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The Integration Between the Structural System and the Envelope System in Earthquake Resistance Design

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ABSTRACT

Earthquakes are one of the most serious natural disasters affecting the stability and the durability of buildings, threatening the life of its occupants. These buildings should be withstanding earthquakes by both architectural and structural engineers. The Integration between structural and envelope system is negatively affected due to; the lack of architectural knowledge in earthquake resistance, and the absence of cooperation between architectural and structural engineers in earthquake resistant design. In this research the lack in the nature of the integrative relationship between the structural and envelope system of earthquake-resistant buildings design is presented. Also, the relationship between these systems, their patterns, and levels in the building to resist earthquakes are highlighted. Where the concept of integration, patterns and levels are verified, using inductive methodology (descriptive, and analytical) through election, analyzing of two different case studies.major result show that the performance pattern is the most common type of three other integration patterns.Also the envelope ,structural system response achieves an equal degree of response as both of them are integrated with each other without revoking one the role of other or affecting the optimal seismic resistance of buildings, and conclusion are presented further.

1. Introduction

Integration can be defined as the nature of relationship between a set of structural components forming the physical shape of the building, linking these components to each other to find common functions between building's systems. The concept of integration refers to the importance of reciprocal relationships between building systems, to achieve the integration between these systems with deferent levels. Where the ability to change the nature of integration, according to the hypothesis that suggests every building must consist of several integrated systems. The chance of vagueness in integration between them is possible in each system separately according to predefined criteria. But if the integration occurs, it will be according to a set of criteria that ensure the integration of all systems of current building together according to the functionality of the building, and the needs of its occupants in specific time and place [1].

The concept of integration in current building refers to the interrelationship of its systems with mutual relations aiming to unify the building to achieve its design purposes with the highest level of design flexibility. The integration of building's systems has countless advantages in the design process such as reducing the time spent in the process of construction. Also building materials required which entails the reduction of economic cost, obtaining a building with spaces properly studied and expressive of its

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functions taking in to consideration the possibility of future expansion [2].

Therefor it can deduce that the concept of integration refers to the possibility of connecting the parts with each other to achieve an integrated system. From architectural point of view, the concept of integration takes place between different systems of a building to obtain high performance and flexible building to achieve its designed purpose, in addition to its ability of changing to meet the requirements of the users.

The importance of research is dedicated in clarifying the role of integration between the structural system and the envelope system facing earthquakes, according to that the research methodology included:

•Building a cognitive framework that clarifies the concept of integration patterns, and levels between the structural system and the envelope system.

•Extracting the vocabulary of the theoretical framework through the analysis of previous knowledge.

•Electing projects as case study.

•Apply the theoretical framework on the elected projects to acquire the final results and conclusions.

2-Theortical Frame Work

In this paragraph, the concept of integration, the relationship between the structural system and the envelope system, and the nature of integration between them will be discussed and clarified as follows: -

2-1 Integration Linguistics and Terminology: -

Integration is a noun that means formation and association that forms an integral system, which is linked to the concept of idea and form, body and soul, and defers from the concept of unity that is often associated with the concept of form and formation [3].

Integration also could be defined from Latin word "Integritan", which means the fulfillment or the completion of something to achieve whole unification, within the building's system it known as the process of creating common functions between deferent systems [1].

From the above-mentioned paragraph "integration" could be defined as the process of connection and communication between building's systems to achieve unity in the building by finding common functions between them, which is linked to the concept of idea and form soul and body, and defers from the concept of unity that is often associated with the concept of form and formation.

2.2 Integration patterns.

There are three patterns in integration between building's systems are: -

2.2.1. Physical integration: this type of integration occurs between the architectural systems that are located in the same space, which have interrelationships between them, such as interference and interlock. It is considered as the most complicated pattern of integration because it is not possible to make a mistake as a result of the overlapping systems, therefore; it is difficult to mend any error that might occur due to the lack of flexibility in the integrated patterns [4].

2.2.2Visual integration: This integration is projected as the external appearance of the architectural systems and it doesn't require functional interaction between the integrated systems. This type of integration can be achieved by unifying building materials, or unifying masses of the building in order to give the recipient a meaningful view. In addition to the meaning of the parts integrated with each other. This pattern of integration focuses on the use of visual effects, such as lighting elements, as well as other influences, to deliver the meaning by merging between the expressive aspect and technology [4].

