AN ENHANCED PARTICLE SWARM OPTIMIZATINON FOR RETROFIT PLACEMENT IN NON-CODE REINFORCEMENT CONCRETE STRUCTURE

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Abstract : Earthquake that create the maximum damage of life, while forceful, were deadly because of their presence to either heavily occupy areas or the ocean, where earthquakes often create tsunamis that can destroy populations thousands of kilometers away. Optimization methods were used with the structural analysis to decrease cost and enhance the performance of seismic reduction in retrofit scheme . To reduce the seismic risk of weak structures, different retrofit options are available.

I. INTRODUCTION .

The 2004 Indian Ocean earthquake occurred at 00:58:53 UTC on 26 December with the epicenter off the west coast of Sumatra, Indonesia. The shock had a moment magnitude of 9.1–9.3. The undersea mega thrust earthquake and triggered a series of devastating tsunamis along the coasts of most landmasses bordering the Indian Ocean, killing 230,000– 280,000 people in 14 countries, and inundating coastal communities with waves up to 30 meters (100 ft) high. Indonesia was the hardest-hit country, followed by Sri Lanka, India, andThailand.

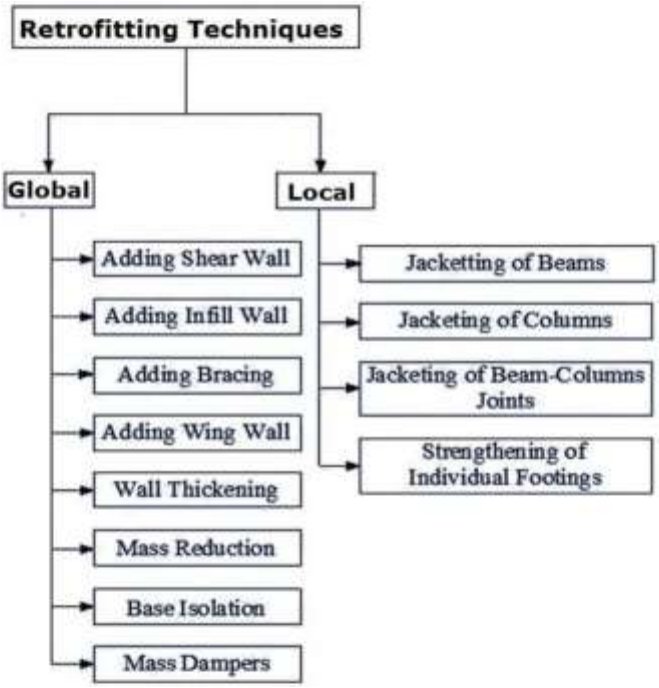
(Indian ocean earthquake affected countries) Fig(1)

The 2010 earthquake by 24 January at least 52 aftershocks measuring 4.5 or greater ad been recorded. An estimated three million people affected by the earthquake .The government of Haiti estimated that 250,000 residence and 30,000 commercial buildings had collapsed or were severely damaged. The earthquake caused major damage inPort-au-Prince ,jackmel and other cities in the region.

(Building crashed in Port-au-Prince)
Fig (2)

The structural detrimentfrom the Chile earthquake was reduced because of the modernistic design standards used in that area. Old structures, however, in many locations, built before modern seismic design practices, are still weak (Kovacs, 2010; Tesfamariam and Saatcioglu, 2008,2010).

Seismic Retrofitting Techniques are required for concrete constructions which are vulnerable to damage and failures by seismic forces. In the past thirty years, moderate to severe earthquakes occurs around the world every year. Such events lead to damage to the concrete structures as well as failures. In this topic main objective is retrofit location. Classification of retrofit techniquesare



TYPESOFMETHODSAREUSED

1. Optimization techniques play an important role as a useful decision-making tool in the design of structures.
2. 2.Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fishschooling.

Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust. PSO has been successfully applied in many areas: function optimization,

artificial neural network training, fuzzy system control, and other areas where GA can be applied. The remaining of the report includes four sections:

1-Background artificial life. 2-The Algorithm.

3- PSO parametercontrol

4- Comparisons between Genetic algorithm andPSO

Data and Sources of Data

- **FEMA P695 Ground Motion Records**

Ground motion record sets include a set of ground motions recorded at sites located greater than or equal to 10 km from fault rupture, referred to as the “Far-Field” record set, and a set of ground motions recorded at sites less than 10 km from fault rupture, referred to as the “Near-Field” record set. The Near-Field record set includes two subsets: (1) ground motions with strong pulses, referred to as the “NF-Pulse” record subset, and (2) ground motions without such pulses, referred to as the “NF-No Pulse” record subset..

