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Research Paper

STRUCTURAL SAFETY OF A BUILDING: AN IMPORTANT ASPECT

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The paper represents the Structural safety of a building as an important aspect, often neglected in today's construction of building. The Safety of a building is very important because it deals with the people. If the safety criteria's are neglected, it may endanger the people who are living in buildings or any civil engineering structures. The Foreign countries are very much well aware of safeties of building and the requirements for the same. But in India, there is no such mandatory requirement which is followed while construction of buildings. The safety of a building should be maximum in order to increase the life span of building and for the safeties of people.

Keywords: Structural safety, Civil engineering, Building safety, Life span

INTRODUCTION

As the cities are expanding in India, selecting a safe and trouble free home in urban areas of our country is increasingly becoming a problem. There is mass population rise in the country. So to deal with this population rise, the vertical expansion of building is currently in demand as there is no horizontal space available. So by the expansion and speedily rise in construction industries, the 'Safety of Building' should be considered. The main aim is to construct the building which is as safe as possible in worst scenario. Practically, No building is considered safest, because of natural calamities there is some harm occurs to any building. Our aim is to

build the building which is optimum in terms of safety (Boskey Vishal Bahoria and Dhananjay K Parbat 2013). Mostly the building is built of typical Reinforced Cement Concrete(RCC) members. So first we have to understand the mechanism of RCC building.

MECHANISM OF RCC BUILDING

A high rise multistoried structure is generally constructed using load bearing reinforced cement concrete in its framework and different types of materials as filler within the voids of framework. This filler material protects the persons and their belongings against wind, rain, sun, and other elements of nature and at the same time also

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protects them and their belongings from other human beings. The reinforced concrete framework is designed and constructed to carry various loads and to withstand various forces.

As shown in Figure 1, the Reinforced Cement Concrete (RCC) framework consists of various members such as foundations, columns, beams, slabs etc. They carry their own weight besides the load of the persons, furniture, internal partition walls, external walls and all other fittings and fixtures GOI (2004). The RCC framework, whether in an apartment building or a bungalow must remain structurally strong and stable throughout its life. The RCC framework of an apartment building or a bungalow is like the strong backbone of the human body. Natural calamities like earthquakes or storms often induce additional horizontal loads to act on the structure. These can cause tremendous damage to life and property if the structure is not properly designed or constructed to cater to such loads (Shweta A Wagh and U P Waghe 2014). Hence STRUCTURAL SAFETY of RCC framework must be given prime importance.

BUILDING FAILURE :IT'S CAUSES

Structures which are planned, designed and constructed properly should have a very long life. Safety and stability do not get so easily affected in such cases. The Gujarat earthquake on 26th Jan 2001 was an eye opener. Several structures collapsed within a matter of a few seconds. Earthquakes do not kill people, but buildings do. So, the building should be designed and maintained in such a way that minimum damage is faced by people and the building itself.

Few causes which can collapse a building in general are as under:

- Inadequate planning and architectural layout GOI (2004),
- Poor RCC structural design and detailing, not considering ductility requirement of RCC framework under horizontal loads (earthquake and wind) or correct vertical loads and moments GOI (2004).
- Use of poor quality materials, especially steel and cement, with intentions to reduce cost.
- Improper proportioning of materials in concrete mixes (Shweta A Wagh and U P Waghe 2014).

Figure 1: RCC Frame Work



Figure 2: Building Failure



- Weak foundations or providing wrong type of foundation.
- Sub-standard construction practices and lack of or total absence of experienced, trained and qualified supervision during construction.
- Poor maintenance of the structure, e.g. leakage, seepages, corrosion etc.
- Structural and non-structural cracks not attended to, causing loss of durability and ultimately loss of strength.
- Neglect of general hygiene and cleanliness due to which rodent nuisance and harmful vegetarian growth is caused. These weaken the foundations and the superstructure respectively (Shweta A Wagh and U P Waghe 2014).
- Additional loads (not planned earlier) imposed on the structure by the occupants, for which the structure was not designed. eg. Additional overhead or loft tanks, terrace gardens, mezzanine floors, swimming pool, air conditioning plants, cooling towers, balcony enclosures etc.
- Modification or removal of structural members such as slabs, beams and columns.
- Tampering with structural columns and beams to conceal electrical conducts water supply and drainage/ sewerage lines by cutting into the concrete. This often results in removing or damaging reinforcement steel and causes cracks in concrete.
- Deep excavation very close to the existing structure's foundation causing undermining and differential settlement (Shweta A Wagh and U P Waghe 2014).
- The natural calamities like Landslides, Hurricane, Fire, Floods, Earthquake etc.

