RESEARCH ARTICLE OPEN ACCESS

A Study on Seismic Retrofitting Of Buildings and Experimental Investigations by NDT Methods.

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ABSTRACT:-
The seismic evaluation process consists of investigating if the structure meets the defined target structural performance levels. The main goal during earthquakes is to assure that building collapse doesn't occur and the risk of death or injury to people is minimized and beyond that to satisfy post-earthquake performance level for defined range of seismic hazards. Also seismic evaluation will determine which are the most vulnerable and weak components and deficiencies of a building during an expected earthquake.
Seismic Retrofitting is process done for resisting any type of seismic action that is caused under the structure and inside the earth soin order to resist it we need to concrete should be highly performance and highly strengthen.
Generally, the structural retrofit of concentrically braced frames improved the seismic resistance of the building and it can be considered in the retrofit of moment frame structures to prevent the risk of structural collapse underthe design load with much more confidence.
Keywords:-Seismic, Earthquake,retrofit, resistance ,design load.

Date of Submission: 13-02-2021 Date of Acceptance: 27-02-2021

I. INTRODUCTION:-

The main purpose of the system is that seismic retrofitting need to be done for the existing buildings and some types of non- destructive test are been used for future assessment an for life of structures and there are various objective which results in

1. to analyse performance based design and compare different seismic analysis method
2. to evaluate the feasibility of seismic evaluation of buildings and advantages of applying the retrofit measures developed for strengthening etc.……

An overview of Earthquake ResistantDesign
Most earthquakes occur through the sudden movement of earth crust in faults zones. The sudden movement releases strain energy and causes seismic waves through the crust around the fault.
These seismic waves cause the ground surface to shake and this ground shaking is the principal concern of structural engineering to resist earthquakes amongmany other effects.
Historical records and geological records of the earthquakes are the main data sources in estimating the possibility of ground shaking or seismicity at a certain location. Both data sets have been taken into account to develop the seismic hazard maps. The earthquake forces are generated by the inertia of buildings as they respond to earthquake induced ground shaking. In design, the response of a structure to an earthquake is predicted from a design spectrum such as specified in ASCE-7.
To create a design response spectrum, the first step is to determine the maximum response of the structure to a specific ground motion.

Nonlinear Static Procedure

The nonlinear static procedure (NSP), also known as pushover analysis, was introduced back in 1970's and is becoming a popular tool for seismic for seismic performance evaluation for existing and new structures. Pushover analysis is much more realistic and more comprehensive than linear methods explained above. On the other hand, compared to nonlinear dynamic analysis, it is relatively simple and much less time consuming (Krawinkler, 1996).

The purpose of the pushover analysis is to evaluate the strength and deformation capacities and compare these capacities with the demands at the performance level of interest, by using a static nonlinear analysis algorithm. It is carried out under constant gravity loads and monotonically increased lateral forces, applied at the location of the masses in the structural model, to simulate the inertia forces until a target displacement is exceeded or a failure mechanism develops. The target displacement is intended to be the maximum displacement likely to be experienced by the building during the design earthquake. If an appropriate lateral load pattern is used, the structural member forces predicted bythe model should be a reasonable approximation of the actual earthquake forces (FEMA 356, 2000). The method is able to describe the evaluation of plastic mechanism and structural damage as a function of the lateral forces since they are increased monotonically. The pushover analysis can provide information on many response characteristics that can't be obtained from linear methods such as (Krawinkler, Seneviratna, 1997); • Evaluate force demands on potentially brittle elements, such as axial force demands on columns, force demands on braced connections, moment demands on beam-tocolumn connections, etc. • Estimates the deformation demands for elements that deform inelastically in order to dissipate energy. • Identify the critical regions in which the deformation demands are expected to be high and requires thorough detailing. • Estimates of the interstory drifts that account for strength or stiffness discontinuities • Verify the completeness and adequacy of load path.

The advantage of the outputs given above comes at the cost of additional analysis effort, associated with modeling inelastic properties of all important elements. Three dimensional analytical model of a structure would be the most preferable one, but as expectedly requires more computational effort.