2.2.3. Performance integration: This type of integration occurs between two systems combined with one function to achieve the functional requirements of building users, by providing stability in addition to building protection, and earthquake resistance by providing durability and safety, and reducing the complexity and cost during design process [4].

2.3 Integration levels

There are five types of integration levels [1], and they are: -

2.3.1. Remote integration: it isn't commonly used because of the physical separation that happen between the architectural integrated systems, although there is a functional consistency between the integrated systems.

2.3.2. Touching integration: this type of integration depends on the gravity forces as a connection and supportive to the integrated systems. systems that use this level of integration are connected without a constant connection between them as the integration between structure system and envelope system.

2.3.3. Connected integration: where integrated system is connected to each other by connection tools, these tools must be constant or variable.

2.3.4. Meshed integration: The integrated system is interacted with each other within the boundaries of the same space.

2.3.5. Unified integration: it is the most complicated level of integration, where integrated systems share everything together till it's very hard to differentiate between them, such as the unification between the structural system and the envelope system.

The building systems differs from each other according to the interaction and connection degrees, whenever the connection and interaction between these systems increase the interaction level shall increase

but this increasing doesn't mean the optimal state of the building. Thus, if the systems are well interacted and well connected that will lead to a difficulty in maintenance and replacement for the damaged parts when they exposed to earthquakes. Therefore, the ideal level of integration must be chosen according to the building systems in addition to function requirements [2].

There are four major system in every building:

- Structural system
- Envelope system
- Mechanical system
- Interior system

Table (1) Levels of Integration Between the Most Common Systems in The Building [1]

Building systems	Integration levels				
	REMOTE Integration	Touching Integration	Connected Integration	Meched Integration	Unified Integration
Structure +envelope		●	●		●
Structure +Mechanical			●	●	
Structure + Interior		●	●		●
Envelope + Mechanical			●	●	
Envelope + Interior	●		●		●
Interior + mechanical		●	●	●	●

The relationship between the structural system and envelope system only in order to reach will be discussed further so as to evaluate an integration formula between them so as to activate their role in earthquake resistance. Table (1) shows the levels of integration between the most common systems in the building.

2.4 The Relationship Between Structural and Envelope Systems.

Every building consists of many systems that works together to form the design concept of the building, also to maintain building's stability, durability and ensuring its function efficiency, which can unify the building with the surrounding environment. Since the architectural design focuses on the aesthetics and symbolic manner, earthquake resistance depends primarily on the structural system. Therefore, the complementary relationship between these two systems will be considered as the base on which the architectural design process depends on.

2.4.1 Envelope System:

The architectural forms differ from each other according to the design concept that is adopted from number of factors related to the project's environment such as the location history, project's functionality, and the time period which the design belongs. As well as the architectural theories of the era, as these forms were closely related to the architectural theories that expresses them. Therefore, the architect has been concerned over ages to the meanings of forms and their interpretations and spiritual correlations to its place and location. Some of the architectural forms have been devastated due to its symbolism connections and strong associations with a time period or certain symbol of the surrounding environment [2]. The form is a set of elements connected with each other reflecting a certain appearance, also form is a set of physical elements represented by the mass surrounding's related to the non-physical elements of the space that is created to serve the users which is the most important step of the design process, where the designer always seeks for achieving the user's satisfaction [٥].

Hence, the outer shell has a vital role in protecting the inners of the building from weather conditions, it separates between the inner and the outer environment by a set of materials, shapes and elements that are related together to form this shell. These are influenced by the surroundings, so it lets air and light to flow into the building and prevents negative environmental factors that badly influence inners of the building, in accordance with the function of the building and environmental system that is used to serve the users [6].

As a result, the envelope system is formed by using number of shapes which forms the outer shell of the building that embodies the concept of the designer. It isolates the inner from the outer of the building which is necessary to secure the building, and resisting weather conditions. It exemplifies the surroundings with the inner of the building.

2.4.2 structural system

The structural system is considered as the main supportive of the building, so there is no organic system without structural system supporting it. The structural system is one of the most important architectural system over ages that support's buildings whether it was simple or complex or skyscraper. It represents the basis and the essence of the architecture that contains the aesthetic and expressive meanings.

The structural systems are classified into [7]:

i. Structural system that is set for supporting only.

ii. Structural system that support the movable and fixed parts of the system.

iii. Protection structural system.

iv. Supportive structural system with symbolic and expressive meanings.

