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The Strategies of Architectural Design Resisting Earthquake in Tall Buildings

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Abstract

The target of architecture is present buildings serve the requirements of the human both of aesthetic , functional and safety to serve the people needs , and design buildings could resist the exterior envelopes that may effect on their work in perfect way , and one of the big risks of damage on buildings and people is " the earthquake " and with the scientific developments of buildings field specially the designing of tall buildings ,the architect should have strategies for seismic design for tall buildings. And with The need of founding aclear framework of the strategies of architecture design resistant to earthquake, especially in tall buildings .the research aim to found these strategies by the identification of the main load applied on the tall building structure and the best solution of structure design that serve the resistance of lateral load , then search for the best of configuration for seismic design. Also define the " Damping systems in tall buildings " and clarify the main types and the advantages and disadvantages of each one . Finally discuss the design considerations of using damping systems which found in the research samples .

Keywords: Earthquake, Tall Buildings, Seismic Design, Damping Systems, Architectural Design Resistant Earthquake-

Introduction:

In order to design buildings having the ability to force the completely damage caused by seismic effects on the structure which also cause death for human.

Some of the major problems relating to earthquake design are created by the original design concept chosen by the architect. Almost the ideal aspects of a building form are simplicity, regularity, and symmetry in both elevation and plan. Because any irregularity are likely to lead to an increased dynamic response, at least in certain locations of the structure [11] p.2. but still the architect and the client are looking for high-style design the forms will probably be irregular, unsymmetrical, and fragmented The wise and successful engineer will enjoy the chal¬lenges[2] p.5-53.

So the research found design strategies that help the architect to design tall building resist the earthquakes through the explanation of loads on building and focus on the seismic load , then clarify the options of seismic structural systems that suitable with configuration both horizontal and vertical ,also the research summarize the main structures of tall buildings and explain the control of movements in it through the using of damping systems .

Finally the research takes two international tall buildings and test the supposed strategies arriving to conclusion and recommendations.

1-The basic understanding of the main loads on structure :

It is essential matter for the architect knowing the main loads on the building to be able to design durable Structures resist various loads (gravity, seismic, wind, etc.) in general Load may be static, like furniture, dynamic like earthquakes, or impact load like a car hitting a building. Load may also be man-made, like that may change over time. For example, furniture may be moved and wind may change rapidly.

in general the main load are defined as : dead load(DL) and live load (LL); point load and distributed load, static impact and dynamic load and its details below : [1] p.2-2

1. Dead load: structure and permanently attached items
2. Live load: unattached items, like people, furniture, snow, etc
3. Distributed load (random – snow drift, etc.)
4. Uniform load (uniform distribution)
5. Point load (concentrated load)
6. Uniform load on part of a beam is more critical than full load
7. Negative bending over support under full load reduces positive bending
8. Static load (load at rest)
9. Impact load (moving object hitting a structure)
10. Dynamic load (cyclic loads, like earthquakes, wind gusts, etc.)

Lateral load: (load that acts horizontally) includes:

1. Seismic load (earthquake load)
2. Wind load
3. Soil pressure on retaining walls

1.1 Seismic load:

Earthquakes cause horizontal and vertical ground shaking. The horizontal (lateral) shaking is usually most critical on buildings. Earthquakes are caused by slippage of seismic fault lines or volcanic eruption. Fault slippage occurs when the stress caused by differential movement exceeds the soil shear capacity. Differential movement occurs primarily at the intersection of tectonic plates. Seismic waves propagate generally in radial patterns, much like a stone thrown in water causes radial waves. The radial patterns imply shaking primarily vertical above the source and primarily horizontal with distance. The horizontal shaking usually dominates and is most critical on buildings.[1] p.2-5

Seismic design objectives:

- Minimize mass
- Maximize ductility

The effects of earthquakes on tall buildings caused by the Ground shaking (pushing back and forth, sideways, up and down) generates internal forces within buildings called the Inertial Force, which in turn causes most seismic damage. and in tall buildings this loads will undergo several modes of vibration, but for seismic purposes (except for very tall buildings) the fundamental period, or first mode is usually the most significant as in (figure 1).[16] p.2