The method is based on the assumption that the response of the structure can be related to the response of an equivalent single degree-of-freedom (SDOF) system. This implies that the response is controlled by a single mode and that the shape of this mode remains constant throughout the time history response. Clearly, these assumptions are incorrect, but studieshave indicated that these assumptions have good predictions of the maximum seismic response of multi degree-of-freedom (MDOF) structures, provided that their response is dominated by a single mode (Krawinkler, Seneviratna, 1997). The NSP is only permitted to be used on structures with certain characteristics. The strength ratio, R, must be less than the maximum allowable ratio, as defined by ASCE 41-06 Chapter If the strength ratio exceeds the maximum, the structure experiences significant nonlinear degradation, and a nonlinear dynamic analysis is required. Also, the higher mode effects must not be significant as the nonlinear static procedure is typically only valid for first mode dominated structures, because the procedure fails to account accurately for higher mode dynamic effects (FEMA 356, 2000).

Nonlinear Dynamic Procedure

The nonlinear dynamic procedure (NDP), like the NSP, requires a mathematical model that incorporates the nonlinear load- deformation characteristics of theindividual components.

However instead of using target displacement as in NSP, the design displacements are determined directly through dynamic analysis using ground motion time histories. The ground motion time-histories should be specific to the building site. The resulting internal forces do not need to be modified since the nonlinear response is explicitly modeled, and the displacements can be directly compared to the acceptance criteria (FEMA 356, 2000).

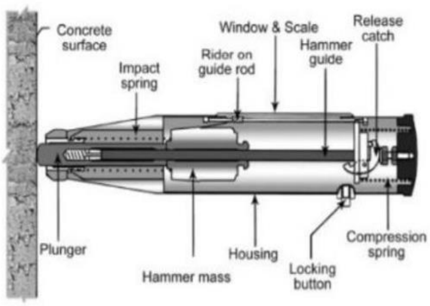
A minimum of seven ground motion analyses are required by ASCE 41-06. The basis and the modeling approaches of the NDP are similar to those for the NSP. The nonlinear dynamic procedure is capable of providing the best estimates under seismic loading. However, time and engineering cost discourage designers from performing a response history analysis on all buildings.

NONDESTRUCTIVE TEST
REBOUND HAMMER TEST:-

Principle: When the plunger of rebound hammer is pressed against the surface of theconcrete, the spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound is read off along a graduated scale and is designated as the rebound number or rebound index. Apparatus Required Fig. : Rebound Hammer It consists of a spring controlled mass that slides on a plunger within a tubular housing. The impact energy required for rebound hammers for different applications is given in Table 1

S. No.	Application	Approx. Impact Energy required for Rebound hammer (Nm)
1	For Testing Normal Weight Concrete	2.25
2	For light-weight concrete or small and impact sensitive parts of concrete	0.75
3	For testing mass concrete for example, in roads, air field pavements and hydraulic structures	2.25

Table 1 : Impact Energy for Rebound hammer for different Applications.



Procedure Checking of Apparatus It is necessary that the rebound hammer is checked against the testing anvil before commencement of 80 a test to ensure reliable results. The testing anvil should be of steel having Brinell hardness of about 5000 N/mm2.

The supplier/manufacturer of the rebound hammer should indicate the range of readings on the anvil suitable for different types of rebound hammers. 4.2 Procedure of obtaining Correlation between Compressive Strength of Concrete and Rebound Number

The most satisfactory way of establishing a correlation between compressive strength of concrete and its rebound number is to measure both the properties simultaneously on concrete cubes. The concrete cube specimens are held in a compression testing machine under a fixed load, measurements of rebound number taken and then the compressive strength determined as per IS:516- 1959.

The fixed load required is of the order of 7 N/mm2 when the impact energy of the hammer is about 2.2 Nm. The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible in order to minimise the size effect on the test result of a full scale structure.

150 mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2 Nm), whereas for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300 mm. If the specimens are wet cured, they should be removed from wet storage and kept in the laboratory atmosphere for about 24 hours before testing.

To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken.

A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cube as cast should be tested. At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers.