Therefore, the structural system is considered as the main system in which the designer depends on to show various designs and evaluating them. Despite the fact that the structural system doesn't construct architecture but it makes it possible, so the structural system is not the designer's target. But it is the mean for achieving it by creating the suitable environment that provides safety, durability as well as function and aesthetic aspects. Therefore, any construction system must provide the structural requirements which is chosen for such as vertical and, horizontal loads. In addition to other requirements of fire resistance, earthquakes, thermal insulation and other requirements that achieve the ideal performance of the building through integration with other construction systems [8].

As a result, the structural system holds the external envelope of the building and maintains the building from the vertical and horizontal loads that affects the stability of the building. Hence, the constancy and durability of any building depends on structural system.

٣-literature survey

This paragraph discusses the previous knowledge for researchers 'studies that dealt with the concept of integration between the various building systems, especially those focused on the integration between the structural and the envelope system showing their role in earthquake resistance.

3.1 study of Rush, 1986,

The Building Integration hand book, The American institute of architecture [1].,

this study focused on finding the nature of the integration in any building consisting of a set of construction systems, that forms the physical shape of the building. The study referred to the concept of integration as the nature of the relationship or the linkage between the structural systems and defined to the levels of integration that determine the nature of that relationship, The integration levels that can occur between the structural system and the outer shell of the building have been determined at three levels are:- touching integration in which the envelope system is based primarily on the structural system, and the relationship between them must be flexible enough to fit with the structural system adopted to withstand against the earthquakes. Also, the connected integration which the envelope system is connected with the structural system by bonding elements, so they associated with each other to do some of the building functions such as the distribution of loads and the protection and safety of the building by separating the inner of the building from the surroundings. In the case of the outer shell or the envelope system must be standing on structural system. And the last type of integration between these two systems is the unified integration on which the two systems are interacted with each other so they have the same materials, elements and the same functions so that it is difficult to distinguish between them.

As a result of the above mentioned this study focused on the relationship between the structural system and the envelope system, so it merges between the structural balance and loads distribution. Also pairing between inner and outer environment of the building. the nature of integration between these two systems has been clarified since they depend on each other. As the envelope system depends on the structural system in supporting it. Also, the structural system depends on the envelope system in closure and protection. Therefore, it could be concluded that the aim of integration between these two systems is to achieve the optimum performance of the building and develop its resistance against external forces affecting it, including earthquake forces.

3.2 study of Hugo Giuliani ,2000

Seismic Resistant Architecture, A theory for the Architecture Design of Building in Seismic Zones [9].

This study deals with the nature of the relationship between architectural and structural engineers to resist earthquakes, ensuring the importance of the architect's role in resisting these hazards, and avoiding errors during design process. Because it effects building resistance negatively. It showed also the importance of interaction between all elements of the building (architectural & structural elements) to protect the building from the seismic impacts and achieve the optimum performance. This study focused on the importance of the design method that is used during design process of the building resisting earthquakes, and distributed it to these main ways: -

- The traditional method: it is a regular method on which the architect designs the building without taking seismic aspects into account. Then the structural handled the structural calculations and makes the adjustments according to the seismic effects that may influence the building. This may result in non-adjusted design that has a weak seismic resistance.
- earthquake-resistant architectural design method: in which the building is designed according to the earthquake determinations, to ensure the contributions of all structural and architectural elements in earthquake resistance. This requires continuous co-operation between the architect and structural engineers to achieve the optimum performance of the building during earthquakes.

This study focused on the importance of the method used to design buildings that is earthquake resistant, by distinguishing between traditional method and earthquake resistant architectural design method. and emphasizing the importance of continuous co-operation between the architect and the structural engineer to reach for seismic resistant buildings.

3.3 study of T. Salk and V. Kilar,2007,

Earthquake architecture as an expression of a stronger architectural Identify in seismic areas [10].,

The study referred to the concept of earthquake-resistant architecture as a real result of the necessity of architect's commitment to seismic determinants in design process, by emphasizing on the nature of relationship between envelope system and structural system In earthquake-resistant architectural design, referring to the importance of interaction between design idea and seismic requirements, the amplitude of seismic resistance (which forms in the structural system) during the architectural design (which forms in the envelope system). requires the integration of both systems together; as earthquake resistance requires the implementation of seismic determinants. which results different response between the two systems. This study identified three types of responses are: -

• Response of the structural system to the envelope system: This response focuses on the importance of the symbolic aspect. So, the earthquake resistance is a concept that inferior to architecture, the designer focuses on the aesthetic considerations and the shape of the building, avoids showing the construction elements at the building's facades.