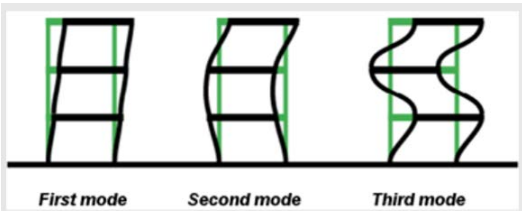

Figure 1: The possible modes under seismic loads in tall buildings source [16]

1.2 The basic seismic structural systems:

A building’s structural system is directly related to its architectural con¬figuration, which largely determines the size and location of structural elements such as walls, columns, horizontal beams, floors, and roof struc¬ture.[2] p.5-1

We can divide the resistance systems in building in to: The Vertical Lateral Resistance Systems and Diaphragms- the Horizontal Resistance System

In The Vertical Lateral Resistance Systems seismic designers have the choice of three basic systems that must be selected at the outset of the architectural design process which is : Shear walls, Braced frames and Moment-resistant frames . the designer may choose one or mix of them but the mixing must be done with care because the different systems are of varying stiffness and it is difficult to obtain balanced resistance when they are mixed. The comparative between the each type is in (figure 2) [2] p.5-3

And in Diaphragms- the Horizontal Resistance System: The term “diaphragm” is used to identify horizontal-resistance members that transfer lateral forces between vertical-resistance elements (shear walls or frames). The diaphragms are generally provided by the floor and roof elements of the building. The diaphragm is an important element in the entire seismic resistance system. [2] p.5-4

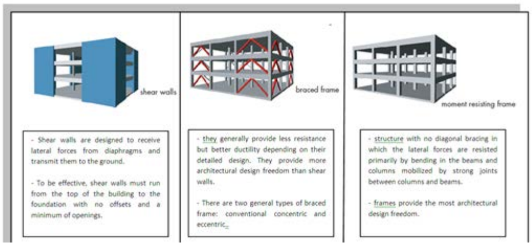

Figure 2: The three basic vertical seismic system alternatives. source [2] p.5-3

2. Configuration challenges horizontal and vertical:

‘ Configuration ’ describes the layout of structure both in plan and elevation. The term encompasses a global 3–D appreciation of how structure and building massing integrate to achieve seismic resistance. horizontal configuration; namely the floor plan geometry of a building as well as its structural layout in plan.[3] p.125

Architects are primarily responsible for building configuration. They determine the overall form or massing of a building and, with or without input from structural engineers, determine the structural layout to suit building function and space planning requirements as well as to express their architectural concepts.

Structural engineers, on the other hand, take a completely different approach towards plan regularity. They adopt the KISS Principle – Keep It Simple and Symmetrical – preferring floor plans as well as structural layout to be as regular and symmetrical as possible.[3] p.126

As the European seismic code reminds us: ‘To the extent possible, structures should have simple and regular forms both in plan and elevation. If necessary, this may be realized by subdividing the structure into dynamically independent units ’.[4] p.45

In horizontal configuration One code lists and defines five types of horizontal irregularities in order to classify a building either regular or irregular: [5] p.37

- Tensional and extreme torsional
- Re-entrant corner
- Diaphragm discontinuity

● Out-of-plan offsets
● Non-parallel systems.

And in vertical configuration the following vertical irregularities repeatedly observed after earthquakes to have initiated severe damage:[3] p.143

● Soft stories
● Short columns, strong beam, weak column
● Discontinuous and off-set structural walls
● Setbacks and planes of weakness

2.1Optimizingthe structural/architectural configuration

After the knowing of resistance systems in building both vertical and horizontal "FEMA,2006" summaries the best building attributes in:[2] p.5-6

•Continuous load path :uniform loading of structural elements and no stress concentrations.
•Low height-to base ratio : minimizes tendency to overturn and buckling
•Equal floor heights: equalizes column or wall stiffness, no stress concentrations
•Symmetrical plan shape : minimizes torsion.
•Identical resistance on both axes : eliminates eccentricity between the centers of mass and center of resistance (shear center) and provides balanced resistance in all directions, thus minimizing torsion
•Identical vertical resistance: no concentrations of stress or weakness.
•Uniform section and elevations: minimizes stress concentrations.
•Seismic resisting elements at perimeter :maximum torsional resistance.
•Short spans Low unit stress in members, multiple columns provide redundancy -loads can be redistributed if some columns are lost
•No cantilevers : reduced vulnerability to vertical accelerations.
•Minimum openings in diaphragms(floors and roof) Ensures direct transfer of lateral forces to the resistant elements

