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# LIFE CYCLE EVALUATION OF REHABILITATION OF RESIDENTIAL STRUCTURES, SUBJECTED TO EARTHQUAKE

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**Abstract -** *Life cycle Evaluation of Rehabilitation of Residential Structures, subjected to earthquake." The rehabilitation of any structure is essential, when the potential strength, as on the date, of the structural element or the global strength, found less than the designed, thereby reducing the factor of safety provided. The reduction in factor of safety alarms the danger signal during the event of crises especially like earthquake. The ageing of the material / s of the building components, environmental effects on the materials, repeated excessive or the change in the pattern of stresses reduces the potential strength. The change of use causing undesired change in nature and or of quantity of loading, change made in seismic zone, by the national authority, are the other factors also contribute in reduction of potential strength of the building. The estimation of potential strength is thus a cyclic process and in turns the process of rehabilitation. The evaluation of strength, of rehabilitated building, is the process contributed by the materials used, the methodology adapted, the workmanship, and the required rehabilitated strength. In this paper focus, and emphases, placed on explaining efficient, economical, eco-friendly and optimistic use these factors. Devastative earthquake that rock the Gujarat region in 2001, selected to collect the information about the current scenario, in respect of above referred factors and the awareness level among the affected citizens. The information collected from technical professionals, the implementers, and the end users, by method of personal interviews, and analyzed by using IBMSPSS software. Three case studies conducted, the first one explains the advantage of retrofitted building in the form of higher safety level for users, and extended longevity of the serviceable life of the building. Further, maintaining lower level of carbon emission, and ratable value for the tax calculation of the building. The second case study of survey in Gujarat for assessment, of current intensity level of implementation of the changes made in Buy laws, rules, and regulations and in specific acceptance and awareness in the construction industry and end users. The awareness level about the safety of occupants and the building is rising and has come to forth as against in the past. The third case study reveals how the decision-making governed by the influence of need, availability of manpower, and commercial aspect, and not only by the optimum utilization criteria.*

***Key Words***: 1) Reduction in Potential strength, 2) efficient, economical, eco-friendly and optimistic use, 3) optimum utilization criteria. 4) The decision-making process.

## 1. INTRODUCTION

Such 'Sweet Dream Home' must be structurally safe, which then and then it will safeguard family, and the fill that it gives. The safety, relaxation, filling to be amongst your family, having together meal, making fun with them, which is in offing at home, is termed as 'The Life' and a worldwide-accepted definition. It is that everything else is secondary to that. The structural safety therefore is of utmost importance, and the residence wherein one is staying or is proposing to shift comply this basic condition.

The answer need to be addressed in respect of the ability of structure, to withstand the calamities, like EARTHQUAKE, Tsunami, excessive wind pressure, weathering effects, degradation effects and so on, unto its designed life span. If the safety, is not up to the mark then the solution is, bring the structure to the required level of safety by retrofitting the existing structure or by judiciously following BIS Code's recommendations and specifications. For a nonprofessional having this technical information is out of scope, and there is no reckoner, spelling out this information in simple words, for him. Safety of a structure defined as, a combination of, potential strength of the material, designing, positioning, and placing of the material, reinforcing if necessary, as and wherever it is required. It is evident from this, that there needs a proper planning, management, methodology in application of resources, stricter adherence to BIS code specifications, and instructions, as well as proper supervision during construction. The above steps followed even for minor and/or temporary structures like a shelter, a shade in absence, they cannot stand safely, leave apart the construction of a bungalow, a multi stored tower, or any other structure. The planning of a structure fundamentally depends on the requirements of owner, the available finance with owner, size and shape of land, demand of the market, the material and labour availability, location of the site. The planes are prepared using optimum 'Floor Space Index' (FSI), the ratio of proposed Built up area to the plot / Land area; shapes of major utility rooms are generally spaced in