• Response of the envelope system to the structural system: It focuses on the importance of seismic resistance so the structural system is the final determinant of the shape of the building and the emergence of the structural aspect, which leads to the absence of architectural influence on the building.

• Envelope and structural response: In which the two systems (envelope system, structural system) integrated with each other to ensure the achievement of optimal seismic resistance of the building. Where the structural elements appear at the facades of the building as well as the interior level in deferent proportions.

This study focuses on the nature of the relationship between these two systems during design process, and attempt to classify the responses to show the pros and cons of each response. So as to achieve the best performance of the building against earthquakes without effecting the symbolic and functional aspects.

3.4 study of M. Mezzi, A. Parducci ,2011,
Architecture towards Seismic engineering [11].,

This study focused on the importance of the relationship between the architect and the structural engineer facing the dangers of earthquakes, explaining this by explaining the nature of the design behavior that is committed in the design of those buildings. The study pointed to the existence of two kinds of behavior when designing buildings resistant to earthquakes:

• Normal or negative behavior: which includes setting the design program as well as the design concept, building shape and plans synchronized with each other, after that the type of structural system and the response to the structural requirements are determined, so there is no cooperation between the structural and the architectural engineer during the design process.

• Positive behavior: includes the continuous cooperation between the architect and the structural engineers during the design process, including the synchronization of architectural design with the structural design of the building and the response to the structural determinants from the early stages in the design process, as early discussions with the structural designer is one of the most important things that clarify a lot of mysterious things from the initial stages of the design process.

The study focuses on the importance of determining the nature of the design behavior between the architectural and structural engineers during the design

Process and indicating the importance of cooperation between them to achive the optimal seismic resistance of buildings by analyzing the descriptive state of the previous studies, it is possible to extract the main vocabulary, its secondary vocabulary and then reach its possible values as shown in table (2) below.

4. APPLICATION

This paragraph focuses on the application of the main vocabulary of the theoretical framework and its secondary vocabularies that has been extracted from the previous studies on the selected two projects as a case study to obtain the results.

4-1 Tod’s Omotesando Building in japan(A):

When Tod's Mace Omotesando wanted to open a new building, the main idea of the building was to express the brand's name, so the architect “Toyo Ito” took into his consideration generating a creative design. The location was chosen on the most prestig-

Table (2) Main and Secondary Vocabulary and Their Relative Possible Values of the Theoretical Framework

Main vocabulary	Secondary vocabulary	Possible values		
The Integration between the Envelope System and the Structural System to Resist Earthquake forces	the pattern of integratio between these systems	Physical integration	Overlapped systems in a complex way	
		Visual integration	Integration at the external level	
		Performanance integration	Integration at the function level	
	the level of integration between these systems	Touching integration	Connected systems without connection elements	
		Connected integration	Connected systems by connection elements	
		Unified integration	Interacted and overlapped systems	
	The Used method in earthquake resistant design	Traditional method	Earthquake resistance is an inferior concept to architecture	
		Earthquake resistant architectural design method	Architectural design according to seismic regulations	
	Type of response between these systems	Envelope response at the level of the facades	Importance of the symbolic & aesthetic aspects	
			Hiding the structural elements from the facades	
			Weak earthquake resistance	
		Structural response at the structural system level	Structural elements composing building’s facades	
			High earthquake resistance	
		Envelope and structural system response at the interior and exterior level	Sympolic aspect	
			Earthquake resistance	
			Structural elements appearing on the facades	
			Structural elements appearing on the interior level of the building	
	Degree of response	High degree	Type of response	Structural response
			Level of response	At the structural system level
			Design method	Earthquake resisrant architectural design
		Equal degree	Type of response	Envelope and structural response
			Level of response	At the structural and envelope level
			Design method	Earthquake resisrant architectural design
		Low degree	Type of response	Envelope response
			Level of response	At the facades
			Used method	Traditional method