2.2 Tall building System Configuration

To the extent possible, configure the structure to include a simple arrangement of structural elements with clearly defined load paths and regular structural systems. Configurations and geometries that complicate behavior, add to complexity of analysis and uncertainty, and that should therefore be avoided to the extent possible include: (Figure 3) [17] p.29-31

•Large changes in building stiffness (1) in (Figure 3)
•Large changes in building mass (1) in (Figure 3)
•Repositioning of bracing elements from floor to floor (2) in (Figure 3)
•Interaction of two or more towers through a common base structure (3) in (Figure 3)
• Significant column transfers or offsets (4) in (Figure 3)
•Gravity induced horizontal shear forces caused by system eccentricities(5) in (Figure 3)
•Limited connectivity of bracing elements to floor diaphragms

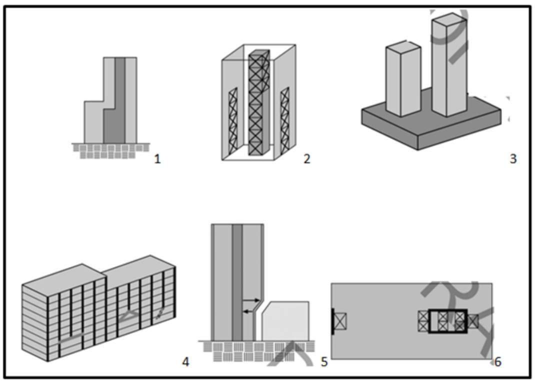

Figure 3: the systems configuration of tall building that should be avoided in seismic design [17] p.29-31

3. Tall building structure:

the structure of tall building based on new structural concepts with newly adopted high-strength materials and construction methods has been towards "stiffness and lightness [6] p.18

The lighter a structure is, the higher it can rise. A high-rise structure needs both stiffness and damping characteristics [7]

Structural development of tall buildings has been stages range from the rigid frame, tube, tube in tube ,core-outrigger to diagrid systems. Structural systems of tall buildings can be divided into two broad categories: interior structures and exterior structures. This classification is based on the distribution of the components of the primary lateral load-resisting system over the building.

The interior Structures is categorized when the major part of the lateral load resisting system is located within the interior of the building and its main types shown in (Figure 4). and the exterior structures when the major

part of the lateral load-resisting system is located at the building perimeter and its main types shown in (Figure 5). It should be noted, however, that any interior structure is likely to have some minor components of the lateral load-resisting system at the building perimeter, and any exterior structure may have some minor components within the interior of the building.[8] p.210

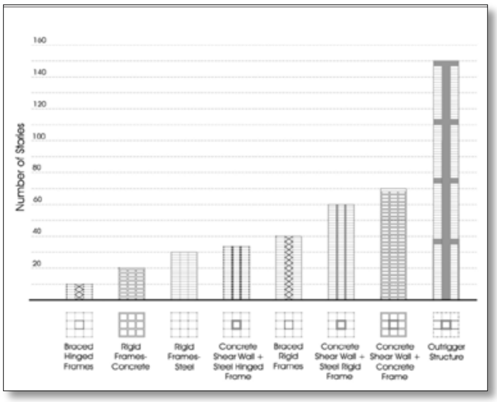

Figure 4: The interior structure in tall buildings , source [8]p.211

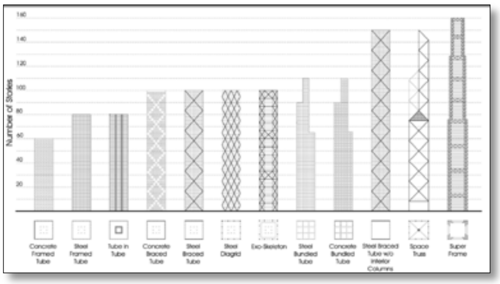

Figure 5: The Exterior structure in tall buildings source [8]p.211

4. Damping strategies in tall building structure:

The trend of the last years is to build taller, slimmer, and lighter structures the latest advancements in high-strength materials, with the same modulus of elasticity (i.e. less stiff structures) and construction methods have led to more efficient solutions [8] p.216 However, these lighter systems could lead to structures more prone to vibrations, which can cause discomfort, damages, and eventually, structural failure.[19]p.3. Taller and slimmer buildings need to withstand a variety of external forces that are different from those of low-rise constructions, different structural solutions need to be used. Moreover, many major cities are threatened by a variety of extreme events such as earthquakes and strong winds.[19] p.2