ratio 1: 1.5 -1.8 of width to length. In a bid to utilize the complete available FSI other rooms like store, servant room, sometimes the leaving room etc. provided with odd dimensions, shapes. In order to add aesthetic aspect some irregular shapes and sizes are incorporated in plan or in front view of the structure. These aesthetic aspects can be like doubling the height of the leaving room (Hall), for entry porches, accommodating mechanical multi level parking, at the top level of stair case cabin, provision of double height to upper level water tank, considering probability addition of floor in future. Some unforeseen changes required accommodated during execution of project, the designing sub divided in two parts, the first architectural design, and the second structural design. The architectural design deals with requirements of the owner, and size and shape of land. Architect prepares the plan for the proposed structure in accordance with the building byelaws, rules, and regulations. The structure that has survived the calamity of earthquake but has sustained minor defects and has residual strength, whose safety and life will be enhanced by retrofitting." The need to rehabilitate the structure arises, in principal for safety of occupants and other following cases:- To enact change of use, or to opt change of seismic zone, structure-having strength but has deformed during the calamity. Change the safety of home from calamities became the necessity, which first assessed in two stages i.e. Visual Inspection followed by NDT's. The results obtained indicated the level of weaknesses. It further processed for selection of strengthening method. The strengthening in respect with earthquake is termed as retrofitting.

## 2. SEISMIC TRAMORS & REHABILITATION PROCESS OF BUILDINGS, FOR SAFETY

1. Effect of Structures' dead weight and height in seismic conditions explained in the following paragraphs.

The structures' dead weight acts cumulatively at foundation level, in vertically downward direction, and transferred to the soil. This way the entire structure connected to ground. The structure now resembles the inverted pendulum with pivot point at the base of the structure and top as free end. The seismic force acts at the base, moves the structure in horizontal direction. The impact so received, generates acceleration at the base of the structure, this structurally and proportionately transferred to all the walls, joints of wall-floor slabs, slab-beams column in case of RCC frames and at all the levels of the structure. The reaction developed at all the levels is product of dead weights and the structurally effective vibrations, at locations, the force thus developed known as 'Inertia force.' For, in depth understanding of this behavior, the example of resembling situation explained in the following paragraphs. On a moving vehicle, sudden/emergency application of break, our upper body experience forward swing as against the seat. In that situation, breaking force applied, acts similar to the seismic force on the structure, in horizontal direction at our seat level, our body weight is acting downward on the seat, as that of the structure on the ground. The seat is firm and the upper part of the body is support less, i. e. The body behaves like a vertical cantilever, the structure resembles in the same way. The breaking force received at the seat level of the body in reverse direction as that of motion of the vehicle, retards the the motion of seat instantly but the upper body being unsupported, keepsake on moving at the same direction (i. e. upper body swings ahead), as that of the vehicle before application of the break. When our body's potential ductile strength is sufficient to resist the jerk generated, we recover and match the deceleration, if not; the weaker part / s of the body is damaged.

The structure's behavior resembles i. e. when structure's potential ductile strength is sufficient to resist the seismic jerk, it recovers and matches the deceleration, if not, and the weaker part/s of the structure damaged / collapsed. In case of building structure the height play a vital role. The total dead wight of the structure increases as the height increases, and Vic. Viz., the inertia force developed is proportionate to the dead weights of different magnitude and located at different levels, gets summed up at the base, as the entire structure behave like

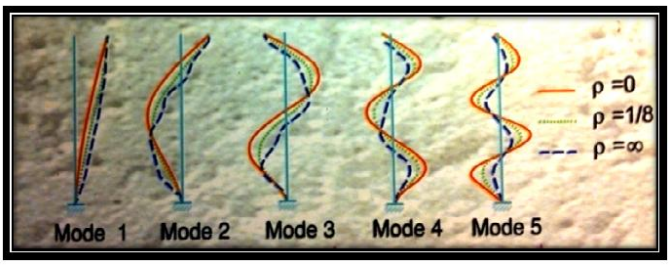


Figure 1:- The Natural Vibration Modes of Uniform Five

Where ρ = Stiffness ratio.

The Natural Vibration Modes of Uniform Five-Storey Building Frame, Cantilever this summed up force called 'Base Shear', developing maximum stresses at the base level. This tells us, taller the building grater the dead weight and grater the 'Base Shear' and greater the risk of collapse of the structure a human lives the great Assam. Earthquake of 1897 (magnitude than 8.1 Richter scale) destroyed many buildings taller 2 storey's, giving a lesson. This disaster result resulted in limiting the development of dwellings as G or G+1 (G-Ground floor) with light-weight roofing, this is known as "Assam Pattern." This is opted wisely and widely in seismic

zone V of North North-East India, ["Assam type" dwellings with light roofing (Figure 0.7) as ideal earthquake-resistant construction in North -East India] to be added from Hand book. It appears that, the lesson taught by the 'the great Assam earthquake of 1897 (magnitude 8.1) is now forgotten. There looks a competition going - on of constructing high rise buildings in urban areas, all over the country; many of them would be deficient in reasons, one for the heavy dead weight and second for insuf design and detailing. The multistoried construction are in demand in Urbana's prime locations and are surrounded by structures and therefore all are subjected to additional effect of pounding along with seismic forces in case of disaster to take place.