Main vocabulary	Secondary vocabulary	**Possible values**		
The Integration between the Envelope System and the Structural System to Resist Earthquake forces	Architecture behavior during design process	Positive behavior	Structural design is part of the design process	
			Responding to seismic determinants	
		Negative behavior	Structural design is separated from design process	
			The architectural design doesn't respond to seismic determinants	
	The relationship between The architectural and Structural engineer	Cooperation between the architectural and structural engineers	Behavior of the designer	Positive behavior
			The sense of time	Responding to seismic determinants since the initial stages of design process
		No Cooperation between the architectural and structural engineers	Behavior of the designer	Negative behavior
			The sense of time	Responding to seismic determinants after implementation
	Degree of communication between the architectural and structural engineers	Strong connection	Positive behavior	
			Continuous cooperation between the architectural and structural engineers	
		Weak connection	Negative behavior	
			No cooperation between the architectural and structural engineers	

ious street in Tokyo, "Yoyogi" shopping street within "Aoyama" sector in Japan [14]. The design concept was objectified by surrounding the building with an outer shell of concrete which appears as branches of trees to mimic the organic nature surrounding the building, especially the trees in this street in cold months, when tree leaves fall down and branches become bare, and its reflection begun to appear on the facades of the building [15].as shown in fig (1). Where fig (2) shows the structural system elements at the interior level, fig (3) shows a section in the building, as for fig (4) shows the structural system elements at the exterior level, while fig (5) shows the finishing material of

building facades, and fig (6) shows the ground floor plan.

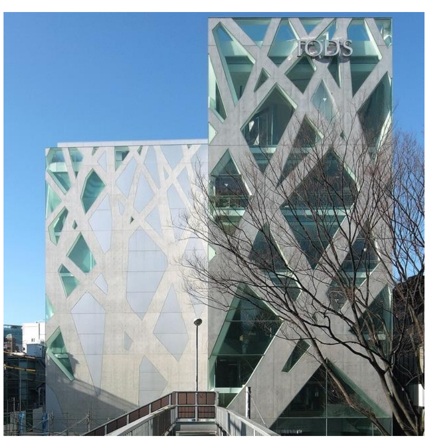

Fig (1) elevation of the building [15]

Structural system formed by concrete branches with thickness of 30 c.m

Fig (2) the structural system elements appears at the interior level [15]

Fig (4) the structural system elements appears at the exterior level[15]

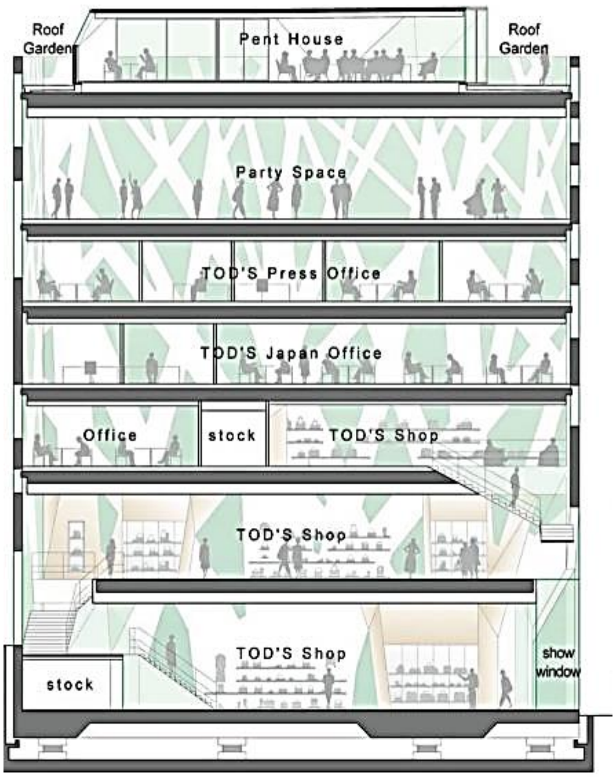

Fig (3) section in the building [15]

Fig (5) appearance of concrete material at elevation level[15]

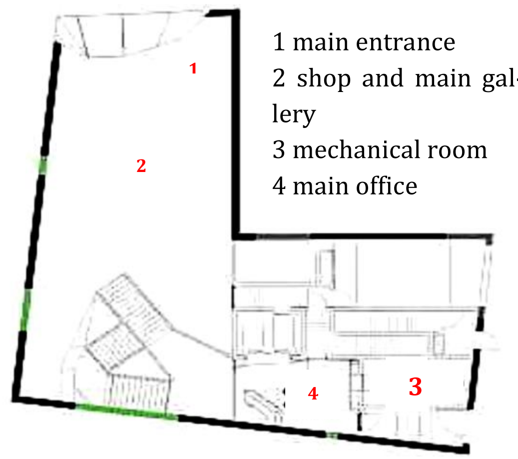

Fig (6) ground floor plan [15]