- **Record Selection Criteria**

This section describes record selection criteria developed to meet Methodology objectives. Each criterion is listed, followed by a brief discussion of the intent of the rule.

- **Source Magnitude**

Large-magnitude events pose the greatest risk of building collapse due to inherently longer durations of strong shaking and larger amounts of energy released.

- **Source Type**

Record sets include ground motions from earthquakes with either strike-slip or reverse (thrust) sources. These sources are typical of shallow crustal earthquakes in California and other Western United States locations.

Record sets include ground motions recorded on either soft rock (Site Class C) or stiff soil (Site Class D) sites. Records on soft soil (Site Class E) or sites susceptible to ground failure (Site Class F) are not used. Relatively few strong-motion records are available for Sit Class B (rock) sites. The 10 km source-to-site distance boundary between Near-Field and Far-Field records is absolute, but generally stablewith the “near fault” region of MCE design values maps in ASCE/SEI 7-05. Several different measures of this distance are available. For this project, the source-to-site distance was taken as the average of Campbell and Joyner-Boore fault distances provided in the PEER NGAdatabase.

- **Number of Records per Event**

Strong motion instruments are not evenly distributed across seismically active regions ,Due to the number of instrument in place at the time of the earthquake, some large magnitude events have generated many records, while others have produced only a few. To avoid potential event-based bias in record sets, not more than two records are taken from any one earthquake for a record Strong-motion instruments are not evenly distributed across seismically active regions

- **Strongest Ground Motion Records**

The limits of greater than 0.2 g on PGA and greater than 15 cm/sec on PGV are arbitrary, but generally represent the threshold of structural damage (for new buildings) and capture a large enough sample of the strongest ground motions (recorded to date) to permit calculation of record-to-record variability.

- **Strong-Motion Instrument Capability**

Some strong-motion instruments, particularly older models, have inherent limitations on their ability to record long- period vibration accurately. Most records have a valid frequency content of at least 8 seconds, but some records do not, and records not valid to at least 4 seconds are excluded from the record sets. The record sets are considered valid for collapse evaluation of tall buildings with elastic fundamental periods up to about 4 seconds.

- **Strong-Motion Instrument Location**

Strong-motion instruments are sometimes located inside buildings (e.g., ground floor or basement) that, if large, can influence recorded motion due to soil-structure-foundation interaction. Instead, instruments located in free-field location or on ground floor of a small building should be used.

- **Scaling Method**

Scaling of ground motion records is a necessary element of non-linear dynamic analysis.

