis of historical masonry constructions is a complex task. Firstly, limited resources have been allocated to the study of the mechanical behavior of masonry Significant changes in the core and constitution of structural elements, associated with long construction periods;

- Construction sequence is unknown;
- Existing damage in the structure is unknown;
- Regulations and codes are non-applicable.

Anamnesis, diagnosis, therapy and controls, corresponding respectively to the condition survey, identification of the causes of damage and decay, choice of the remedial measures and control of the efficiency of the interventions. Thus, no action should be undertaken without ascertaining the likely benefit and harm to the architectural heritage. A full understanding of the structural behavior and material characteristics is essential for any project related to architectural heritage. Diagnosis is based on historical A combination of both scientific and cultural knowledge and experience is indispensable for the study of all architectural heritage. The purpose of all studies, research and interventions is to safeguard the cultural and historical value of the building as a whole and structural engineering is the scientific support necessary to obtain this result. Diagnosis and safety evaluation of the structure are two consecutive and related stages on the basis of which the effective need for and extent of treatment measures are determined. If these stages are performed incorrectly, the resulting decisions will be arbitrary: poor judgment may result in either conservative and therefore heavy-handed conservation measures or inadequate safety levels. Evaluation of the safety of the building should be based on both qualitative (as documentation, observation, etc.) and quantitative.

The case studies are at different levels of remedial measures. In the first case study (Church of Saint Christ in Outeiro), the works have been completed. In the second case study, the works are to be initiated in the coming months (Monastery of Salzedas).Finally, it the last case study (Monastery of Jerónimos in Lisbon), an iterative diagnosis procedure is under way. For the analysis of the façade subjected to vertical loading a plane stress representation of the façade has been adopted. The thickness of the façade took into account the three-dimensional shape of the structure. The adopted elastic values were representative of the type of masonry found in the structure. The vertical loads considered in the analysis included the self-weight of the structure, the weight of the pyramidal roof of the bell-towers and the weight of the main nave roof. The soil-structure interaction has been modeled by interface elements, with properties obtained from in-situ testing of the soil.

Hypothesis that all permanent loads are applied simultaneously and not in agreement with the construction phases, it is observed that the maximum value of the tensile stresses

Conservation, analysis, understanding and strengthening of ancient structures remain a true challenge from the engineering point view, despite the considerable investment in research and development in the last decades.

Recommendations are currently available taking into consideration the expertise and diversity of different countries. Nevertheless, the application of the recommendations will always depend on the skills and experience of the practitioner. Examples of recent case studies in Portugal are provided here, to serve as a database of possible solutions and to act as guidelines for possible similar cases.

2. MASONRY SHEAR WALLS

Although many forms of masonry produce walls with sufficient strength for use as shear walls, the construction widely used in regions of severe windstorms or high risk of earthquakes is that using hollow units of precast concrete (concrete blocks), now referred to as CMU construction. This construction may be used with only minor reinforcing (technically qualified as *unreinforced masonry),* but it is usually developed as *reinforced masonry* for structural applications.

Reinforcement usually consists of small-diameter steel bars placed in continuous vertical and horizontal voids that are then filled with concrete. The filled voids and reinforcement literally form a planar rigid frame of reinforced concrete within the masonry wall.

Design codes require minimum amounts of reinforcement and maximum spacing of the filled and reinforced continuous voids. This, together with other minimum requirements, produces a minimal form of construction that typically has a rating equal to that at the high end for wood-framed walls. Above this minimum is a significant range of increase—up to a fully concrete-filled wall with major reinforcement and a capacity well above that of the minimal construction. The minimum wall (created with a single-block thickness) is a nominal 8-in. thick (usually 7.5 in. actually). A 10-in.-nominal thickness block is available, but for reasons of coordination of dimensions, the most used blocks are S, 12, or 16 in. thick.

Code requirements also provide for the reinforcement of wall tops, ends, and intersections and the edges around wall openings. For anchorage and continuity of the vertical reinforcement, dowels are placed in concrete supports to match the bars in the wall above.

Unlike wood-framed shear walls, masonry walls are used frequently also as bearing walls for support of roof or floor structures or for walls above in multistory construction. Therefore, complete design must deal with the loading combinations that occur.

For alignment of vertical reinforced voids, a regimented order of placement of units required. The face pattern of the wall is restricted on this basis. Blocks cannot be cut Tor a custom-dimensioned wall length, as is possible in other forms of masonry construction. For these reasons, the building plan must be carefully developed with the block modular dimensions in mind.

In general, the strength and stiffness of masonry walls approaches that of walls of precast or site cast concrete. Masonry and concrete walls generally produce the stiffest bracing systems for low-rise buildings.

As discussed previously, a long wall may be constructed as continuous, despite the existence of some openings. When these occur, there is a range of behavior for the wall based on the frequency and size of openings and the net dimensions of solid wall elements. Figure 3.18 shows the general relationships and the range of character of the continuous structure, from solid wall to flexible rigid frame. A wood-framed wall may proceed through this range, hut the rigid frame actions are mostly limited to masonry or concrete walls.