The points of impact on the specimen must not be nearer an edge than 20 mm and should be not less than 20 mm from each other. The same points must not be impacted more than once. 4.3
Test Procedure

1. For testing, smooth, clean and dry surface is to be selected. If loosely adhering scale is present, this should be rubbed of with a grinding wheel or stone. Rough surfaces resulting from incomplete compaction, loss of grout, spalled or tooled surfaces do not give reliable results andshould be avoided.
2. The point of impact should be at least 20 mm away from any edge or shape discontinuity.
3. For taking a measurement, the rebound hammer should be held at right angles to the surface of the concrete member. The test can thus be conducted horizontally on vertical surfaces or vertically upwards or downwards on horizontal surfaces. If the situation demands, the rebound hammer can be held at intermediate angles also, but in each case, the rebound number will be different for the same concrete.
4. Rebound hammer test is conducted around all the points of observation on all accessible faces of the structural element. Concrete surfaces are thoroughly cleaned before taking any measurement. Around each point of observation, six readings of rebound indices are taken and average of these readings after deleting outliers as per IS:8900-1978 becomes the rebound index for the point of observation.
5. Influence Of Test Conditions: The rebound numbers are influenced by a number of factors like types of cement and aggregate, surface condition and moisture content, age of concrete and extent of carbonation of concrete.

Influence of Type of Cement Concretes made with high alumina cement can give strengths 100 percent higher than that with ordinary Portland cement. Concretes made with super sulphated cement can give 50 percent lower strength than that with ordinary Portland cement.

Influence of Type of Aggregate Different types of aggregate used in concrete give different correlations between compressive strength and rebound numbers. Normal aggregates such as gravels and crushed rock aggregates give similar correlations, but concrete made with light weight aggregatesrequire special calibration.

Influence of Surface Condition and Moisture Content of Concrete The rebound hammer method is suitable only for close texture concrete. Open texture concrete typical of masonry blocks, honeycombed concrete or no-fines concrete are unsuitable for this test. All correlations assume full compaction, as the strength of partially compacted concrete bears no unique relationship to the rebound numbers.

Trowelled and floated surfaces are harder than moulded surfaces, and tend to over estimate the strength of concrete. A wet surface will give rise to under estimation of the strength of concrete calibrated under dry conditions. In structural concrete, this can be about 20 percent lower than in an equivalent dry concrete.

Influence of Curing and Age of Concrete The relationship between hardness and strength varies as a function of time. Variations in initial rate of hardening, subsequent curing and conditions of exposure also influence the relationship. Separate calibration curves are required for different curing regimes but the effect of age can generally be ignored for concrete between 3 days and 3 months old. Influence of Carbonation of Concrete Surface The influence of carbonation of concrete surface on the rebound number is very significant. Carbonated concrete gives an overestimate of strength which in extreme cases can be up to 50 percent. It is possible to establish correction factors by removing the carbonated layer and testing the concrete with the rebound hammer on the uncarbonated concrete.

Interpretation of Result

1. The rebound hammer method provides a convenient and rapid indication of the compressive strength of concrete by means of establishing a suitable correlation between the rebound index and the compressive strength of concrete. The procedure of obtaining such correlation is given above.
2. It is also pointed out that rebound indices are indicative of compressive strength of concrete to a limited depth from the surface. If the concrete in a particular member has internal microcracking, flaws or heterogeneity across the cross-section, rebound hammer indices will not indicate the same.
3. As such, the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ±25 percent. If the relationship between rebound index and compressive strength can be checked by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence thereon are greatly increased.

Objective: The rebound hammer method could be used for:

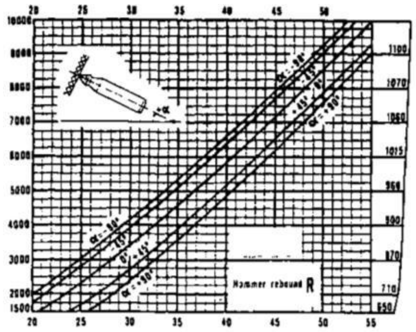
(i) assessing the likely compressive strength of concrete with the help of suitable corelations between rebound index and compressive strength,

(ii) assessing theuniformity of concrete,

(iii) assessing the quality of the concrete in relation to standard requirements, and

(iv) assessing the quality of one element of concrete in relation to another

With the help of calibration chart leading procedure is done.



Ultrasonic pulse velocity test:- Ultrasonic Testing is one of the non-destructive test method based on the transmission of the ultrasonic pulse in the component or materials 85 like concrete, steel, etc. Ultrasonic testing is known as UT or Ultrasonic Pulse Velocity Test or UPV Test.

The ultrasonic testing method is based on the use of equipment composed of transducers which produce and receive the ultrasonic wave of 0.01 to 60 MHz. The pulse (wave) depends on the density and the elastic properties of the materials of RCC structure.