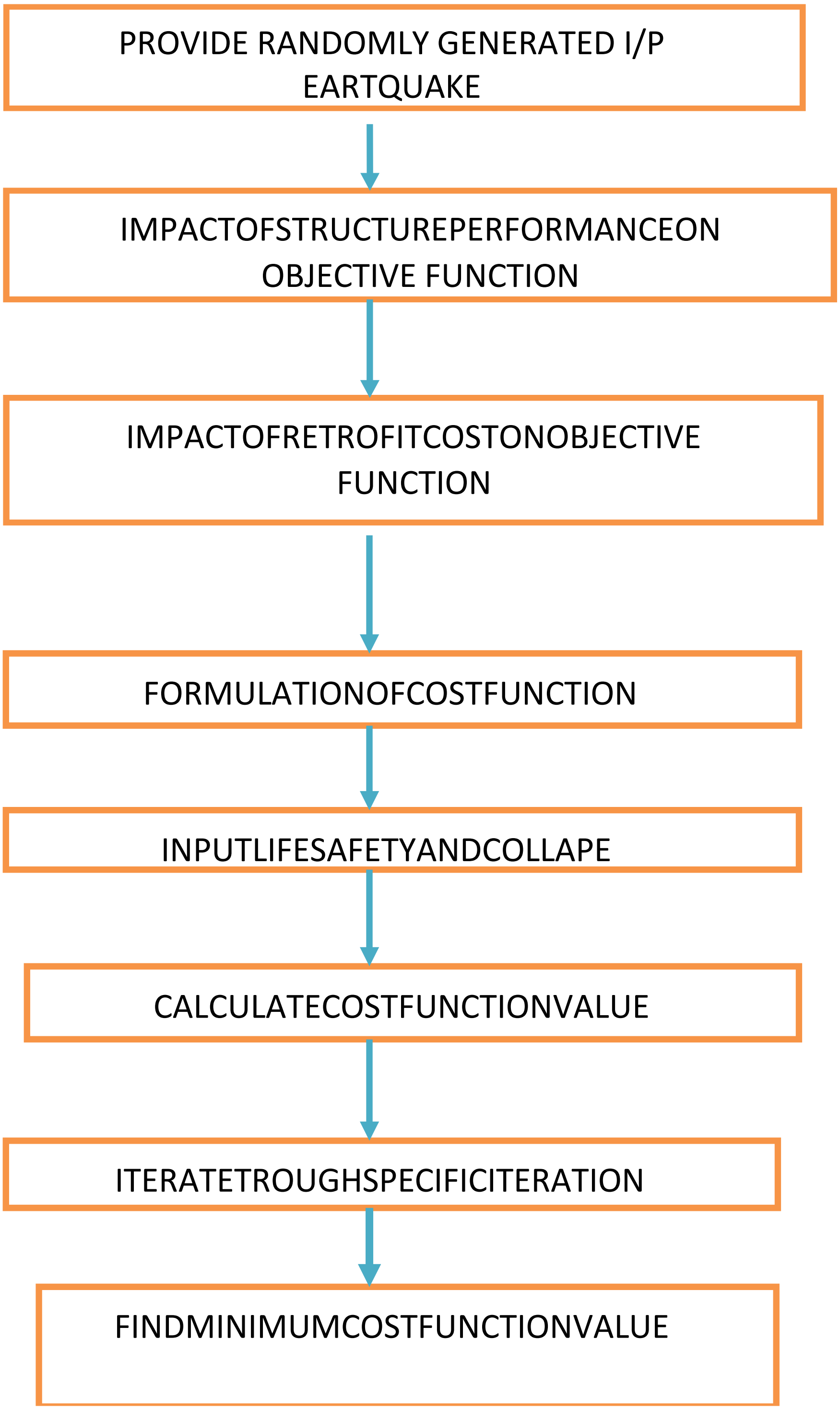
- **Normalization of Records**

Individual records of a given set are normalized by their respective peak ground velocities.

- **Far-Field Record Set**

The Far-Field record set includes twenty-two records (44 individual components) selected from the PEER NGA database using the criteria discussed.

RESEARCHMETHODOLOGY



Data Collection

FEMA695 analysis the characteristics of the Far-Field and Near-Field record sets and defines the scaling methods appropriate for collapse evaluation of building archetypes based on incremental dynamic analysis. This method utilizes the far-field record set for nonlinear dynamic analysis and related collapse assessment of archetype models.

2. **Impact of structureperformance**

The Methodology is consistent with the primary "life safety" performance objective of seismic regulations in model building codes. Design for performance other than life safety was not explicitly considered in the development of the Methodology. Accordingly, the Methodology does not address special performance or functionality objectives of ASCE/SEI 7-05 for Occupancy III and IV structures.

In general, life safety risk (i.e., probability of death or life-threatening injury) is difficult to calculate accurately due to uncertainty in casualty rates given collapse, and even greater uncertainty in assessing the effects of falling hazards in the absence of collapse

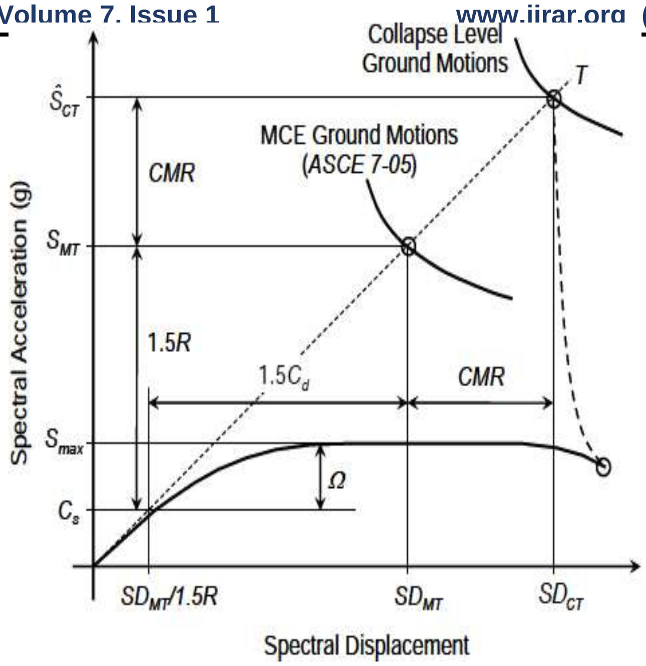


Illustration of seismic performance factors (R and Cd) as defined by the Methodology.