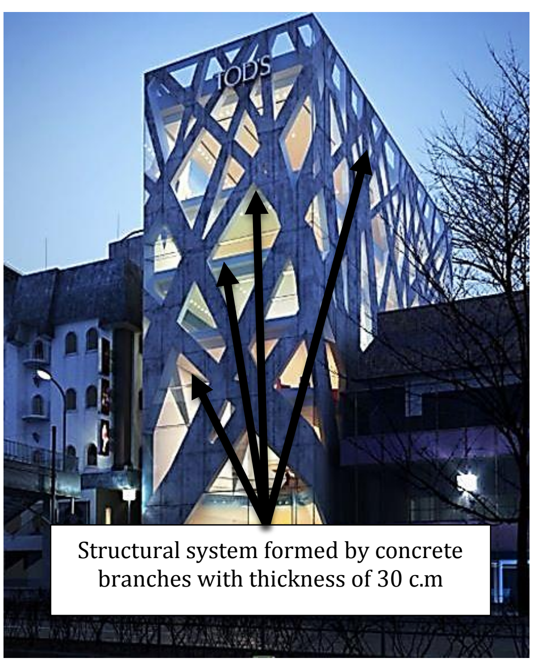

Table (3) Discussion and analysis according to the selected vocabulary for application

The integration between the structural system and the envelope system	
Main description	Analyzing project according to the Main and Secondary Vocabulary of the Theoretical Framework
The design concept was embodied by using the shape of the tree branches which was reversed on the outer shell of the building that was formed by concrete with 30 cm thickness forming these branches. fig (3) & (4) shows the structural system in the form of tree branches configuration building's facades. This enables the designer to initiate his concept using a network of concrete in the form of tree branches that compose the facades of the building, in the same time. This network transfers the vertical loads of the building down because it is connected to the building's floors, also reduces the horizontal loads resulting from the effects of seismic forces [12]. This network works as a structural system and an envelope system at the same time as shown in fig (2) &(3) ,thus it was covered with the same material "concrete" to achieve the interaction between this two systems .Hence, it is very difficult to differentiate between them , the architect was able to overcome the difficulties of the traditional structural elements of columns and beams through the usage of this outer shell, .This which gave the designer freedom at the interior design by providing free plans with no columns fig (6).This innovative system don't form the shape of the building only but it works as structural system that transfers the vertical loads dawn and also reduces the horizontal loads that may affect the building[17] .	• The pattern of integration between the envelope system of the building and the structural system can be determined by the **performance integration**. Both systems share the same function of transferring the vertical loads of the building downwards and facing the horizontal forces to achieve stability and safety of the building. • The type of integration between these systems is unified integration resulting from the interaction of the envelope system with the structural system so that it is difficult to distinguish between them. • The method used by the designer in the design of the building, is earthquake resistant architectural design method which depends on the continuous cooperation between the architect and construction engineers to achieve the optimum performance of the building during earthquakes. • The type of response in this building can be determined as a structural response resulting from the uniform integration between the envelope system and the structural system, the structural system was used to determine the final shape of the building, which formed the facades of the building through elements of the structural system • The degree of response in this building can be determined as high degree of response resulted from the structural response type, also using the earthquake resistant architectural method. • The behavior adopted by the architect is positive behavior due to the fact that the structural design is part of the design process. In addition, the designer's response to the seismic determinants in terms of the type of construction system used and building materials used in it • The relationship between architectural and structural engineers. based on cooperation between them and the degree of cooperation between them is strong resulting the integration between the structural and envelope system

4-2. Philippine Arena project.

Philippine arena is one of the largest indoor stadiums in the world, with a capacity of 55,000 spectators as shown in fig (7) below. Due to the large number of spectators and the difficulty of providing everyone a clear view angle, this shape was chosen to accommodate such a large number of crowds in addition of providing a clear and easy enter and exit axes[18], The arena's shape looks like a single-sided oval bowl that rises from the center and is compressed from both sides to achieve clear viewing angles for all viewers. In addition to the display panels that are installed to give clear watch to all viewers. This form was chosen to suit the wind movement, As shown in fig (8), (13) & (14). Thus, the horizontal forces generated by the movement of wind does not affect the building [13], while the seismic forces that may affect the building has been resisted

by isolating the lower part of the building from the surface with lead rubber isolators (LRB). Accordingly, when the building is exposed to strong earthquakes, the lower part moves while the surface remains constant. These solutions made the building one of the most powerful earthq
uake-resistant buildings in the world [19], fig (9) & fig (10) & fig (11) shows the elevations of the building, while fig (12) shows the structural elements at the interior level of the building, as for fig (13) shows the structural system of the building.

