ARCHITECT’S ROLE IN BUILDING’S SEISMIC PERFORMANCE

Enhancement of the seismic performance of a building should be the priority of the architect as well as the client. Common irregularities brought in to entertain unnecessary area encroachment should be avoided.

A building is a combination of art and science, which are put together to function as a living structure. The increasing complexity of integrity ensures simpler functioning of the building. Therefore, building science is an unending process, which achieves its perfection at infinity. There is no end to the possibilities for improvement.

Building construction is a complex phenomenon involving many parameters and factors, such as planning, designing, construction, management, logistics and budgeting. Therefore, it clearly requires expertise from various fields and brainstorming by many specialists, professionals and technicians, including architects, civil engineers, project managers, contractors and various other authorities who contribute in sequential or parallel processes involved in construction. They work together to produce a design, which is simple, sustainable in functioning, aesthetically pleasing and structurally strong. Therefore, the three most important aspects of building design are: (i) Function (ii) Form and (iii) Strength.

American architect, Louis Sullivan, referred to as the father of modernism and skyscrapers, stated in one of his poems, that ‘the form follows function’. This statement is now a doctrine for modern architects. Here, ‘function’ refers to the usage of the building and ‘form’ refers to its overall geometry, composed in an aesthetically pleasing manner in keeping with the requirements of the user or intended functions.
The practicality of a structure is more important than the aesthetics. This could not be more significant in today’s world where the natural and anthropogenic catastrophes have hit the world in the form of deadly disasters. These disasters, such as earthquakes that severely damage buildings, prove fatal to life. However, the truth remains that it is not the disasters that are responsible for the loss of lives, but the buildings that are incapable of withstanding these disasters. Loss life can be drastically reduced by ensuring that the structures of buildings are strong enough to bear the impact of earthquakes.

Let us now look at the importance of building performance, with respect to architectural form and functional usage. The meaning of function may vary on the basis of the context, person(s) and area. A country like India, ranking second in the world in terms of population, is extremely susceptible to disasters. The weak technological advancement in its building industry, is yet another issue. In such a scenario, defining ‘function’ can be quite a challenge!

Ideally, buildings should be designed to serve different purposes. They should be:

1. Structurally strong
2. Practical
3. Suitable for use
4. Aesthetically pleasing

It is up to the architect to take up the challenge of designing a building, which will not only serve all these purposes but also conform to building regulations, codes and budgets. The architect is solely responsible if the building is not fit for the functional usage. He is also responsible for the form derived from the function of the building structure. At the appropriate stages, he brings in the civil engineers, project managers, contractors, other specialists and technicians to work on and produce a living space. It is the architect’s duty to look after the purpose of the building, area requirements, accessibility, ventilation and associated configuration, and so on. He creatively configures the structural and non-structural components in a manner that ensures the durability of the building in times of disasters, and also gives it a unique appearance.

The role of a civil engineer is to give enough strength to his ideas and look after endurance and seismic strength of the structural members. For achieving a high degree of functional perfection, the plans need to be relooked at and improvised several times by the architect and the engineer. In this process, the building risks a trade off between architectural form and structural strength. The architect, personally, gives more importance to the functional use of the building. However, he has to go with the client’s wish to design the most appealing form. At the same time, he has to create maximum habitable space out of the limited area at hand. The client’s demand for innovative designs forces the architect to go for unconventional, asymmetrical and new creative building forms. Unfortunately, the Indian building regulations and codes do not acknowledge such forms. These codes recognize buildings with a regular square or rectangular plan, symmetrical in horizontal and vertical planes, with little liberty for innovation. Thus, in India, the building designs are supposed to be very limited and rigid according to these regulations and codes. Also, the usage of a single building for multiple purposes is yet not acknowledged in the Indian codes, giving rise to the issues of strength and durability. In a seismically active area, this issue is further aggravated.

**Indian Scenario**

In India, earthquakes are still viewed as rare events that occur once in a 100 years. In the face of such a conception, the client is unwilling to allocate a significant part of the budget on seismic strength, preferring to spend instead on architectural form, which costs less and gives more habitable space. As a result, more habitable space in lesser area and superficial beautification becomes the focus of building design. The common configuration problems, mostly seen in the conventional construction system in India are as follows:

1. **SOFT STOREY AND WEAK STOREY**

The ‘soft storey’ problem is the existence of a building floor that possesses 70% lesser lateral stiffness than the immediate superior floor or 80% lesser average stiffness of the three floors above (Refer Figure 1).