Safety Expressed in Terms of Collapse Margin Ratio

This method definecollapse level ground motions as the intensity that would result in median collapse of the seismic-force-resisting system. Median collapse occurs when one-half of the structures exposed to this intensity of ground motion would have some form of life-threatening collapse. As shown in above Figure, collapse level ground motions are higher than MCE ground motions. As such, MCE ground motions would result in a comparatively smaller probability of collapse. in Equation 1a, the collapse margin ratio (CMR) is the ratio of the median 5%- damped spectral acceleration of the collapse level ground motions CT S(orcorresponding displacement CT SD) to the 5%-damped spectral acceleration of the MCE ground motions MT S (or corresponding displacement MT SD) at the fundamental period of the seismic-force-resisting system.

$$CMR = \frac{\hat{S}_{CT}}{S_{MT}} = \frac{SD_{CT}}{SD_{MT}} \qquad \text{......................1a}$$

3. Impact of retrofit cost on objectivefunction

The recommendations below are on how to consistently record data in a retrofit cost plan.

1. Appoint engage with a cost professional in the early stages of the project (alternatively, identify who in the project team will have the responsibility for managing the early-stage costdata).
2. Use a standardized cost plan to set out costs and quantities. Initiate this early in the project. An example is provided on the nextpage.
3. When populating the cost plan, record: i) where the data is coming from, e.g. specification documents/ spreadsheets/ SAP (Standard Assessment Procedure) analysis, and; ii) from whom, e.g. architect/ engineer/ contractor. Recording the source of the data will be beneficial for laterreference.
4. Provide as much explanatory information as possible with the cost data, e.g.: product obtained from supplier X; bulk discount obtained due to ordering >X no.; minimum quantity X number; typical delivery time X weeks/months,etc.
5. Ensure that correct and consistent units are used. For example, it is more difficult to compare two PV systems if the data for one is in £/kWp and the other is in£/m2.
6. Clearly disaggregate costs (e.g. materials/ equipment/ labour/etc.).
7. Try to identify what 'additional costs' might arise (e.g. dealing with complicated dwellings or making good after the retrofit)andwhere theyare more likelytoarise (e.g.propertiesofa certain age and type). It is important to understand whether these costs are likely to occur across many properties or whether they are one-off costs unique to the project.

Considering above points of reducing retrofit cost it has been seen in many cases that cost is usually high for any type of retrofit. So, the only step left to reduce cost is by reducing number of Retrofits.

4. Formulation of costfunction

For this case, an objective function was selected that incorporated both the structure performance and retrofit cost parameters as ratios. The objective function (see equation (1)) quantifies the performance by comparing the PGA and PGV data collected, to a defined required performance level. Both the ground motion and number of retrofit variables represent competing factors within the objective function. The variables were normalized to values representing a practical maximum. This normalization has the effect of weighting the two competing variables differently. The performance is averaged over a set of earthquake records selected from FEMA P695 that are numbered from 1 to nEQ.

The 'life safety' and 'collapse prevention' performance levels (PLS and PCP, respectively) correspond to a MISDR of 1.5% and 2.5%, respectively, and if the drift is beyond these limits, the objective function is penalized. The penalty factors shown in equations (2), and (3) were selected based on the FEMA 356 performance-based design principles. The number of applied retrofits, (nr), is used as a proportional cost measure, comparing number of applied retrofits to a defined maximumnumber.

So, for PGA data the objective function is as follows

$$F = \left[\frac{\left(\frac{\sum_{i=1}^{nEQ} PGA}{nEQ} \right)}{nr} + \frac{nr}{56} \right] \times Pls \times Pcp$$

If Pls=1 if dmax < 1.5 (2)

1.5 if dmax>= 1.5

If Pcp =1 if dmax< 2.5

2 if dmax>= 2.5

And for PGV data the objective function is as follow

$$F = \left[\frac{\left(\frac{\sum_{i=1}^{nEQ} PGV}{nEQ} \right)}{nr} + \frac{nr}{56} \right] \times Pls \times Pcp \quad (3)$$