Motion control of tall buildings, therefore, should take into consideration both static and dynamic loads be accomplished by increasing the structural stiffness and damping while keeping the material amount at a minimum ,a stiffer building can be achieved with a proper selection of the structural configuration. Tubes, diagrids, and core-supported outrigger structures could be considered more optimal solutions than others. .[19] p.2

The current available damping systems can be subdivided into two main categories: passive and active systems [18] p.210. Passive systems have fixed properties while active systems change their properties based on the load demand and require an external energy source to be activated. Therefore, while more efficient, active systems are less common due to economic and reliability constraints.

Passive systems can be further divided in two subcategories:

(i)material based dissipation systems (e.g. viscous and visco-elastic dampers);

is typically an integral part of the primary structural systems, and they are positioned in optimal locations (e.g. in bracing systems) to reduce the building's dynamic motion. The force generated by these devices is a function of the time rate of change of deformations, and the relative damping comes from the phase shift between force and displacement, the main types of devices of this category are:viscous ,viscoelastic hysteretic, friction ,electro-magnetic dampers. Damping is accomplished through the phase shift between the force and displacement. An example of viscous dampers, installed as an integral part of the bracing members, can be found in the 55-story Torre Mayor in Mexico City – the tallest building in Latin America at present, and visco-elastic dampers were installed in the destroyed World Trade Center Towers in New York. Other types of damping systems in which the damping mechanism is through direct dissipation of energy from the system include hysteretic damping and friction damping.(Fig. 6) presents an example of a viscous dampers system applied to a Diagrid high-rise building [20] p.315,[21] p.639,[22] p.311

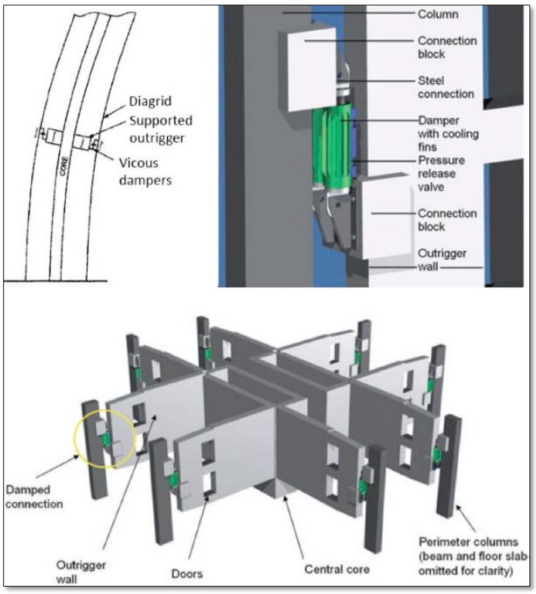

Figure 6: Example of a viscous dampers system applied to a Diagrid structure source[7]

(ii) additional mass generating counteracting inertia forces (e.g. tuned mass dampers and tuned liquid dampers

is based on the counteracting inertial force created by an additional mass generally allocated at the top of a building , There are two main categories of devices belonging to this family:

- tuned mass dampers (TMD) ; the mass is supported by an appropriate mechanical system that allows it to move out-of-phase with the fundamental period of the building [23]
- tuned liquid dampers (TLD); the mass is composed of waving water, and for this reason, the existing building's water source can be utilized (e.g. water tanks located near the top of the building) [24]

The active system: have properties are adjusted from a computer control system. and its types are : mass dampers and active variable stiffness devices[10]

There are also several examples of innovative solutions for damping in tall buildings such as :

•Inclusion of dampers in outrigger systems.[25]

•Dampers in shear walls. this solution was already proposed for low-rise building. In recent years, several papers have discussed their application for tall buildings [26]

•Adjacent buildings equipped with dampers These are utilized to reduce and avoid the possible pounding between abjection buildings.[27]

•Double skin façade as mass damper Double skin façades can be utilized as a structural motion control device in tall buildings. Two different strategies have been developed :one with low connection stiffness between inner and outer skins together with a damping mechanism, and one with inserting additional masses in the cavities of the double skin façade that could act as distributed tuned mass dampers.[28]

•Self-Mass Damper : Based on a project completed in Tokyo in 2007, and inspired by the pendulum movement of an antique clock, this system utilizes the existing mass of the building to act as a mass damper without adding any additional mass. the system is created by disconnecting the upper floors via a system of sliders and high-damping rubber bearings[29]

After the clarifying of the all types of damping devices the selection of one of them is depend on several factors including: efficiency, compactness and weight, capital cost, operating cost, maintenance requirements, and safety.