Figure 2:- Assam type roof (Light in weight)

## 3. RESEARCH METHODOLOGY

### Research Design

The definition as stated and quoted from Business Dictionary is: "A detailed outline of how an investigation will take place. A research design will typically include how data is to be collected, what instruments will be employed, how the instruments will be used and the intended means for analyzing data collected." Data collected by interviewing the Senior Architects and Sr. Structural Designers, Builders, and Developers (with Experience >20 yrs. in the construction industry), Site Engineers (with Experience 10-15 yrs. in the construction industry), the bungalow, flat owners, construction contractors. All the interviewes were from seismic zones III, IV & V from Ahamdabad, Bhuj, Adipur, Gandhidham locations in Gujarat. The site engineers selected were with experience mainly after the 2001 earthquake, in order to asses the level of implementation of BIS code provisions. All other members selected were having more than 20 yrs in the field so that they account for both pre and post scenario of quake.Database developed from Collected Data by random Sampling method; this database was analysised and tested with 'One tailed significance method of testing'.

### Research Area

1) City of Ahemdabad, falling in seismic zone III, herein about 75 multi-storeyed residential buildings copllapsed in 2001's earthquake.

2) City of Bhuj, the epicenter of the earthquake, falling in seismic zone V, wherein important building like Hospital, G+5 storeied residential buildings, and many old houses closely spaced in village area collapsed, with high number of casualties.

3) Cities of closely located to epicenter like Gandhidham, Adipur, falling in seismic zone V, wherein G+2-3 RCC buildings, bungalows, old houses, collapsed, for more than one or any specific reason. Few Buildings as old as 45 years or more survived, without significant damages.

### Research Arena

The research problems need boundaries to define domain of scope, and limitations, they are:

A. To Study of traditional methods and newly developed methods of retrofitting, for their relative advantages and disadvantages.

B. To compare in respect of safety, economic and Eco friendly values of newly developed methods of retrofitting, and Traditional Methods.

C. The Process of "The Life cycle evaluation in respect of residential buildings"

D. Analysis of data collected and discussion about findings.

E. To ascertain the probable reasons for non-implementation or negligent attitude towards life safety of occupants, with the help of data collected.

## 4. PRECAUTIONARY MEASURES, TO BE OPTED BY, PROPERTY OWNERS.

The professionals & hiring process of their duties, services. the owner to receive, certification and the under taking of the professional on completion of project.
The many professionals play a role in construction industry and they are as per there sequential entry in project,
1. Lawyer
2. Architect
3. Geotechnical Soil Engineer.
4. Structural / Civil Engineer
5. Project Engineer/Construction Supervisor/Project Management Consultants,

6. Contractor,
All the professionals, be registered with their respective government departments i.e. Bar council, Municipal corporation/Authority, and be well versed with the current D.C. RULES AND REGULATIONS and Bylaws of development.

**1. Lawyer**
The lawyer must verify all the documents of the land, should conform about the clarity of the title of the project land, and the legal part of the terms and conditions of tender and contract agreement.

**2. Architect**
The architect, to prepare building plan as per development rules and regulations, and Bylaws, submit it to the authority for the approval, along with his certificate of undertaking, do over all supervision of the project, on finishing the project get the occupation certificate from the authority.

**3. Geotechnical Soil Engineer**
The Geotechnical Soil Engineer to survey the land of the proposed project, teak the samples of strata, test the samples, workout the soil bearing capacity, conform the seismic zone, submit the detailed report in respect of construction of foundation and along with his certificate of undertaking. He should specifically, to conform susceptibility of flood, in respect of location (If in vicinity of a river), and sand behavior in respect of water.

**4. Structural/Civil Engineer**
The structural engineer to design structure, based on the report of Geotechnical Soil Engineer, sufficiently strong, resistive to earthquake in compliance with seismic zone specified, in accordance with the updated IS Code's recommendations and specifications for the safety of occupants and structure. Further, he should issue certificate of undertaking of project, and prepare drawings showing details of reinforcement, and sizes of slabs, beams, and columns. Check the detailing on site from time to time and certify before concreting work of respective items.