SAFETY ASPECT

In order to prevent the collapse of a building or increase the life of building, the structural engineer should check all the above causes in building. If there is any chance of failure of a building, the building should be taken into consideration.

The buildings which are built should conform to seismic resistant design (S K Dave, N K Pandya and B V Modi 2015). It should follow the required IS codes for safety purpose of building.

Figure 3: Collapse of Building



Figure 4: Several Distress in Building



As shown in Figure 4, spalling of concrete occurs, If the Building codes are not followed. Severe distress in the structure occurs after some years or a collapses triggered due to structural deficiencies or inadequate maintenance (Ail K Sharma 2002). It may be understood clearly that for a safe house, structural design, RCC construction and specifications have to be properly defined and executed.

COST V/S SAFETY: A COMPARISON

Cost is often the first criterion for selection of building. Therefore, People are always inclined to buy the house at the cheapest price. So the building may be built using cheap quality concrete materials, inadequate structural design, often compromising on safety aspect of the structure against natural calamities like earthquakes (Boskey Vishal Bahoria and Dhananjay K Parbat 2013). Development of inadequate supervisory force and not exercising quality control of design and construction of RCC work are other cost

saving methods which may lead to costly repairs or even a collapse.

As shown in above Figure 5, failure during earthquake due to inadequate strength to withstand horizontal seismic forces occurred.

POST ASSESSMENT: SAFETY FACTORS TO BE CONSIDERED

In order to avoid problematic situations in future, the following factors must be given full consideration.

- Structure's ability to withstand vertical loads as well as horizontal forces like earthquakes and wind or any other can be best checked from the structural drawings and architectural layout (Ail K Sharma 2002).
- Verification of documents from the Builder/ Developer/Society containing names, addresses, telephone numbers of all agencies/ authorities, who were instrumental during the construction of the building in which the flat is located (Ail K Sharma 2002).

These details can come in very useful for maintenance or additions or alterations at any time. It Includes Builder / Developer, Architect, Structural and Geotechnical consultant/ Engineer, Constructor of both RCC works and other finishing works, Supervising agency or Engineer, Licensed electrical contractor, Contractor of firefighting system, Local Municipal authority in charge of sanctioning/ approving the building & Municipal ward offices and fire station under whose jurisdiction the plot is located.

KEY POINTS FOR INSPECTION

Properly planned architectural layout plays an important role in the structural stability. If the layout is not suitable, then it can cause structural

Figure 5: Failure During Earthquake of Building



instability or damage resulting in reduction of life of the structure (durability).

Balconies

Certain areas like balconies are exempt fully or partly from the calculation of Floor Space Index (FSI). In order to get full advantage of more area, the engineer exploits such rules of building by-laws. As a result, the architectural layout is prepared to such needs. Large cantilever (projecting out and supported at one end only) slabs and beams to accommodate such balconies are designed by the structural consultant to the architectural layout and developer’s requirements. If adequate care is not taken initially during its design and construction and later during its service life, these beams and slabs often show signs of distress. They are also likely to collapse during an earthquake if the structural design is not done considering the earthquake forces (S K Dave, N K Pandya and B V Modi 2015).