The ‘weak storey’ problem is the existence of a building floor that possesses 80% lesser lateral strength than the immediate superior floor.

These deformities are found in places, where more space with large span (without structural obstruction), is required, for example, parking lots, large assemble areas, shopping complexes and display areas with large openings. These result from little consideration given to the strength of building with an intention of having maximum area to be occupied for use.
This issue can be solved through simple design intervention. A little consciousness regarding lateral strength and stiffness, and uniform load distribution to structural members, in both horizontal and vertical planes, would be enough to remove such atrocities from new building designs. For the existing buildings, there are several solutions to choose from, for example, the use of additional columns, buttresses, shear wall or bracing (Refer figures 2 to 5).

2. VARIATION IN PERIMETER STRENGTH AND STIFFNESS

The issue of seismic strength arises when there is wide variation in strength and stiffness of the building perimeter. The building may appear to be geometrically regular, but the design and planning of building elements like elevators and staircases along one side of the perimeter makes it seismically irregular. The center of mass shifts due to the extra elements and makes the structure vulnerable to damage (Figure 6).

Designing the ‘problem causing building elements’ at the center or near the center of mass, without lining with the perimeter or providing uniform strength and stiffness to the perimeter, can be an easy solution. There can be many other solutions possible, which may remove or at least decrease the problem to a manageable extent in the early stages of design.

3. RE-ENTRANT CORNERS

The buildings with shapes like L, T and H or a combination of these tend to produce differential motions between different wings of the building, for the same earthquake force. This results in differential concentration of stress and torsion in different wings, making them vulnerable to breakage (Refer figures 7 and 8). Of course, this effect may depend on a number of factors like:

- Characteristics of ground motion
- Mass of building
- Type of structural system
- Length of the wing and aspect ratio
- Height of wing and height/depth ratio

![Fig. 1: Building with ground floor soft storey](image1)

![Fig. 2: Addition of shear wall to existing soft storey](image2)

![Fig. 3: Addition of extra columns to existing soft storey](image3)

![Fig. 4: Addition of bracing to existing soft storey](image4)

![Fig. 5: Addition of external buttress to existing soft storey](image5)

![Fig. 6: Showing unbalanced front side of perimeter](image6)
Two strategies can help solve this issue:

i) Structurally separating the building into simpler shapes by giving joints

ii) Tying the building together so strongly as to stand the earthquake forces

4. CAPTIVE COLUMN AND SHORT COLUMN

This is the case when a structural column is lined by a structural or non-structural member, only up to a specific height. This makes the single structural member (column) behave as two distinct members and alter its envisioned performance. The column is weaker at the open junction and tends to deform easily under earthquake loads. There can be various reasons for this configuration problem (Refer figures 9 and 10), such as provision of ventilation in basements, open corridors in building complexes, and building on slopes are a few of them. Location of other building elements, such as a staircase, beam, slab or girder framed at different heights of columns by splitting them, can also be possible reasons for the same.

Consideration of this issue during designing of the building plan can help eliminate the problem. For the location of building elements placed at different heights of the columns, a new structural member or a wall can be erected in order to take the load of those elements. This would help in delimiting the issue of short column or captive column in the structure.

What we have mentioned till now are few commonly found configuration irregularities in building structures. By considering these small issues during the planning and designing process, one can eliminate these problems from the root itself. The architect plays an important role in this decision-making process. These conflicting configurations can be avoided, or at least minimized up to a manageable extent where they cause no harm to life or property. It is the sole responsibility of the architect to act wisely and understand the need of structural congruity along with the architectural form of the building.

The architect’s knowledge and understanding of zoning regulations, building by-laws and seismic codes, put together, not only improve the building design in the present but also save lives from being harmed in the event of some disaster in the future.

While it is crucial for the architect to intimate the client about these essentials to secure the building, it is also important for Indian investors to understand the significance of the seismic strength of the structures, as earthquakes are no longer rare. Seismic resistivity should be the priority of the client, the architect and the engineers. The design of the building should be processed keeping in mind the seismic zone in which the site is located. The codes should be followed strictly. There is also a need to improvise the Indian building codes with respect to the architectural needs and demands. The provision of different forms should be included and the present codes should be made more flexible so as to allow the liberty to use different architectural forms. Efforts should be made to strengthen the different architectural forms rather than prohibit their creation.