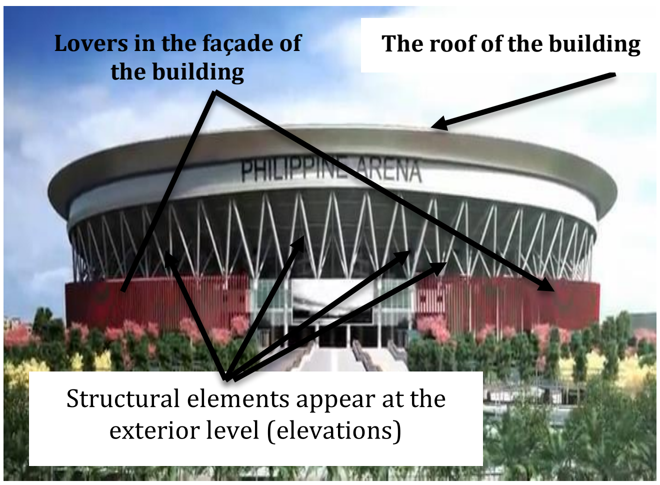

Fig (7) Perspective of Philippine Arena

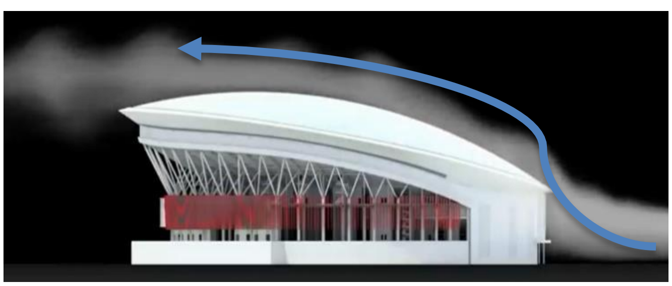

Fig (8) Shows the wind movement when they reach the building's mass

Fig (9) Front Elevation of philippene Arena

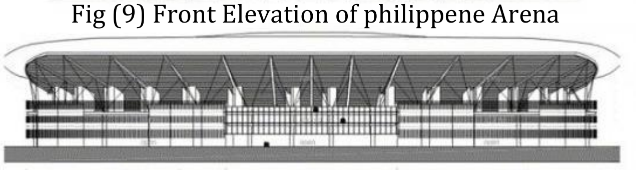

Fig (10) Back elevation of Philippene Arena

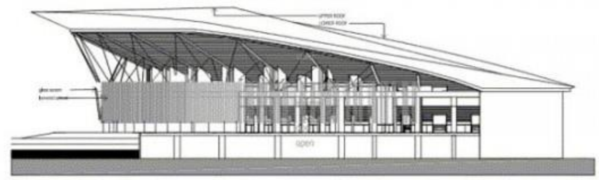

Fig (11) Side elevation of Philipene Arena

Fig (12) Interior perespective of Philippene Arena

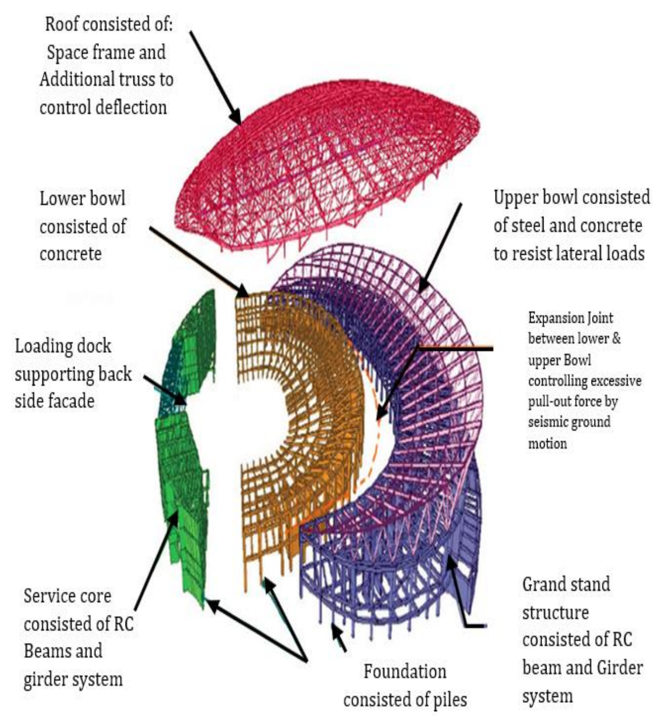

Fig (13) Shows the structural system of Phillippene Arena

5. Measurements of Selected projects outcomes.

In this section, the variables of the theoretical framework will be measured on the selected sample using a descriptive comparative analysis of the projects through a table that includes a verification field to verify the possible values of the indicators, defined by the researchers to evaluate the outcomes based on the information obtained from each project, where

(1) conform the possible values, and (0) refers to non conformance of the possible values, These measurements are shown briefly in table (5) below.

