Online Journal of Art and Design
volume 13, issue 2, April 2025
DOI: https://doi.org/10.30935/ojad/2513037

A Review on the Effects of Planning Decisions on Earthquake Design in Urbanism and Architecture

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Abstract
Earthquakes are one of the natural disasters that occur frequently in many parts of the world, and architecture plays an important role in dealing with such natural events. it is an important field that improves the safety of people's lives by ensuring that buildings are designed and constructed to be earthquake resistant. Based on building codes, earthquake regulations and the latest scientific research, architects focus on creating an environment where people can live in safe and sound structures. Architects design and plan for emergencies that may occur after an earthquake. Important safety details such as evacuation routes, emergency exits and assembly areas should be considered during the design phase of the building.

This study analyses the importance and impact of architectural design before and after earthquakes. It highlights how buildings should be designed to withstand the effects of earthquakes and how precautions can be taken against the damage that may occur after the earthquake. It also defines the purpose and scope of this study, analyses architectural design before and after the earthquake in detail, and examines the importance and impact of architectural design. It emphasises how the structures should be designed under the influence of earthquakes and how precautions can be taken against the damage that may occur after the earthquake. It also defines the purpose and scope of this study and provides a detailed analysis of architectural design before and after the earthquake. The aim of the study is to show why architectural design before and after the earthquake is important and what its effects are buildings fail in earthquakes when major damage occurs to structural systems.
Keywords: Planning Decisions, Seismic Design, Urbanism, Architecture.

Introduction

Architecture plays a major role in determining the seismic performance and functional congruence of a building. The architect should take responsibility for ensuring the seismic performance of the building from the outset. The building should be designed/built to withstand seismic forces and not to be retrofitted after completion. Improving cooperation and communication between the architect, urban planning and government authorities, and earthquake engineering disciplines (seismology, structural engineering, lifeline engineering and emergency response) can greatly help to reduce the seismic vulnerability of buildings.

In an ideal scenario, buildings would be designed in such a manner that they are capable of withstanding moderate earthquakes, thereby minimizing non-structural damage. Moreover, they should be engineered to withstand structural damage in strong and large earthquakes, thereby preventing collapse and ensuring the safety of individuals. It is imperative that these structures are resilient enough to resist non-structural damage in moderate earthquakes, to resist collapse with structural damage in strong and large earthquakes, and to guarantee the safety of lives by preventing building collapse.

Planning Decisions at Settlement Scale

The demand for housing to meet the needs of an increasingly dense population has, in a short period of time, led to the construction and urbanisation of buildings that do not meet

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the latest technical and scientific standards, by stimulating the appetite of opportunistic builders and sellers. The preparation of Master Development Plans and Implementation Development Plans, which are the documents that guide the development of cities, requires serious geological studies of the areas where people will live and work, and the relationship of the area to the earthquake fault lines. Master development plans that are not based on all the research reports should not be valid. To this end, an institution such as the Earthquake Supreme Council should be established and empowered to approve plans. Individual or group buildings should be designed according to the characteristics of the seismic zone in which they are located, and there should be absolute control over the practical implementation of this requirement. Local authorities should work with professional bodies. Amendments should be made to Land Use Law to ensure that sanctions for non-compliance with this supervision are effective.

Building and land use regulation has proven to be the most effective tool for reducing disaster and chronic risk in developed countries. Focused attention on the building and land use regulatory capacity of disaster-prone countries and communities can ensure positive outcomes (Moullier 2016) Earthquake and urban planning is an important issue related to the planning and organisation of residential areas in earthquake-prone areas. Urban planning aims to create a safe and sustainable urban structure that is more resistant to the effects of earthquakes. This will minimise the loss of life and property caused by earthquakes and increase the resilience of society to disasters.