If Pls=1 if dmax<1.5

1.5 If dmax>=15

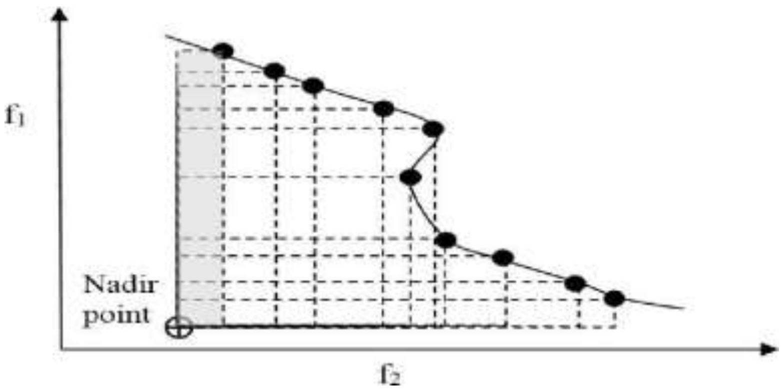
If Pcp=1 if dmax<2.5

2 if dmax>=2.5

5. Iteration and ObjectiveFunction

Each iteration follows following steps to converge. To get a clearer picture of the idea the Pareto-compliance, the concepts of Pareto dominance needs to be defined. Pareto dominance can be categorized into three types which are; strictly dominates (>), weakly dominates (>=) and indifferent (~). Let two solution vectors be a and b. Then if the solution vector a dominates the vector b in all the objectives then a strictly dominates b (a >b). If the solution vector a dominates the vector b in some of the objectives but not all, then a weakly dominates b (a>=b).

Finally, if the solution vector a does not dominate the vector b and the solution vector b does not Dominate a as well in all the objectives, then a is indifferent to b (a ~ b). Strictly Pareto-compliant can be defined as the following: Let there be two solution sets say; X and Y for a specific MO problem. If the hyper volume coverage for X is greater than Y, then the solution set X >Y or X >=Y. The hyper volume measures the volume of the dominated section of the objective space and can be applied for multi-dimensional scenarios. Implementation of the hyper volume requires a reference point or a 'nadir point'. The nadir point is a



point which is dominated by all the solutions from the approximate Pareto frontier. Relative to this point, the volume of the space of all dominated solutions can be computed. A bi-objective depiction of the hyper volume is given in Figure:

Figure(6): Hyper volume Construction for a Two Objective Maximization Problem.

The larger the value of the hyper volume, the more dominant the solution is in the objective space. The hyper volume is strictly monotonic. Its computational effort is exponential to the amount of solution vectors however requires a bounding vector (nadir point).

Resultanalysis

At first, the successive pursuit calculation finished with just two retrofits put in the structure, bringing about a target work esteem objective function value F = 1.40 and a MISDR = 2.25%. Upon examination, it was clear the calculation had halted at a nearby least. The calculation was changed to enable it to proceed and potentially locate a superior arrangement with resulting retrofit situations. The calculation was permitted to continue to 10 set retrofits (515 function evaluation) and gave the arrangement appeared in bringing about a target work esteem F = 0.747 and a MISDR = 1.42%.Compared to the base structure, this is a noteworthy change as it could bring the structure beneath the existence security executionconfine.

Executing a straightforward calculation like the consecutive inquiry has a disadvantage of additionally having basic ceasing cases. For this situation, the calculation at first ceased after it neglected to locate any prompt change. Extra retrofits did not enhance the target work for various retrofit applications however brought about an enhanced plan with a bigger number of utilizations. The essential consecutive hunt calculation needs enhancements in its capacity to discover arrangements outside of nearby optima.

The advanced arrangement delivered by the GA is appeared in .This arrangement contains 23 retrofitted areas, altogether more than the successive hunt calculation however this additionally required the most extreme number of 900 (30 individuals over 30 generations) work assessments over the span of the GA. This arrangement brought about a target work estimation of 0.56 relating to a MISDR of 0.39%.While the last streamlined arrangement of the GA required the most extreme number of generations, it is likewise intriguing to take note of the rate of change all through the entire improvement technique. the target work estimation of the best answer for every generations. The change profile is like most GA results; there is huge change in early ages taken after by much slower, yet at the same time relentless advance. For this situation there were likewise some expansive changes in two of the latergenerations.

1 Conclusion

The parameters utilized in the target capacity could be enhanced to all the more precisely speak to the execution of the structure. By utilizing a consolidated cost of retrofit application and structure harm, a more precise target capacity can be connected (e.g. Koduru and Haukaas, 2010). The enhanced target capacity would likewise be more appropriate to genuine circumstances as an immediate cost gauge could be utilized for basic leadership.