3. CONCRETE SHEAR WALLS

Concrete shear walls represent the single strongest element for resistance to lateral shear force. When used for subgrade construction (basement walls) or for extensive walls in low-rise buildings, they indeed provide great stiffness and strength for the shear wall tasks. Their greatest strengths are generally developed with site cast construction (concrete poured in forms at the site in the desired position). However, large precast walls are also capable of considerable bracing when properly developed with the total structure.

Of critical concern for concrete walls—and all reinforced concrete, for that matter—is the proper detailing of the steel reinforcement. Recommended details for this are specified in building codes and in the publications of the various organizations in the concrete industry, including the American Concrete Institute (ACI), Portland Cement Association (PCA), and Concrete Reinforcing Steel Institute (CRSI).

Concrete construction is generally similar to the masonry construction discussed in the preceding section. The structures produced are heavy and stiff and weak in tension. Required seismic shear forces for design are a maximum due to the combination of weight and overall stiffness of the structures. For earthquakes, concrete shear walls can work well, but proper detailing of the construction is very important. When used in combination with other structures (wood and steel framing, for example), adequate anchorage or effective separation must be used to provide for the differences in seismic movements. For wind, the heavy, solid, stiff structure (concrete or masonry) is often an advantage, providing an anchor for lighter elements of the construction. Indeed, excessive weight is of opposite concern generally for wind and seismic effects. Typically, concrete and masonry foundation walls are the direct anchors for structures of wood and steel.

An advantage with reinforced concrete over reinforced masonry (particularly concrete block construction), is the greater flexibility with regard to placement of the steel reinforcing bars. These can be placed only in the modular voids and mortar joints of masonry walls, but they can be placed with more freedom in the concrete mass Furthermore the steel rods must be vertical or horizontal in masonry, while the bars can take any direction.

4. SEISMIC DESIGN PHILOSOPHY

The generally accepted objectives of earthquake resistant design in national and state seismic design codes for buildings is that structures should be able to:

a) Resist minor earthquakes without damage.
b) Resist major earthquakes without structural damage but with some nonstructural damage.
c) Resist major earthquakes without collapse but with some structural as well as nonstructural damage.

Although these objectives are widely quoted, they are unstated in many codes. For example the US Uniform Building Code probably the most widely used code in the word, simply states an overall objective of safeguarding life or limb, health, property and public welfare.

The definitions of minor, moderate and major earthquakes are variable but generally relate to the life of the structure, and the consequences of failure. The major level earthquake defined in the life of the structure, and the consequences of failure. The major level earthquake defined in the NEHRP (1988) ode has a recurrence interval of 475 years corresponding to a 10% probability of exceeding in 50 years, which is commonly accepted to be the expected life of a building. The corresponding service level earthquake for a typical building would have a 10 year recurrence interval and a 99.3% probability of being exceeded in 50 years. (Uang,1991).

The practical application of the philosophy is that design is generally carried out at an elastic level (no damage) so that earthquake forces can be treated in a manner similar to that in which gravity, wind and other loads are treated. In order to deal with the second requirement, ductility requirements are stipulated so that the structure is capable of yielding without collapse .Yielding is inevitably accompanied by damage. The argument for accepting damage to structures in major earthquakes is based on cost. Building costs escalate very rapidly with an increase in earthquake level and the current consensus view of the numerous seismic code committees word wide is that major cost in earthquake provisions are not acceptable.

The development of seismic design codes is an interesting sociological phenomenon. The driving force in producing the code may come in various ways:

a) By the structural design profession with the motivation of regulating practice and obtaining a degree of public acceptance for it.
b) As a government driven measure usually following a major earthquake.
c) As part of a general standards programme supported jointly by government and industry.

4.1 Application

The application of codes varies both in the manner in which a code may selected and/or enforced.

a) Codes may be legally enforceable
b) Codes may be a requirement of a regulatory body.
c) Codes may have the status of ‘accepted practice’ and, therefore, place an onus on practicing structural engineers to apply them.
d) The structural engineer may be free to select a seismic code which he/she considers appropriate.

All these situations exist, and the merits of each situation can be argued. Unfortunately, another category exists in practice which possesses no merit whatsoever!

e) There is no legal requirement for seismic design. Therefore, there is no need to take seismic forces into account.

4.2 Effectiveness

The best check on code effectiveness is by examining the behavior of code designed structures in strong earthquakes. Housner (1982) quoted instances where building behavior in earthquake showed the effectiveness of code design. In other earthquakes since that time Meksico (1985), Spitak, Armenia (1988) and Erzincan(1992), there has been less ground for complacency.

5. EARTHQUAKES AND BUILDINGS

In an earthquake the ground rocks, twists, heaves and subsides, changing direction and speed all the while. Such violent and chaotic ground movement sets buildings in motion. Houses tend to shift off their foundations and some structural elements may overturn. Houses literally come apart at the seams, section by section and piece by piece. But wood frame houses, if properly attached to the foundation and tied together structurally, can resist seismic loads and reduce the likelihood of earthquake damage.