Building Height and Building Spacing

Distances between buildings are important for both earthquake safety and urban planning. Regulations generally specify these distances for fire safety, air flow, access to sunlight and to prevent buildings from colliding in the event of an earthquake. In earthquake-prone countries, building codes are very important. Setbacks from roads are considered a measure to ensure order in urban planning and to increase the safety of life and property in the event of a disaster by ensuring that buildings are located at a certain distance from the roadside. These distances are generally determined in accordance with zoning plans and regulations. In the context of an earthquake, setback distances can provide the following benefits: It prevents collapsed buildings from falling onto the street and keeps evacuation routes open. It allows search and rescue operations to be carried out more effectively. Preventing the spread of secondary disasters such as fire and gas leaks. The safety distance between buildings should be maintained (6 m in urban areas; 10 m in rural areas, depending on regulations) in order to minimise the effects of the spread of wildfire or damage due to the collapse of neighbouring buildings (flood, storm, earthquake) (Sapountzaki, 2002). If more than one building is constructed on a plot of land, the distance between the buildings should be at least the height of the buildings. If the buildings are of different heights, this distance is the height of the taller building: If the setback is 5 metres or less, the building may completely block the road when it collapses: If the setback is at least 10 metres, the collapsed building may keep the roads open: It is recommended to increase the setback distances so that the debris does not obstruct pedestrian and vehicle traffic.

Estimation of Collapse Distance According to Building Height

During the collapse of buildings, debris can spread up to a certain distance depending on the type of collapse. In general, the collapse distance can be calculated as follows:

- Vertical Collapse (Flat Collapse): The building largely collapses into its own area, the collapse distance may be 10-30% of the building height.
- Tilting (Overturning): If the building overturns in one direction, the collapse distance may be 80-100% of the building height (Figure 1).
- Pancake Collapse Between Floors: Floors are stacked on top of each other, the collapse distance may vary between 20-50%.

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Figure 1. Overturning Failure of Apartment Complex Buildings During Niigata 1964 Earthquake (Courtesy of USGS) (Jakka, R.S. 2013).

In case of safe distance between adjacent buildings to avoid pounding in earthquakes the distances should be sufficient to prevent the buildings from colliding with each other during the earthquake. When the buildings deflect due to the earthquake, collisions can occur if the spacing between them is insufficient (figure 2). Recommended minimum spacing according to building height (according to seismic regulations) Building height (m) Recommended minimum spacing according to seismic regulations (m) 6 m (2 storeys) 0.2 - 0.5 m 12 m (4 storeys) 0.5 - 1 m 20 m (6-7 storeys) 1 - 1.5 m 30 m and above (10+ storeys) 2 - 3 m.

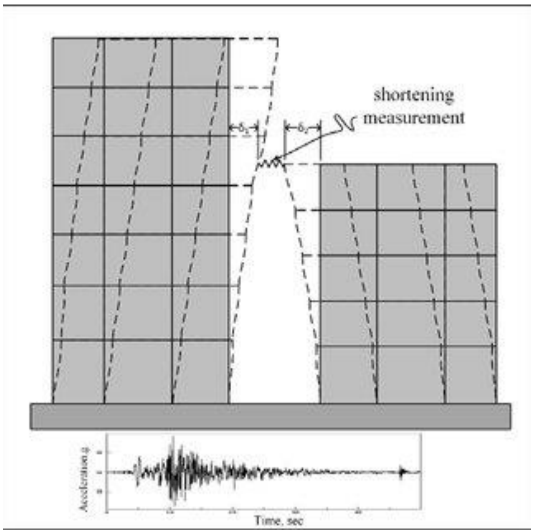

Figure 2. Safe Distance Between Adjacent Buildings to Avoid Pounding in Earthquakes (M. Isteita, K. Porter, 2017)

Design of Green Space and Open Spaces

The presence of open spaces, which are an indicator of well-being and standard of living in normal times, becomes even more important in emergency conditions as a tent or temporary shelter for emergency access and assembly, air access, storage and distribution

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of emergency supplies, emergency shelter (figure 3). For this reason, it is necessary to allocate open spaces, such as squares and open spaces, urban green areas (parks, playgrounds), open-air sports centres, open spaces in general in the vicinity of public or communal facilities (sports grounds, gymnasiums, educational and social institutions, cultural institutions, cultural clubs, etc.), peri-urban green areas in zoning plans, in sufficient proximity and size to the settlement areas. The open areas to be allocated for settlement within the plan should be suitable for settlement, but they should also be areas that can be left empty without being built on. The administrations are authorised and responsible for the construction of necessary toilets, washbasins and prayer rooms in parks, gardens and squares, provided that they comply with the construction conditions specified in this article".

Figure 3. An Aerial View Shows Tents Placed at a Stadium in the Aftermath of the Deadly Earthquake, in Kahramanmaraş, Southern Türkiye, Feb. 9, 2023. (Url 2).