**5. Project Engineer/Construction Supervisor/Project management Consultants**
Is really the caption of the team, he submits certificate of undertaking of the project, gets executed the job of construction from the contractor, as per the IS Code's recommendations, specifications, practices and terms and conditions of contract.

**6. Contractor**
The contractor as per terms and conditions of contract arranges for labour and materials as per specifications, prepares the test specimens, gets them tested from the approved laboratories. In addition, executes the work as per instructions form site Engineer. Undertakes maintains responsibility as per terms of agreement (5 yrs. to 10 yrs).

The owner must receive following reports from the respective professionals

1. Report showing Basie of Structural design, from structural engineer,
2. The Report stating findings from Geotechnical Soil Engineer about of investigation of soil and strata,
3. Approved and certified copies of building plans, completion certificate, and occupation certificate, from Architect.
4. Project Engineer / Construction Supervisor / Project Management Consultant's, Undertaking on stamp paper by the appointed, of proper execution of project by him / her.
5. Final bill of Quantities, undertaking of free service maintenance period, guarantee certificates of manufacturers e.g. water pump/s, Elevators etc. if any from Contractor

## 5. CONCLUSION

Structural Engineers Forum of India (www.sefindia.org) has raised vital issue of lack of "Insurance and Legal Framework" in India, in respect of accountability in construction industry. The insurance companies therefore, do not consider the IS Code compliance in deciding the quantum of insurance premium. It points out further that perquisite of insurance of all the parties in the construction industry and the structure can enhance risk reduction factor. There is no uniform countrywide policy in respect of building Byelaws; this gives rise to grant permissions to conditions generating seismically undesirable situations knowingly or otherwise by authorities in some cities. Structural Engineers Forum of India have distinctly mentioned about constraints and is quoted here as, "India does not have adequate documentation on seismic evaluation and seismic strengthening of buildings. In recent years, many such documents have emerged from other countries but most professionals do not have access to those. Moreover, those documents cannot be implemented as such without first adapting them to Indian conditions. As a result, most of the work on seismic strengthening of buildings in Gujarat after the earthquake left much to be desired (e.g., Jain [3]). Many building owners elsewhere in the country were concerned about safety of their building immediately after the earthquake. However, the professionals could not provide proper services on this due to lack of such expertise. An opportunity for some good retrofitting work was missed."
Earthquake, for that matter any disaster, leaves evastative impacts on, "Economic and Social Health" of the nation. The Economic health of the nation, suffers a setback, to meet the emergency, as economy flow, manpower and civil supply is required to be diverted partially, if not fully, for re-establishing the life and infrastructure in the affected region. The economy flow is required in three parts, To repair and rehabilitate the damaged assets, Re-establish the productivity in the region of; annual output, product output, normalization of market economy flow. Subsides, or offsets

in products or taxes, duties are required to be offered to the affected citizens for a year or two to help them re-establish. The devastation created in the region affects the life of all the citizens, and needs longer duration, may be a year or two, to be re-rolled to the original status. Areas with higher population density have severed devastative effects and especially when the structures are not designed to resist the distractive forces of the magnitude. In urban areas the original settlements might have been built with the than rules, regulations, and code of practice. The codes are in the process of revision, but the revised guide lines issued, are need to be followed rigorously both by designers and implementing authorities. Just like KYC is being made mandatory, every house, must be, designed earthquake resistant and have the 'Capacity certificate' to that effect, as per specific Zonal requirements, especially in zone IV & V areas, for issuing or continuing the use of electric power connection. The earthquake-engineering subject consists of higher level mathematical part and looks to be difficult to understand for majority of students, hence the subject is a secondary choice in optional subjects, leave apart that as Main Stream subject. Less demand for designers specialized in earthquake field; hence the job opportunities are limited. 'The Architect, the Structural designer, or supervision by qualified Engineer is not sought for construction in rural areas, nor the services are offered by these professionals, for in convenient location of the site of work, and more form earning point of view.

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Nishchay Singh is an M.Tech Scholar & currently researching on the Life Cycle Evaluation Of Rehabilitation Of Residential Structures, Subjected To Earthquake A part from this he is studious & have sound knowledge of the subject.

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