Table (5) Application of the theoretical framework to the elected projects

Main vocabulary	Secondary vocabulary	Possible values			PROJECTS A	PROJECTS B
	the pattern of integration	Physical integration	Overlapped systems in a complex way		0	0
	The relationship between The architectural and Structural engineer	Cooperation between the architectural and structural engineers	Behavior of the designer	Positive behavior	1	1
			The sense of time	Responding to seismic determinants since the initial stages of design process	1	1
		No Cooperation between the architectural and structural engineers	Behavior of the designer	Negative behavior	0	0
			The sense of time	Responding to seismic determinants after implementation	0	0
	Degree of communication between the architectural and structural engineers	Strong connection	Positive behavior		1	1
			Continuous cooperation between the architectural and structural engineers		1	1
		Weak connection	Negative behavior		0	0
			No cooperation between the architectural and structural engineers		0	0
The Integration between the Envelope System and the Structural System to Resist Earthquake forces			High earthquake resistance		1	0
		Envelope and structural system response at the interior and exterior level	Sympolic aspect		0	1
			Earthquake resistance		0	1
			Structural elements appearing on the facades		0	1
			Structural elements appearing on the interior level of the building		0	1
	Degree of response	High degree	Type of response	Structural response	1	0
			Level of response	At the structural system level	1	0
			Design method	Earthquake resisrant architectural design	1	0
		Equal degree	Type of response	Envelope and structural response	0	1
			Level of response	At the structural and envelope level	0	1
			Design method	Earthquake resisrant architectural design	0	1
		Low degree	Type of response	Envelope response	0	0
			Level of response	At the facades	0	0
			Used method	Traditional method	0	0
	Architecture behavior during design process		Positive behavior	Structural design is part of the design process	1	1
				Responding to seismic determinants	1	1
			Negative behavior	Structural design is separated from design process	0	0
				The architectural design doesn't respond to seismic determinants	0	0

6. Conclusions:

This section presents the final conclusions of the research that has been Extracted from the theoretical framework and application, they are:

- The seismic resistance of the building is related to the integration between the structural system and the envelope system.
- The performance pattern is one of the most common types of integration used in the design of earthquake-resistant structures. Whereas other two patterns are less commonly used.
- Unified integration is one of the strongest and the most widely used level of integration between the envelope and structural systems. in designing buildings resistant to earthquakes.
- The method that achieves the optimal integration between envelope and structural systems is earthquake resistant architecture design method,so it should be adopted in designing buildings resistant to earthquakes.
- The usage of the traditional method should be avoided by the designer in designing earthquake resistant buildings because it does not guarantee the building's resistance to seismic effects.
- The envelope, structural system response, achieves an equal degree of response as both of them are integrated with each other without revoking the role of each other or affecting the optimal seismic resistance of buildings.
- The structural response achieves high seismic resistance of the building because it focuses on the prevention of the seismic forces on buildings.
- Most buildings focus on the importance of the seismic resistance. Therefore, the structural system response to the envelope system is avoided because it achieves weak seismic resistance, and low response to seismic effects.
- the high degree of response between envelope and structural systems achieves the structural requirements and the seismic determinants, in addition to the optimal seismic resistance of the building.
- On designing earthquake-resistant buildings the designer should fallow the positive behavior that requires his commitment to the seismic determinants, and designing the structural system during the design process.
- Passive or negative behavior sould be avoided when designing earthquake-resistant buildings because this behavior ignores seismic determi nants from the design process and not concerning about the structural design, which leads to the weak seismic resistance of the building.
- The architectural designer should be highly cooperative with the structural engineer on designing earthquake-resistant buildings to indicate the type of seismic determinants. This result in positive response to both of them in a way that does not affect the integration of the two systems together.
    - The inadequate connection between architect and structural engineer result in weak or non-cooperation between them, which leads to weak seismic resistance building due to non-adherence to seismic determinants by the designer.

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