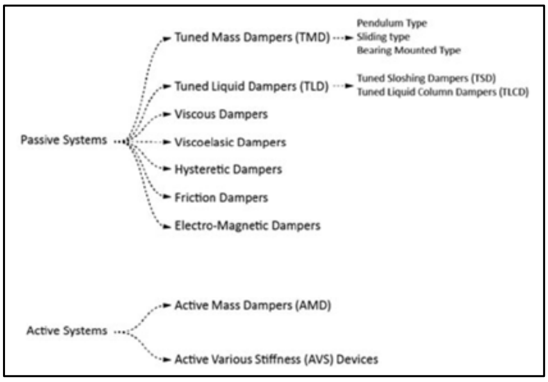

Figure 7: Auxiliary damping systems for tall buildings, source [19]

Figure 8: Dampers installation in Torre Mayor, source [12]

4.1 Design considerations of using dampers :

Some types of dampers need architectural solution to be taken into account to achieve an economical and practical solution. For example passive tuned mass dampers need addition of mass on the top of the building does not have to exceed one to two percent of the building's modal mass. And the moving of the additional mass even during small excitations. The easiest way to obtain this is with a pendulum. However, this requires a lot of headroom; that is why alternative solutions have been proposed (like inverted pendulums or multistage pendulums).[19]

Another important aspect is that these systems can be precisely tuned after the building characteristics are known (i.e. when the building is complete). In the case of large movements of mass, safety devices need to be installed to limit the motion for safety measures in order to control the forces generated.

The advantage of an active system is the smaller mass and the higher additional damping provided, that can be 10 percent or more, compared to three to four percent foe a passive system. However, this increases the costs. A passive system can reach up to one percent of the building cost, while an active system costs up to two percent (with maintenance costs being higher too).[19]

When larger damping and motion control are required, active systems are usually used, and for low damping and motion control, passive systems are utilized. These systems, while being more costly than the passive ones due to the presence of an active damper, achieve considerable savings in operating and maintenance costs

In the Damped outrigger concept for tall buildings this should consists of inserting dampers in the outrigger of a building. One of the main advantages of this system is to increase the damping (around five to 10 percent), and to reduce the variability of the inherent damping. Viscous dampers are utilized as damping devices, and two different configurations are proposed: dampers at the connection of the external column with the outrigger, and dampers in the coupling beams. Together with these innovative solutions, this provide a design procedure for tall buildings that adopt this technology. [30]

In general the installing of dampers in building have many possibilities :

First : Installing the damper as an integral part of the bracing members , for example the viscous dampers, installed as an integral part of the bracing members, can be found in the 55-story Torre Mayor in Mexico City [8].

Second :As composed of a counteracting-inertia-force-generating huge mass accompanying relatively complicated mechanical devices that allow and support the intended performance of the mass. the TMD system, located near the top of the building for its best performance

The designer having the choice of installing it in a room that usually not accessible to the public as in the cases of the sliding type TMDs installed in the John Hancock Building in Boston or the choice of appear it as a decorative element in the building interior to attracting interest of visitors and this we can found it in the pendulum-type TMD installed in the Taipei 101 tower.

5. The Non-Structural elements : those likely to cause structural damage

Non-structural elements are, by definition, not intended to resist any seismic forces other than those resulting from their own mass. They are also, in the main, elements that structural engineers do not design and for which architects, and mechanical or electrical engineers take primary responsibility. The diverse types of non-structural elements can be divided into three groups:

1. Architectural elements such as cladding panels, ceilings, glazing and partition walls
2. Mechanical and electrical components like elevators, air conditioning equipment, boilers and plumbing, and
3. Building contents, including bookcases, office equipment, refrigerators and everything else a building contains.