The Procedure of Ultrasonic Testing for the Compressive Strength of Concrete: Ultrasonic testing consists of measuring the travel time of an ultrasonic pulse or wave of 25 to 60 kHz. The ultrasonic pulse or wave is produced and received by an electro- acoustical transducer. The transducer is held in contact with one surface of the concrete member and receiving the same by a similar transducer in contact with the surface at the other end.

The speed of the pulse or wave is the function of the density of the material. It allows the estimation of the porosity and the detection of discontinuities like cracks in the house. Once the distance between two probes (path length) and time of travel is known, it is possible to determine the average pulse velocity by the following equation.

Pulse velocity= Distance between the two probes (Path Length)/ Time of travel

The higher pulse velocity indicates higher elastic modulus, density and integrity of theconcrete.

Pulse velocity also depends on the method of propagation and the arrangement of transducers. There are three primary ways in which the transducers may be arranged.

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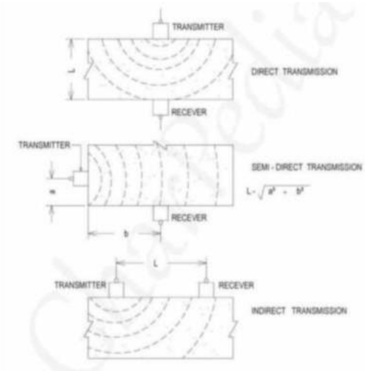


Method of Propogating And Receiving Pulses

Arrangement of Transducers in Ultrasonic Testing

01. Opposite Faces (Direct Transmission): If one transducer is placed at one end, and the other one is placed exactly at the opposite end, it is the direct method.
02. Adjacent Faces (Semi-Direct Transmission): In this method, both transducers are placed on the same surface of the concrete. The receiver receives the ultrasonic pulse coming after striking the molecules of the concrete.
03. Same Face (Indirect Transmission): It is mostly used for corners of the concretemembers.

The maximum pulse energy is transmitted at right angles to the face of the transmitter. The direct transmission method is considered to be the most reliable way.

The Relation between Pulse Velocity of Ultrasonic Testing and the

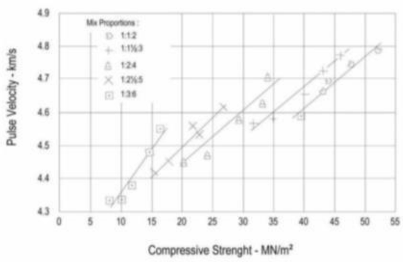
Compressive Strength of Concrete:

The pulse velocity basically does not directly measure compressive strength. The compressive strength of concrete is influenced by many variables. It is influenced by the types of aggregates, age, moisture content, and mix proportion of concrete. It is also influenced by curing of concrete and others factors. The factors affecting the compressive strength have an influence on the pulse velocity. As a result, a statistical study is essential to relate the pulse velocity and the compressive strength.

Bad concrete (which has been poorly compacted concrete or, there is segregation of materials, internal cracking, or flaws) has the lower pulse velocity although the same materials and mix proportions are used. Good concrete has high pulse velocity thought the materials and mix proportions may be same.

Estimation of the concrete strength can be done by establishing the suitable correlation between the pulse velocity and the compressive strength of concrete specimen made with same mix proportions of materials and in same environmental conditions similar to that of the structure.

the compressive strength of the concrete.



Ultrasonic Testing Graph

Ultrasonic Testing Graph shows the correlation between the pulse velocity and the compressive strength of the concrete.

he estimated strength may differ from the actual by 20 percent or more. The correlation so obtained may not be applicable for concrete of another grade or made with different types of materials.

General Guidelines for Concrete Quality based on the UPV Test Results:

Pulse Velocity in Concrete (Km/Sec)	Concrete Quality (Grade)
>4.0	Very Good to Excellent
3.5-4.0	Good to Very Good, Slight Porosity may Exist.
3.0-3.5	Satisfactory but Loss of Integrity is Suspected
<3.0	Poor and Loss of Integrity Exist

The Realistic Assessment of the Condition of Concrete Surface:

The realistic assessment of the condition of the concrete surface can be done by the combination of the results of UPV test and rebound hammer test.

Following table identifies the location of corrosion in concrete by combining the results of ultrasonic testing and reboundnumbers (rebound Index).