The other facts leading to improper design and construction methodology can be the project budget, lack of contact between architect and structural engineer and lack of synchronization between different professionals. These minor
bugs at the initial stages do not show effects at the time of construction. The adverse effects of these are observable only when disaster strikes, damaging the building and making this damage responsible for loss of lives.

**Lessons to be learnt**

Building by-laws can be easily trespassed to create irregular configurations. Laws are broken and plans are sent off-limits only when there is pressure from the client to create more livable space in the limited area available. Buildings so created, are unable to withstand earthquakes leaving a number of lessons to be learnt for the professionals as well as the clients. However, the post-earthquake reports, including the detailed documentation of the building damages are rarely created with cognition. The reports are mere substantiation or a visual survey of the damages. Proper validation of the details and comparison with the other existing buildings is rarely done in our country. In many foreign countries, post-earthquake lessons are important documents for the future studies and amendments in existing codes. The damaged structures are carefully studied with advanced software for earthquake forces and analyzed for further assessments. The results are further utilized for future cases and it is ensured that the errors and discrepancies are not repeated.

The professionals in India also need to learn from these examples and work efficiently to produce a better end-product.

**Conclusion**

To sum up, we should realize that architectural configuration plays a major role in deciding the seismic strength and functional congruity of a building. The architect should shoulder the responsibility of ensuring proper seismic performance of the building since inception.

The clients should understand the importance of disaster mitigation rather than management. The building should be created/built to withstand earthquake forces rather than to retrofit after its completion. The project budget should be distributed wisely with the major share going into structural strength.

Improving the collaboration and communication between the architect, urban planning and government authorities, and earthquake engineering disciplines (seismology, structural engineering, lifelines engineering and emergency response) can greatly help in reducing the seismic vulnerability of buildings.

**Acknowledgments**

I would like to express my sincere gratitude and heartiest thanks to Dr. D.K. Paul, Emeritus Fellow, Department of Earthquake Engineering, Indian Institute of Technology Roorkee, who provided me invaluable guidance and assistance in research work which materialized in this article. I would also like to thank Ar. Sonam Sahu for her constant support and unbreakable patience in guiding me.

**References:**

ARCHITECTURE Time Space & People is one of the most inspirational coverage of the present times. Every month, it presents wide-range of topics providing readers with detailed and finely-illustrated reviews of various dimensions relevant to architecture.

The articles published in the magazine address the Architects Fraternity on issues pertaining to the Built Environment. The articles in every issue remain an assortment of various topics relating to Projects, Concepts, Heritage, Sustainability, Technology and Urbanism among others.

Authors interested to contribute articles for ARCHITECTURE Time Space & People may kindly refer to the Structure of the Article we follow in the magazine. The same shall provide you with necessary guidelines regarding formatting and submitting the article for publication.

**STRUCTURE OF THE ARTICLE**

1. **Layout:** An article should start with an introduction, continue with a clear structure, and end with bibliography and references. For Text Content, it should comprise of 1,200 words on the minimum side and 1,800 words on the maximum side.

2. **Title:** The title should comprise of a few words (max-one liner) explaining the theme/subject of the article.

3. **Introductory material:** The article should begin with a broad summary or overview of the theme and then should be followed by the lead sections.

4. **Body of the Article:** (5-6) Paragraphs: Paragraphs should be explanatory and short enough for readability, to develop an idea. Overly long paragraphs should be split up so that the focus doesn’t get diluted.

5. **Subtitles:** Every paragraph should be followed with a Subtitle or a Heading to help clarify the article at every point and create a structure for the entire article.

6. **References:** The article should give complete bibliography and referencing at the bottom of the article. Credits and sources for images used to be provided correctly.

7. **Images:** The article should be illustrated with high-res (300 dpi) pictures/images attached separately for referencing. Suitable captions should be given for all images.

8. **Illustrations, drawings, images etc:** For the article to be inserted at appropriate places may also be emailed as separate jpg attachments of at least 300 dpi resolution.

9. **Submission:** When sending the article, the text part can be emailed to us directly in Word Doc. The text should have Calibri font style, 12 font size and single line spacing.

10. **Author Details:** Kindly send us the articles with your complete postal address, telephone no./mobile no. and present work profile. Details of co-authors if any should also be provided accordingly.

The contributions and other editorial/content related queries can directly be mailed at editor.atsp@gmail.com. All other general queries can alternatively be mailed at architecture.tsp@gmail.com.

We are certain that with your support the publication shall continue to be the epitome of Architectural vocabulary, proving to be the finest knowledge resource for our readers.

Thanking you and looking forward for your valuable contributions.