Non-structural elements, therefore, transform a structure into a habitable and functional building. The occupants, the fabric and contents of buildings and the activities undertaken in them are the life-blood of society. So it should come as no surprise that architects need to ensure, on behalf of their clients, that non-structural elements perform adequately during earthquakes. The two compelling reasons for taking the seismic performance of non-structural elements seriously are: firstly, the danger these elements pose to people both within and adjacent to the perimeter of a building, and secondly, the economic investment in buildings and enterprises occurring within them.[3] p.173

The value of non-structural elements expressed as a percentage of the total cost of a building, excluding the price of the land, depends upon the type of building considered. In an industrial or storage building with few mechanical services and architecturally designed elements, non-structural costs can be in the 20 to 30 per cent range. In more heavily serviced and complex buildings non-structural elements can comprise up to 85 per cent of the total cost. It makes sense to protect this investment from earthquake damage. Non-structural elements have proven to be very vulnerable to seismic damage as evidenced by the 1994 Northridge, California earthquake. If a quarter of the most severely damaged of the 66,000 buildings surveyed are excluded, most of the remaining damage occurred to non-structural elements.[31]

In a seismic study of a 27-storey building in Los Angeles subject to the Maximum Credible Event, direct economic loss of non-structural elements exceeded by six times the cost of structural damage.[32]

During earthquake shaking, non-structural elements represent a significant hazard to people. Injuries are caused by building elements such as glazing or suspended ceilings shattering or collapsing, or by building contents being flung around. Filing cabinets and equipment overturn, containers of hazardous materials break open or gas from ruptured pipes ignite. Damage scenarios vary from building to building and room to room. The main non-structural architectural elements is : [3] p159-187

1. Infill walls
2. Staircases
3. Cladding
4. Windows and curtain-walls
5. Parapets and Appendage
6. Partition wall
7. Suspended ceilings and raised floors

6. Case Studies:

We will study two samples of research, describes the tall buildings have been designed to resist earthquakes.

6.1 Research samples:

6.1.1 Taipei 101 Tower:

6.1.1.1Some basic information

Taipei 101 a structural marvel created by combining the best of all structural systems it's have 101 floors above ground, as well as 5 basement levels with Total Height 508m. It was the world's tallest building from March 2004 to 10 March 2010 As of 28 July 2011, it is still the world's largest and highest-use green building.it was designed by Architect – C.Y.Lee & Partners and the Structural Engineer – Shaw Shieh.[14]

The building frame materials is (60ksi Steel &10,000 psi Concrete) Systems (Outrigger Trusses, Moment Frames ,Belt Trusses)

And the Lateral Load Resistance(Braced Moment Frames in the building's core, Outrigger from core to perimeter, Perimeter Moment Frames, Shear walls, Basement and first 8 floors) [14]

The challenges faced the tower are: Weak soil conditions (The structures tend to sink) Typhoon winds (High lateral displacement tends to topple structures).Large potential earthquakes (Generates shear forces).

The Structural system of Taipei 101 is Braced core with belt trusses. For additional core stiffness, the lowest floors from basement to the 8th floor have concrete shear walls cast between core columns in addition to diagonal braces. Within the core, sixteen columns are located at the crossing points of four lines of bracing in each direction.

Taipei 101 is designed to withstand the typhoon winds and earthquake tremors that are common in the area east of Taiwan. Planners designed Taipei 101 to withstand gale winds of 60 meters per second (197 ft/s), (216 km/h or 134 mph), as well as the strongest earthquakes in a 2,500-year cycle. [13] .

101 Taiwan's former king of skyscrapers needed some large-scale engineering to withstand the country's frequent earthquakes and typhoons not to mention sitting near a huge fault line. The solution came in the form of a 730-ton ball of steel which hangs inside it like a gigantic pendulum to counteract any swaying. Known as a tuned mass damper, the ball rests inside a sling made of steel cables and has its own shock absorbers.

6.1.1.2 Earthquake Resistance:

The main objective of such a system is to supplement the structures damping to dissipate energy and to control undesired structural vibrations .A common approach is to add friction or viscous damping to the joints of the buildings to stabilize the structural vibration .