As shown in Figure 6, due to inadequate design, specification & improper construction,

Figure 6: RCC Balcony

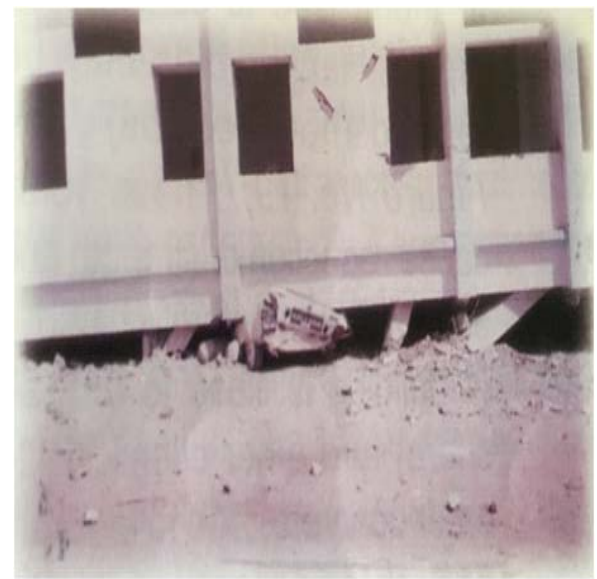


cantilever RCC slabs of balconies have deteriorated.

Building on Stilts

The ground floor is often used for parking cars. This area too is exempted from FSI calculations. Such buildings at the ground floor level generally have only columns with no masonry or concrete walls in between the columns. As shown in Figure 7, the building is therefore termed as “Building on Stilts”. The lower storey is called a “Soft Storey”. Structures which are on stilts along with large cantilever projections on all sides to accommodate balconies have to be designed and constructed with adequate care as they are most vulnerable to collapse during an earthquake. It is advisable to get the design verified in such cases to assure safety of a new home.

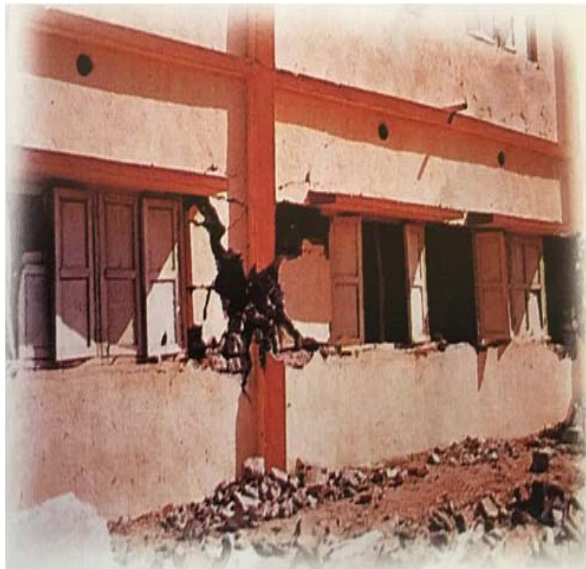
Figure 7: Soft Storey Collapse



Doors and Windows

Large windows and doors are good for air and light entry into a home. Aesthetically also the structure looks good with elegant looking windows and doors. However, large openings between

Figure 8: Failure of RCC Columns



columns reduces the lateral restraint during an earthquake and therefore the RCC framed structure has to be properly designed to cater to this weakness. Also adequate care must be taken to avoid any opening with 0.6 m from the corner of the building as per IS Codes. As shown in Figure 8, due to large openings and inadequate structural design, RCC Column is failed.

Slender Concrete Members

Slender RCC columns, canopies and other members look architecturally good and elegant. Slender columns also occupy less floor space. However, generally slender RCC members are densely reinforced and it is very difficult to place and compact concrete in them. Due to construction lapses, large voids may be formed. These voids cause reduction of strength and also permit moisture, chlorides (if building is close to the sea shore) and other chemicals to enter concrete. Due to moisture and chloride entry into the concrete, the steel in RCC structure is attacked and corrosion of steel commences. It

has to be stopped or else it starts spreading, causing concrete to crack. Steel when it reacts with water and/or chloride gets converted to ferrous oxide and later to ferrous hydroxide. This chemical conversion causes the steel bars to grow in volume resulting in spalling of concrete.

Figure 9: Corrosion of Steel in RCC Column



Figure 10: Leakages on Ceiling



As a result, Figure 9, RCC members having corrosion and cracking problem lose their stiffness and strength and if neglected can fail, causing the structure to collapse. Slender concrete members when visually inspected must be free from honeycombs and large voids.

Leakage

Leakage through roof, walls, toilet blocks are a constant source of lack of safety. The paint peels off and the interior of the building looks ugly with wet patches. Besides giving an ugly appearance, the presence of moisture over a long period of time can cause corrosion of steel in the RCC members and reduce their strength considerably.