Transportation Planning

In the event of a possible earthquake, the organisation of the transport network according to the priorities of emergency services such as fire brigades, ambulances and construction equipment is crucial for the effective and rapid management of post-earthquake rescue and relief operations, and for the planning and cooperation of emergency services. Pre-earthquake planning of the transport network should identify alternative routes and access points in the event of damage to major roads and bridges. In this way, emergency vehicles will be able to overcome obstacles in the transport network. Special traffic restrictions can be imposed on the roads that emergency services should use first before the earthquake. In summary, organising the transport network according to the priorities of emergency services such as fire brigades, ambulances and construction equipment in the event of a possible earthquake is vital to increase the effectiveness of post-disaster intervention processes. Advance planning is important to minimise the impact of earthquakes and other disasters and to ensure the safety of people.

The layout and configuration of a building can influence its response to seismic forces. Regular building shapes, such as square or rectangular floor plans, perform better in earthquakes than complicated or irregular geometries. Regular geometries distribute forces more evenly, reducing concentrated, localised stresses [Guevara 1989]. Simple, regular, symmetrical and convex building plans should be preferred for earthquake resistance. Where complex plans are unavoidable, bracing walls, diagonal elements or seismic isolation systems should be used to organise load paths in such geometries. Where complex plan geometry is used, material selection should also be optimised to increase lightness and durability. These principles help to achieve a balance between architectural aesthetics and seismic safety. The most important aspects affecting the seismic design of buildings are the overall geometry, the structural systems and the load paths. In narrow and tall buildings, forces may be less evenly distributed, especially along the long axis, and torsional effects may occur.

Planning Decisions at Building Scale
Renovation Processes
Renovation processes involve the alteration or reorganisation of an existing structure and should be managed effectively for building safety, building quality and social life. Renovation projects can affect the structural safety of buildings. Renovations to structures in seismic zones can affect the seismic performance of structures and are critical to their structural safety. All refurbishment projects, particularly for structures in seismic zones, should be subject to approval and inspection. Approval and inspection processes are necessary to improve the seismic performance of structures, ensure the safety of people and reduce damage to buildings. Permits and inspections ensure that appropriate building materials are used in the renovation of structures, that structural changes are made correctly, and that safety is ensured.

The implementation of permits and inspections serves to guarantee that, in the course of renovations, the utilisation of building materials conforms to the prescribed standards, that structural alterations are executed in accordance with the stipulated protocols, and that the requisite safety measures are adhered to. Construction and renovation projects are to be executed in accordance with local building standards and regulations. Permits and inspections serve as mechanisms to guarantee that these standards are adhered to during construction and renovation projects. This ensures that buildings are used safely and appropriately throughout their life cycle. Building owners and contractors are obliged to adhere meticulously to the requisite permitting and inspection processes for renovation projects.

It is imperative for the safety and durability of buildings that all types of renovations in seismic zones are subject to approval and inspection. These processes ensure that buildings are constructed in accordance with earthquake risk and that post-earthquake damage is reduced. Local building codes should be adhered to for renovation projects, and the requisite permitting and inspection processes must be diligently observed.

This is particularly crucial for buildings that contain units such as mezzanine floors, bakeries, car washes, and column shearing possibilities, or that are exposed to humidity and previously used as heating rooms in the basement, prior to the implementation of the building inspection system. Such buildings require meticulous assessment to enhance safety and mitigate risk. Such structures are deemed to be high-risk and are particularly vulnerable to natural disasters such as earthquakes, floods, and fires. It is imperative that the relevant licences and permits for existing buildings are duly updated. During the transition to the building inspection system, the compliance of buildings with the existing building standards should be checked, and licences and permits should be renewed when necessary.

Soft Floor Effect
It is a widely acknowledged fact that earthquake damage caused by soft story effects is a common occurrence. In the event that soft story formation cannot be prevented during architectural design, for whatever reason (commercial etc.) re-determination of ground floor heights in new buildings in terms of seismicity is an important step to improve the seismic performance of structures and reduce earthquake risk. The phenomenon of 'short column effect' arises when the ground floor of a building is higher than the other floors and may have adverse effects on the structure during an earthquake (Turan et al., 2024).

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The phenomenon is attributed to the bending or damage of columns due to their shorter length, as earthquake loads within a structure increase. This phenomenon can potentially result in structural weakness and undesirable behaviour during seismic events (figure 4).