They used Tuned Mass Damper (TMD) that take excess energy away from the primary structure. A TMD is a passive damping system, which consists of a spring, a viscous damping device, and a secondary mass attached to the vibrating structure.and By varying the characteristics of the TMD system, an opportunity is given to control the vibration of the primary structure and to dissipate energy in the viscous element of the TMD.

6.1.1.3 The design consideration of the damping system:

The Taipei 101 uses a 800 ton TMD which occupy 5 of its upper floors (87 – 91). Figure(9).The ball is assembled on site in layers of 12.5-cm-thick steel plate. It is welded to a steel cradle suspended from level 92 by 3" cables, in 4 sets of 2 each .Eight primary hydraulic pistons, each about 2 m long, grip the cradle to dissipate dynamic energy as heat .A roughly 60-cm-dia pin projecting from the underside of the ball limits its movement to about 1 m even during times of the strongest lateral forces. The 60 m high spire at the top has 2 smaller 'flat' dampers to support it. this huge mass of the pendulum-type TMD the designer decided to appear it as a decorative element in the building interior to attracting interest of visitors not just services space not accessible to the public. Figure(10), Figure(11).

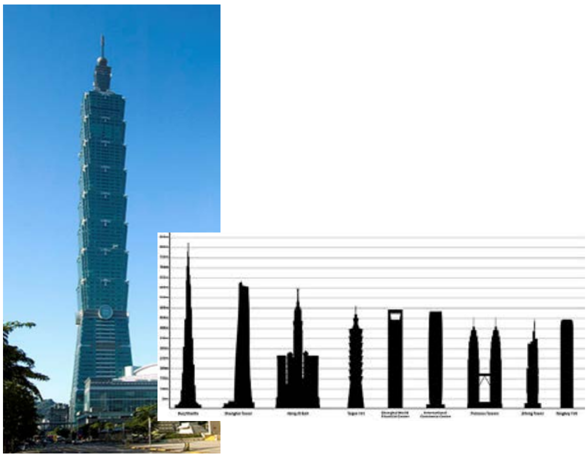

Figure 9: Taipei 101 Tower source [13]

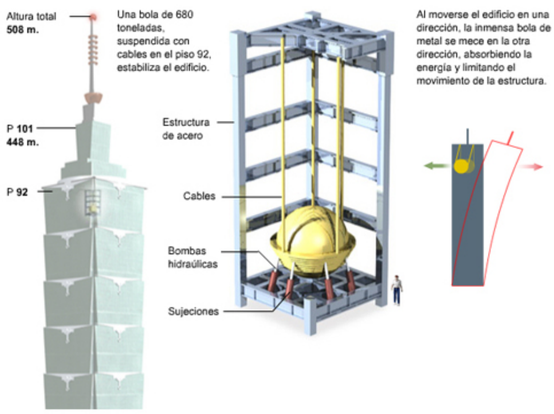

Figure10: Taipei 101 Tower's TMD system. source [14]

Figure 11: Location of Taipei 101's largest tuned mass damper.source [13]

6.1.2 Torre Mayor Tower:

6.1.2.1Some basic information

Torre Mayor Tower is a skyscraper in Mexico City, Mexico. With a height of 225 metres (738 feet) to the top floor and 55 stories, it is the third tallest building in Mexico. It was surpassed in height by Torre BBVA Bancomer, which in turn was surpassed by Torre Reforma. From its completion in 2003 until 2010 (when it was surpassed by the 236 meter (774 ft) high Ocean Two in Panama City. it was also the tallest building in Latin America.. The building was designed by the architectural firms of Zeidler Partnership Architects and Executive Architects Adamson Associates Architects, both of Toronto.

Construction work began in 1999 and was finished in late 2003. Due to Mexico City's high propensity to earthquakes, the tower incorporates several anti-earthquake measures. [12]

6.1.2.2 Earthquake Resistance:

The main design challenge of Torre Mayor Tower is its location in the lakebed area where most of the 1985 earthquake damage occurred.so the designer team , being designed to withstand earthquakes measuring 8.5 on the Richter Scale. [14]

A total of ninety-eight dampers are used, including twenty-four large dampers, each rated at 570 tonnes of output force, located in the long walls of the building. The short walls utilize seventy-four smaller dampers, each rated at 280 tonnes of output force.[12]

These diamond-shaped dampers are seen architecturally on its perimeter. With this extra bracing, this tower can withstand earthquake forces nearly four times as efficiently as a conventionally damped building. The dampening system proved its worth in January 2003, as a 7.6 earthquake shook the city. Not only did the building survive undamaged, occupants inside at the time did not know a tremor had occurred [15]

Figure 12: Mayor Tower. source [15]

Steel, reinforced concrete and an innovative system of 98 dampers bordering the building make Torre Mayor resilient to tremors.