Thought of the calculation time is likewise imperative for improvement technique choice. As parallel registering accessibility expands, its effect on the reasonable utilization of improvement techniques will increment. Mimicking different tremor records at the same time, as was done in this paper, enormously diminished an opportunity to finish the full improvement calculation. Contingent upon the structure of the advancement and recreation strategy picked, there are numerous levels where parallel figuring ideas could be connected to extraordinarily diminish the general time for count. Because of the distinctions in serial and parallel registering, the determination of the best improvement technique would rely upon the calculation offices accessible. Also, the structure of the issue can affect which advancement technique gives the best or quickest arrangement. Subsequently, more examination concerning diverse advancement calculations isrequired.

Limitation of the Study and Future work

There are several possible avenues to improve the proposed methodology to characterize seismic performance using economic loss metrics or extend these results. These areas can be organized in several categories including, model improvement and validation, treatment of source of uncertainties, and estimation of inventory losses.

Model improvement

Successful implementation of performance-based earthquake engineering requires development of computational model that accurately represents nonlinear characteristics of RC facilities. Several aspects present in this investigation that may provide opportunities for future studies concerning modeling of non-ductile RC frames:

- Model in this study do not account for the contribution of flat-slab system to the lateral resistance of the structure. These gravity frame elements should be incorporated into the analytical model to improve seismic performance assessment, and consequential seismic-induced economic losses. Further research is required to develop mathematical model that incorporates thisfailuremechanism.
- Model could also be advanced by accounting for the contribution of non-structural component on the lateral strength and stiffness of the RC frame; as well as, incorporating performance of non-structural components on limit states of fragilitymodels.

The use of performance-based approach to predict economic losses of non-ductile RC structure may require validation with observed long-term performance of building stock in the region of interest. This validation requires documentation of structural response and financial losses to identify discrepancies between the predicted results and reported documentations based on experience. It is also of interest to examine suitability of the presented methodology to prioritize retrofit selection for other type of structures including steel, composite, and masonry structures, as well as bridge structures.

Treatment of uncertainties

This investigation can be expanded in various ways:

- Characterizing and treating the effect of structural modeling uncertainties shall yield a better seismic performance assessment of the frame structure. Also, examination of different types of structural systems would help to generalize the results.
- Investigation of construction and human error in design may influence the estimated financial losses for a given earthquake, and yield different conclusions concerning the best retrofit measure to manage seismicrisk.
- Accounting for possible deterioration and aging of material properties, variations in maintenance, damages from past earthquakes since the time of construction; as well as, accounting for site conditions may yield more realistic assessment of seismic performance of thestructure.

Economic loss estimation

Possible avenues for future research include the followings:

- Estimation of indirect losses, such downtime losses, illustrated that much higher financial benefits were attained due to mitigation. An interesting extension of loss estimation results is to compare the reduced downtime losses due to mitigation of non-ductile andcode-conformingstructures.
- Building residual drift induced by earthquake may significantly contribute to owner's susceptibility to financial losses. Consideration of residual drift shall reveal more financial benefits associated withseismicrehabilitation.
- Decreasing uncertainties in damage assessment and improve data for loss assessment shall establish better economic loss assessment for a given earthquakeintensity.

- In addition to financial losses, this work can be extended to predict earthquake related fatalities to illustrate effectiveness of seismic strengthening to reduce life threat posed by non-codeconformingstructures.

Need for Archetype data for policy development

This study implemented performance-based paradigm to provide informed decision on seismic safety policy. This provides motivation to establish archetype data concerning the following areas:

- Archetype data can be used to characterize influence of different heights, typical key design and detailing features, and type of irregularities commonly found in non-code conforming structures. This shall generalize the conclusion on seismic retrofits to manageseismic risk.
- Variation of building sites and hazard levels may have significant impact on thecost-benefit assessment.
- Structures with irregular infill walls, irregular plan causing torsional demand, and structures susceptibility for shear failures may need to be incorporated in the cost benefit assessment of seismicrehabilitation.

Concluding Remarks

Results of this study serve the debate on managing seismic risk through implementation of retrofit schemes by providing loss estimate measures that explicitly illustrate effectiveness of mitigation strategies to reduce owner's susceptibility to earthquake induced monetary losses. The provided information may be used to establish well-informed decisions related to identification of vulnerable non-ductile RC structures, assessment of polices and performance targets for intervention methods; as well as, provide transparent incentives for stakeholders to invest in seismic

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