Good and dense quality concrete is must required. Proper specification and construction can go a long way in preventing such leakages. Waterproofing treatments of various types are available. However, they are not solutions for bad porous concrete works. Waterproofing treatments are a second line of defense and can work satisfactorily if an only if the original concrete is of reasonably good quality. It is therefore necessary to examine the concrete specification, the method of construction, concrete mix design and supervision at site. Leakage can also occur through the plaster and masonry during the monsoon. It should be ensured that the joints are properly packed and sealed prior to plastering. All joints between the courses of bricks/ blocks must also be properly sealed. There are several other parameters which are also required to be taken into consideration for masonry and plaster work. A good construction agency and good supervision should be able to prevent these defects.

Concrete Specifications

Life of a structure and its stability during its service life will greatly depend upon the specification of concrete materials and concrete parameters recommended. However, professional view to ensure safety, stability and durability of the structure may be taken.

Some salient features regarding concrete specifications are being covered below.

- Selection of concrete materials and specification will depend upon the environment around the structure.
- Dependent on the environment conditions, cement type, water to cement ratio of the concrete mix, grade of concrete and minimum quantity of cement in a mix are specified (Shweta A Wagh and U P Waghe 2014).

Water to cement ratio of the concrete mix is extremely important as it directly influences the strength and durability of concrete. Addition of water in concrete becomes weak and porous. Higher grades of concrete are generally preferred because they are produced with lower water to cement ratio. Many consultants still specify low grades of concrete than actually recommended in code of practice. Eg. M15 (concrete compressive strength of around 150 Kg/cm² or 15 N/mm² at 28 days age) (S K Dave, N K Pandya and B V Modi 2015). This is usually done in 1:2:4 volumetric proportion of cement : sand : stone chips or coarse gravel without usually studying in the properties of these ingredients. These mixes have very high water to cement ratio and generally do not result in out depending on the strength of cement, shape and grading of sand and stone chips and suitable water to cement ratio to give concrete mix enough fluidity without affecting the strength. For example, a city like

Mumbai located on the coastal belt with heavy rainfall, minimum concrete grade N25 to N30 is recommended. So, the location is also important.

To conclude, specifying proper grade of concrete and proper process of fixing the proportions of all ingredients is of utmost importance. Besides it is essential that after all material proportions are fixed, one has to ensure that they are correctly batched at site.

Ready Mixed Concrete (RMC) is available in certain metropolitan cities. RMC plants, under proper control, supply concrete mix to the builder or his contractor as per the specifications given to them by the builder's consultant or architect (Shweta A Wagh and U P Waghe 2014).

CONSTRUCTION

Selection of good quality and correct type of concrete materials, adoption of proper Concrete Mix Design, providing a site laboratory for testing materials and concrete, having a good constructor. Proper quality control and quality assurance methods along with a good, experienced, well trained and properly qualified supervisor will ensure stable and durable structure.

GENERAL CHECKS: ASSESSMENT

It is essential to check the following:

- Damp patches, leakages, cracks etc. in all the parts of the building should be checked out. If there are several damp patches, leakages and cracks, it should be repaired (Shweta A Wagh and U P Waghe 2014).
- Leakages in water supply, drainage, sanitation lines should be checked (Shweta A Wagh and U P Waghe 2014).

- Ensure that leakages from the flat or terrace above are stopped (Shweta A Wagh and U P Waghe 2014).
- The leakages and damp spots in the flat located below should also be examined.
- Internal layout of concealed electrical wiring, plumbing and drainage systems must be examined by competent persons for their adequacy.

CONCLUSION

This paper gives some guidelines regarding the safety aspect of building. It is required to create awareness in the construction of building. It is upto the person to decide to follow these guidelines. If the structure in which you reside is not healthy and is weak and needs continuous and endless repairs.

The structure can collapse if the safety aspects are ignored. This means that lives of people are not safe. There are also good chances of considerable loss of personal belongings and one may have to start life from scratch once again. Hence, while selecting a home one must give top most priority to structural safety and give less importance to other considerations. A home is as precious as life and the lives of family members. So, Building should be Structurally Safe.

After construction of a structurally safe building, it is also important to look after it and maintain it properly.

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