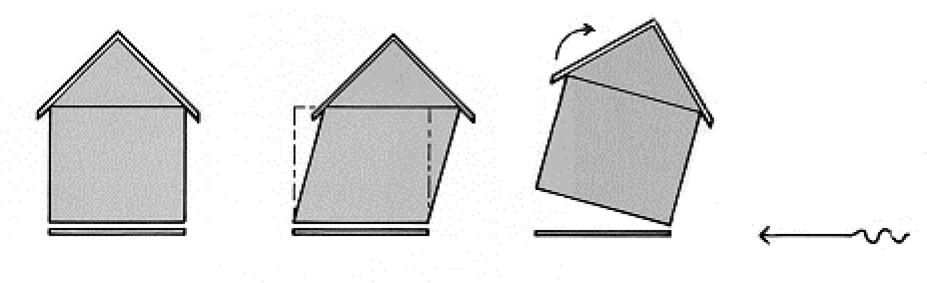


Figure 1.

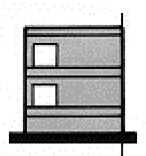
5.1 The Effect of Lateral Force on Structural Elements

The light weight of wood frame buildings results in less force from inertia. Less force means less damage (Figure 1.4.). Wood's natural flexibility also is an advantage when seismic forces are brought to bear and the nailed joints in wood frame buildings dissipate energy and motion.

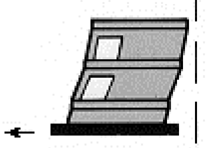
But wood's inherent earthquake resistance must be accompanied by design and construction techniques that take advantage of those characteristics. Structural wood panels nailed to wall framing add rigid bracing, help resist lateral loads and help tie framing members together Bolted connections at the sill plate/foundation joint help keep the house in one spot. Securely connected wall, floor and roof framing also help tie a house together and make it a single, solid structural unit. Proper connections will do more to hold a house together during an earthquake than any other single seismic design element.

Modern building codes require seismic design elements in new construction. Those elements typically include the measures mentioned above. Consult your local building codes for the requirements in your area. Older houses frequently need retrofitting if they are to withstand earthquakes. While this brochure deals primarily with retrofit applications, the same principles apply to new construction.

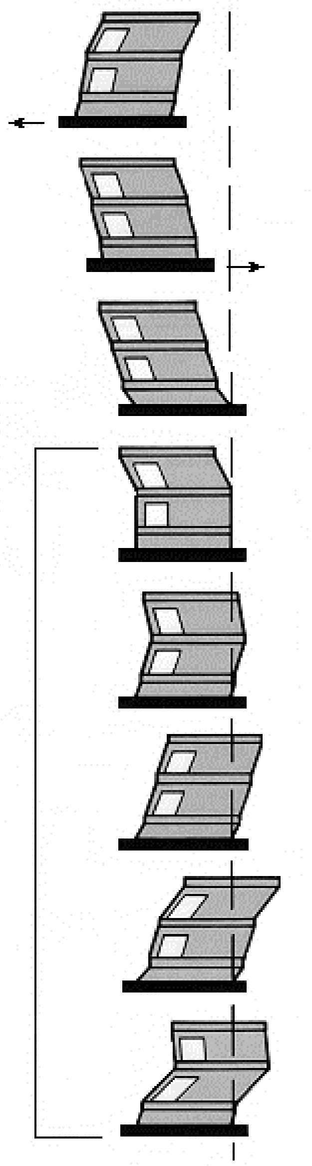
This series of illustrations shows, in an exaggerated way, what a house goes through during and after a simple north-south lurch.



In frame #1, the building and ground are at rest.



In frame #2, the Southern lurch begins and the building follows.



In frame #3, the ground is still pulling the building to the south, but the deformation of the building is reduced. The building is travelling at/near the speed of the ground.

In frame #4, the Northern lurch begins. The building will have to reverse its direction of travel; doubling the forces imposed by the first ground movement.

In frame #5, the building has changed direction. The top floor is the last to feel this change.

In frame #6, the ground is finally a rest, but the building is still in motion.

In frames #7 through #10, the building continues to move until the energy of the earthquake is dissipated.

Energy absorbing construction elements, like plywood shear walls, flex and deform; generating heat in the process.

Less flexible materials, like gypsum wallboard, absorb energy to a point, then they rupture. Diagonal cracks from the corners of doorways and windows are the result.

(Illustration courtesy of Fine Homebuilding magazine.)

Figure 2. - When the Ground Moves

6. CONCLUSIONS

There are ways of making structures safer than the current ones. Researchers and the engineering community have mobilized to achieve that goal, working on removing shortcomings in the design of structures that have not performed well in seismic events and coming up with improved versions capable of standing up to a certain level of earthquakes. The combination of shear walls and horizontal diaphragms is often referred to as diaphragm design. So the using of shear-wall in construction to reduce the disasters and providing the durable buildings are unavoidable.

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