Readings Interpretations of Ultrasonic Testing & Rebound Hammer Testing

Identification of Location According to Readings Interpretations

- High UPV value & high rebound number
- Not corrosion prone
- Medium range UPV values & high rebound numbers • Surface delamination & low quality of surface concrete & corrosionprone
- Low UPV & high rebound numbers • Not corrosion prone however to be confirmed by chemical tests, carbonation & pH
- Low UPV values & low rebound numbers
- Corrosion prone – requires chemical and electrochemical tests.




II. METHODLOGY:

Procedure 1:- For Ordinary Cement Concrete Cubes:-

1. Collection Of Material.
2. Mix Proportions By Code.
3. Casting Of Cube(PCC).
4. Conducting Test.
5. Developmental Analysis.
6. Results.
7. Conclusion According To Experiment.

PROCEDURE 2:-

FOR ADMIXTURE CEMENTCONCRETE BEAMS

1. Collection of Material.
2. Mix Proportions By Code.
3. Casting Of beams((with and with out admixture's).
4. Conducting Test.
5. Developmental Analysis.
6. Results.
7. Conclusion According To TheExperiment.

EXPLANATION IN BRIEF:- Procedure 1.

1. Collection of material :-

The material like fine aggregate, coarse aggregate, cement , water have been used

2. Mix proportion of material by code:- According to is 10262:2009 M30 concrete is designed and all materials are mixed according to the quantity required and as per code .

1. Casting of cubes (PCC):- The concrete in plastic state have been placed in mould and been cured it for 28 days.

2. Mix proportion of material by code:- According to is 10262:2009 M30 concrete is designed and all materials are mixed according to the quantity required and as per code .

3. Casting of Cubes:-

The concrete in plastic state have been placed in mould and been cured it for 80 days.

4. Conducting Test:- Since it is non-destructive and destructive test will also be done like compression test at last but at initial test we need to do rebound hammer test and ultrasonic pulse velocity test which leads to explanation of seismic effect of building .

5. Devlopmental Analysis:-

The experimental values will be explained according to the limitations of experiment done

6. Results:- As the recorded values of experiment will be demonstrated.

7. Conclusion According to the experiment:- conclusion based on experiment done whether the concrete cube having grater performance , ability, strength 9

Therefore the best concrete will be used seismic retrofitting of build

EXPLANATION IN BRIEF:- Procedure 2.

1. Collection of material :-The material like fine aggregate, coarse aggregate, cement, water, mineral and chemical other material which strength and mainly liquid admixture are used have been used.

2. Mix proportion of material by code:- According to is 10262:2009 M30 concrete is designed and all materials are mixed according to the quantity required and as per code .

3. Casting of Beams (with and without admixtures)

The concrete in plastic state have been placed in mould and been cured it for 80 days.

4. Conducting Test:-

Since it is non-destructive and destructive test will also be done like compression at last but at initial test we need to do rebound hammer test and ultrasonic pulse velocity test which leads to explanation of seismic effect of building .

5. Developmental Analysis:-

The experimental values will be explained according to the limitations of experiment done.

6. Results:- As the recorded values of experiment will be demonstrated.

7. Conclusion According to the experiment:-

Conclusion based on experiment done whether the concrete cube having grater performance ,ability, strength

Therefore the best reinforcement will be used in seismic retrofitting of buildings.

III. RESULTS:-

FOR CUBES (PCC)

S.NO	SET NO	GRADE OF CONCRETE	COMPRESSIVE STRENGTH OF CONCRETE(N/mm²)		UPV TEST (Km/second)	
			THROUGH Rebound Hammer Test	THROUGH Compressive Strength Machine	Average velocity	Quality
1	SET NO:1	M20	24.5	25.73	3.24	
2			25.9	25.29	3.27	
3			24.5	25.94	3.23	
		Avg Result	24.96	25.65	3.24	MEDIUM
1	SET NO:2	M30	36.1	37.89	3.63	
2			38.2	37.65	3.55	
3			34.4	36.94	3.62	
		Avg Result	36.2	37.94	3.60	GOOD

Hence the quality of concrete need to be similar to the properties of grade M30 as above shown in table