This elevation reveals the function of each floor from the underground parking up to the heliport. It demonstrates how the dampers are positioned around the building.

6.1.2.3 The design consideration of the damping system ; to implementation process optimizes the performance of the individual dampers within the structure , varying the damping coefficients and exponents. it was decided to use twenty-four large dampers of 570 tones rated force in the long walls of the structure. Each damper spans multiple floors, using a so-called “mega brace” element, installed in a diamond pattern. In the short walls of the structure, seventy-four pieces of a smaller 280 tonnes rated force damper are used. (Figure 13) is a photo of the building frame taken during construction. This photo shows the diamond arrangement of the installed large dampers in their mega brace elements. [12]

Figure13: The large dampers in their mega brace elements during and after construction of Torre Mayor Tower source [12] p.11

Torre Mayor is the first tall building to use mega brace damping elements, where a single damper spans multiple floors. This allows the interior of the building to have maximum floor space with minimal obstructions to the architectural theme. Figure 12 shows the completed Torre Mayor and provides visual evidence of the building’s dominance of the city’s skyline. The dampers are plainly visible through the window glass.

7. Conclusions and recommendation:

This research has presented many conclusions represented in :

1. The architect should have completely knowledge of the conflict of architectural design in the risk of earthquake which having the aspect of simplicity , and regularity and symmetry but still the architect have looking for high style and creative design which its form is almost irregular and unsymmetrical and fragment ,the architect should enjoy this challenge and present realistic and creative design and this should built depending upon general strategies

The strategies of seismic design in tall building are :

a) Architectural design configuration both horizontal and vertical that resist the seismic loads.

b) Architectural non- structural elements design that resist earthquake damage.

c) Chose the suitable type of structure for tall building that resist the lateral loads specially seismic loads .

d) Chose the suitable damping systems in tall buildings and show the possibilities of use it in architectural view.

2. knowing the damping systems types and there installation in building help the architect to utilize from it as attracting feature in the building and he could show it in the exterior or interior of the building in distinctive way .

3. the non-structural element design may cause damage and effect on the economic investment in buildings and enterprises occurring within them.[3] p.173

The research recommends to educate the architect in the general strategies of seismic design and the risk of damage of some architecture decisions and configurations which start from the lake of architect knowledge. also the design near the optimum seismic performance to arrive to the perfect functional and aesthetic design .

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استراتيجيات التصميم المعماري المقاوم للزلازل في المباني العالية

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الخلاصة

تسعى العمارة الى ايجاد ابنية تلبي متطلبات شاغليها سواء كانت جمالية او وظيفية , والتي تمتاز بقدرتها على توفير الامان والراحة لشاغليها من الظروف الخارجية المؤثرة , ومن احد اهم تلك الظروف "الزلزال " والذي يسبب في دمار هائل للأبنية والانسان على حد سواء . ومع التطور العلمي الكبير في مجال الابنية وخاصة الابنية العالية ومع "الحاجة الى ايجاد اطار معرفي واضح لاستراتيجيات التصميم المعماري المقاوم للزلازل , ولاسيما الابنية العالية " يسعى البحث لإيجاد تلك الاستراتيجيات من خلال التعريف بالأحمال الاساسية المسلطة على المباني العالية والتطرق الى الحلول الانشائية لها والتي تقاوم الاحمال الجانبية , كما تطرق البحث الى افضل احتمالات التشكيل الافقية والعمودية لتصاميم ابنية الزلازل , كما عرف نظام التخميد وفصل انواعه المختلفة مع ذكر ايجابيات وسلبيات كل منها .واخيرا ناقش الاعتبارات التصميمية عند استخدام انظمة التخميد وتم تفصيلها ضمن الامثلة البحثية المختارة.

الكلمات المفتاحية :الزلازل – المباني العالية – تصاميم ابنية الزلازل - سياسة التخميد – التصميم المعماري المقاوم للزلازل.