Figure 4. Collapse of Two Identical Buildings Due to Soft-Storey Mechanism in Hatay. (Vuran, E., *et al.* 2023)

Walls built during construction should never be demolished later. Cutting out columns to expand the area means that the building will collapse without an earthquake. There should be normal floor walls on each floor of the building. Never cut into columns for plumbing or electrical installations. If the ground floor is built as a workplace, the walls on the upper floors are not built on this floor. This turns the ground floor into a soft floor, which makes the building easy to demolish in the event of an earthquake. For this reason, the construction method of having normal apartments on the upper floors and workplaces on the ground floor should be abandoned.

Shear Walls

In Turkey, which is an earthquake country, it is inevitable for architects to use shear walls in their designs. The use of concrete shear walls is a mandatory or recommended solution, the correct positioning and design of shear walls in architectural projects is a critical factor both in terms of safety and aesthetics. Properly designed seismic concrete shear wall systems increase both the stability of structures and maximise the safety of occupants. Seismic shear walls should be balanced as a core in the centre and as a support on the long sides. The number of shear walls a varies according to the height of the building and the nature of the ground. As the seismic loads are applied on the X and Y axis (i.e. transverse and longitudinal): the correct positioning and design of the shear walls must be symmetrical and evenly distributed, otherwise the building may be subjected to torsion (figure 5). Around the lift and staircase cores, as this is the most rigid zone, shear walls are integrated here. Shear walls are placed longitudinally to prevent the building from tilting. In areas of weak ground, shear walls should be used.

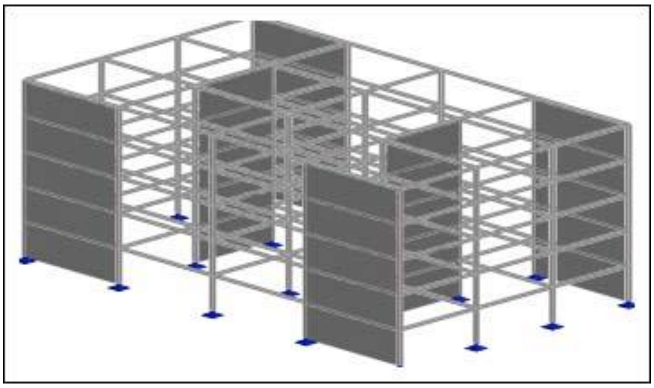

Figure 5. Shear walls as Load Transfer Mechanism (Url 3).

Earthquake shear walls or concrete walls are structural elements designed to increase the durability of structures during earthquakes. These curtains or walls are used as part of the load-bearing system of the building and strengthen the building against earthquake effects. The design of earthquake shear walls or concrete walls is important to increase the safety of buildings to be constructed in earthquake-prone areas. Such structural elements are effectively used to keep earthquake effects under control and to give durability to the structure. Earthquake curtain or concrete walls are designed in line with the principles of earthquake engineering and ensure that the building is safer and more durable during an earthquake. Proper detailing, reinforcement and anchoring of openings and facades are essential [Filiatrault et all 2021]. When combined with appropriate joints and connections, flexible materials such as curtain walls can accommodate structural movement while preventing cladding separation during seismic events (figure 6).

Figure 6. Appropriate Joints and Connections (Url 7).

Console Design

Consoles are often used for balconies, terraces or to provide additional usable space to the building. As consoles can add asymmetry to the building, the balance between the centre of mass and the centre of stiffness should be considered. In seismic zones, the design of consoles should be based on the principles of minimum length, maximum stiffness and balanced structural system integration, as they can increase the building's sway, especially in weak soils or tall buildings. Otherwise, the building may be subjected to torsional effects and the architectural design should be balanced accordingly Figure 5. Unnecessarily long consoles should be avoided, and if they are to be used, they should be reinforced with steel bracing and rigid systems. The coordinated work of architects and engineers can produce safe and aesthetic solutions that comply with seismic regulations. Console design in seismic zones has important implications not only in terms of structural safety, but also in terms of architectural design, functionality and aesthetics. While console design offers benefits such as façade aesthetics, shading and space saving, it can also impose some restrictions on architectural design due to structural balance, internal space organisation and code restrictions.