And the graphical representation is as follows

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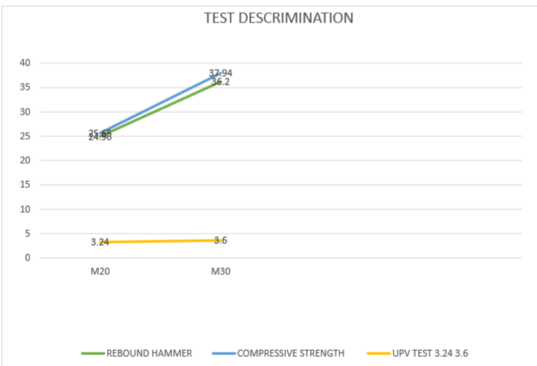
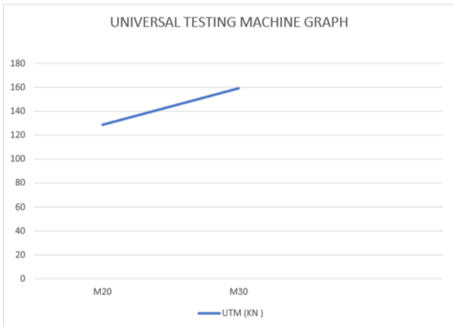


BEAM ANALYSIS RESULT :-

S.NO	SET.NO	GRADE OF CONCRETE	COMPRESSIVE STRENGTH OF CONCRETE(KN) (THROUGH UNIVERSAL TESTING MACHINE)	QUALITY
1.	SET NO:1	M20	128.62	
		TOTAL RESULT	128.62	SATISFACTORY
1.	SET NO:2	M30	159.15	
		TOTAL RESULT	159.15	GOOD



Hence the quality of concrete need to be similar to the properties of grade M30 as above shown in table as shown in beam analysis. Its reinforcement details are being provided as 16mm φ bars in compression and as well as tension zone hence it isdoubly reinforced concrete beam .

NOTE :- For M30 grade the admixture is being used as rice husk ash for strength gaining purpose

IV. CONCLUSIONS:-

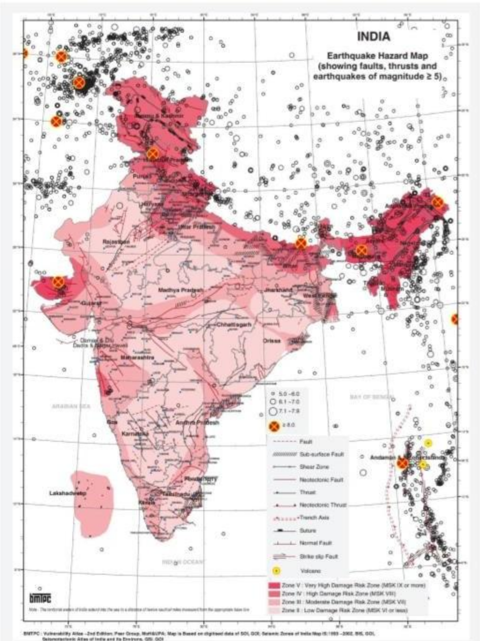
According to the project the best concrete and as well as the best reinforcement design to resist earthquake will be treating it as seismic design of building . So as of now according to project best concrete material will act as high strength concrete and its reinforcement details providing good steel in both compression as well as in tension zones will make the building as over reinforced .(which saves lifes)

So by this project we wanted to convey that the best reinforcement details and best concrete under supervision earthquake design will always be safe and act as seismic retrofitting material of the RCCbuildings.

V. RECOMMENDATIONS:-

Every building in India need to be supervised at some period of time after construction . So when we wanted construct RCC or wooden structures , etc. We need to be care full follow the rules as in codes for RCC we need to follow IS 456:2000, for steel structures we need to follow IS 800:2007 etc . for every structure we have various technologies to resist earth quakes and save life of people those earth quake design need to follow by each and every civil engineer as must . only then we can eradicate some problems in civil engineering duo to earth quakes. Finally we would to recommend that follow the guidelines and codes for every construction make sure that in high zones like in India which are Kashmir, north and middle of Bihar, north east Indian region follow seismic or earth quake design to follow and complete the project. And the seismic load is considered by IS code 1893:2002.

NOTE :- kindly refer the zone while constructing building in locality.



There are many studies for earth quake resistance kindly follow any one of them depending upon the type of building .
1.Active and passive systems2.Bracings
3.Dampers 4.Rollers 5.Shear walls 6.Isolations ,etc.

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