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Figure 7. Consol Damage in 1994 Northridge Earthquake (Url 4)

Use of Non-Structural Materials

According to Feyaz et al 2023, buildings have two important components: structural and non-structural. Structural components are the load-bearing elements of the building such as foundations, columns, beams and walls, etc. Non-structural components include architectural and design features such as doors, windows, suspended ceilings, etc. and services include features such as electrical and plumbing installations. The design of non-structural elements is important because non-structural parts of a building have the potential to affect the seismic performance of the primary structure in an unplanned manner. This can lead to severe structural damage or even collapse. Damage to the non-structural elements themselves can render the building inoperable or unusable after an earthquake, even if the structure remains sound. Failure of non-structural components can cause death or injury from - falling slabs, masonry or glass - collapsing ceiling components - falling fixtures and fittings.

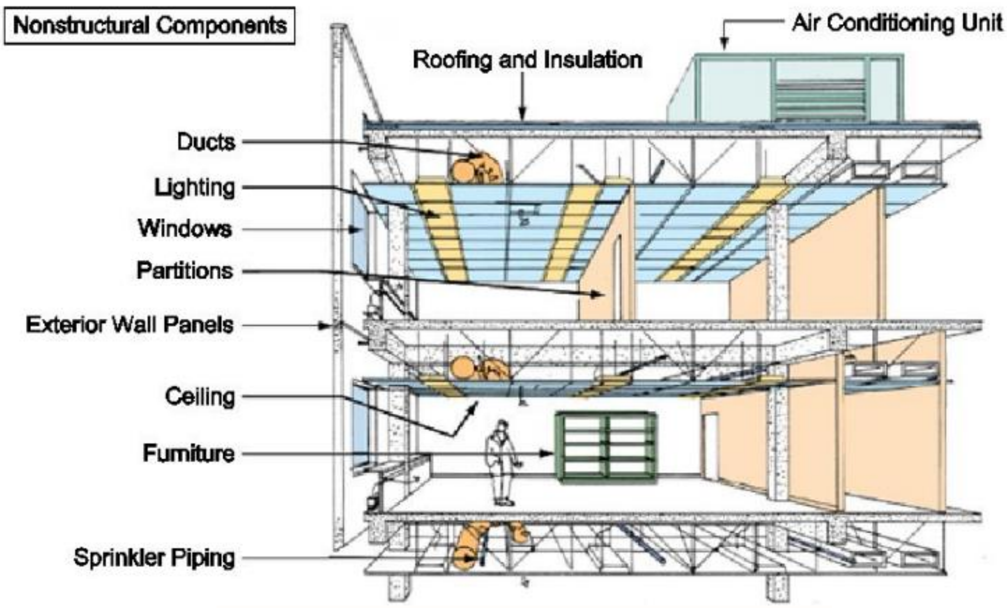

Figure 8. Non-Structural Elements During Earthquakes (Url5).

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The architect and engineer work together to design a safe, efficient and economical 'general purpose' structure for gravity and seismic loads, taking into account the relevant aesthetic and functional requirements. They then jointly select non-structural partitions and façade elements with deformation capacities compatible with the designed structure. This approach allows an optimal result to be achieved. It is therefore in the client's interest for the architect and engineer to work closely together. This collaboration cannot wait until the calculation and detailed design stage, but must begin at the earliest conceptual design stage, when decisions are made that are critical to the seismic resistance and vulnerability of the building. Bachmann 2002 Seismic structure identifies architecture based on the use of structure as the exclusive aesthetic norm, i.e. structure is the only articulated form that determines architecture. This principle could be called (seismic) structure as architecture and allows a high intensity of development in both seismic engineering and architecture (figure 7).

Figure 9. Example of identification of architecture with seismic design and cooperation earthquake engineering: Wool House in Wellington (left), tectonic (trapezoidal) shape of Hancock Building in Chicago (right) and Union House in Auckland with added bracings (T. Slak and V. Kilar 2008).

Conclusion

Appropriate building technology and building typologies should be defined for the seismic zone. Necessary legislative changes should be made to ensure construction supervision and not every newly graduated engineer should be allowed to sign. Titles used in other countries, such as certified engineer or professional engineer, should be awarded by an examination after the internship. Engineers with these titles should have legal liability and professional indemnity insurance. Another lesson we should learn from past disasters is to analyse the structures that have performed well and to combine and apply the techniques that have provided performance in these structures with new technologies. For example, buildings in earthquake zones will be constructed with earthquake-resistant features that reduce the loss of life and property. Construction services and tendering laws should not be revised, but the necessary legal arrangements and audits related to the process should be restructured.

DOI: https://doi.org/10.30935/ojad/2513037

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