Preliminary seismic evaluation aid for reinforced concrete framed structures based on IS 15988 (2013) guidelines

Discussion by N. Prabhakar and N. Subramanian

Reply by Arshad K. Hashmi

Dear Sir,

This has reference to the paper titled 'Preliminary seismic evaluation aid for reinforced concrete framed structures based on IS 15988 (2013) guidelines' by , published in ICJ September 2015 issue (Vol 89, No. 9, pp. 12-16).

The author is to be congratulated for writing a technical paper on a subject which is very vital today on the topic of preliminary seismic evaluation of reinforced concrete structure built few years ago as per the previous codes. Based on IS 15998:2013, the paper provided design charts and a worked example, which may be useful to understand the provisions of this code. However, the discussers wish to add the following comments:

Comment 1. In Clause 6.6 of IS 15988, it gives conditions for conducting detailed evaluation. These are:

a. Building fails to comply with the requirements of the preliminary evaluation

b. A building is 6 storeys and higher

c. Buildings located on incompetent or liquefiable soils and/or located near (less than 15 km) active faults and/or with inadequate foundation details, and

d. Buildings with inadequate connections between primary structural members, such as poorly designed and/or constructed joints of pre-cast elements.

In other words, the above clause restricts preliminary evaluation to buildings up to 5 storeys high, buildings are not over soft soil, and the buildings are deemed to have good joint connections and details. Moreover, there are several notes under clause 5.4, which cautions the following: (1) Buildings designed as per the old version of IS 1893 will be found deficient to some extent; unless over designed and those not designed for earthquake forces will generally need retrofitting. (2) Buildings on stilts (soft first storey) and those using 230 mm or thinner columns will need retrofitting, even though they might have been designed by IS 1893 (part 1):2002. Clause 6.4 of IS 15988:2013 also suggests a number of configuration-related checks, such as load path, redundancy, geometry,

weak Storey, soft Storey, vertical Discontinuities, mass differences in storeys, torsional effects, gap between adjacent buildings, and effect of short columns. That is the considered building should not have any horizontal or vertical irregularity. Only when all these are satisfied, the building has to be checked for evaluation; whether retrofitting has to be done or not. As the paper is discussing the preliminary evaluation, it must have mentioned the above limitations in the usage of the paper. Otherwise, the contents of the paper could be misused for buildings beyond these limitations.

Comment 2. In the preliminary evaluation, the grade of concrete actually used in construction has a lot of bearing on the strength calculations. In the majority of preliminary evaluation of buildings, this information is not at all available from the owners/contractors/consultants, either through drawings, design calculations, or site records, mainly because of the large period gap between the construction and when the evaluation is done. The only option left at the time of preliminary evaluation is to conduct NDT tests by taking concrete core samples and testing it in a laboratory. For this situation, IS 15988 has given a Knowledge Factor, K in Table 1 (whose value ranges from 0.5-1.0), and a value of 0.7 as for item (v) of the Table is recommended for unavailable strength data. Hence, in the preliminary evaluation, the concrete grade obtained by core tests has to be multiplied by factor K.

Comment 3. For the worked example given in the paper, a design data is given in Table 1, where the grade of concrete is given as M20, presumably based on concrete core tests. Hence, the modified concrete grade to be considered for evaluation is 20 x K factor 0.7 = 14 N/mm^2. The permissible shear stress in concrete = 0.1 $\sqrt{(14)}$ = 0.374 N/mm^2, whereas the paper considers it as 0.4 N/ mm^2, which is lesser of 0.1 $\sqrt{(20)}$ = 0.447 N/ mm^2 (without considering the K factor) and 0.4 N/ mm^2 (clause 6.5.1 of IS 15988). The actual shear stress, as worked out by eqn. (2) of the paper = [291000 x 10^3 x 0.06/51.84 x 10^6] x 81/(81-9) = 0.3789 N/ mm^2, which is marginally greater than the permissible value of 0.374 N/ mm^2. Hence, the columns need retrofitting although the paper by its calculations says they are safe. These varying results cast doubt about the accuracy of the preliminary evaluation to rely upon fully.

Comment 4. The code recognizes the fact that the preliminary evaluation, although a quick procedure, is a very approximate procedure based on conservative parameters and on observed damage characteristics in previous earthquakes. In our opinion, for more realistic evaluation, this simple procedure has to be coupled with visual observations of the structure, particularly at column-beam joints, to identify the potential earthquake risk of a building.

Comment 5. It is interesting to note that in the recent 8.3 magnitude Chile earthquake/tsunami of 19th September 2015 (which generated 4.5 m tall waves damaging about 610 homes) claimed only 11 lives, even though it made 1 million people to flee their homes. Even in the severe 8.8-magnitude earthquake/tsunami (generating 15 m tall waves), which rocked southern Chile in 2010, only 500 people died and the property damage was about $30 billion. It is because the buildings were designed based on stringent codes and strict supervision. But in India though the provisions in IS 1893 and IS 13920 are adequate, numerous buildings are designed without following these codes strictly and constructed without any strict supervision. Moreover, seismic detailing is as important as seismic design. In many instances, we have found that closed ties have not been provided in plastic hinging zones in columns and also at beam-column joints; in addition, the 135^o hooks are also not properly made. Moreover, concrete quality control and curing is considered only in a few percentages of prestigious projects. This lack of adherence to codal provisions and construction detailing will surely result in heavy damages to many buildings as happened in the Bhuj earthquake of 26th January 2001. Hence, the authors feel that seismic retrofitting has to be strictly made on almost all buildings in areas of severe seismic zones.

regards,

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THE AUTHOR REPLIES

Dear Sir,

The author would like to show appreciation to the readers for having gone through the paper thoroughly and offering critical comments and concerns about the paper. Indeed, such comments and concerns will be extremely useful for everyone in understanding this topic of research. My replies are given below in sequence of their comments.

Reply to Comment 1:
The configuration related checks (i.e. load path, geometry, weak/ soft storey, mass irregularity, torsion adjacent buildings, short columns) should be done by visual inspection prior to strength related checks (i.e. determination of modified lateral force demand, shear stress and axial stress check for columns) [1]. The paper presented by the author has scope limited to strength related checks only and applies only after configuration related checks are satisfied. The author fully agrees with the concern of the readers that the scope of the paper should have incorporated the point.

Reply to Comment 2:
In the paper, the Knowledge Factor (K) is assumed as 1 [1, 2]. Similar aid can be provided for the different Knowledge Factor (i.e. from 0.5 to 1.0) as well.

Reply to Comment 3:
As the Knowledge Factor is assumed as 1, the illustrated example is self justified.

Reply to Comment 4:
The readers have raised the opinion of more realistic seismic evaluation procedure which couples present simple procedure and visual observation of the structures particularly at column beam joints. Presently IS 15988, couples the visual observation procedures such as 'Site Visit and Collection of Data' and 'Configuration Related Checks' with the 'Strength Related Checks' [1]. The author agrees with the readers' concern about the inclusion of the visual inspection of the beam column joint before strength related checks. Further, the scope of the paper was to provide aid to the established code in strength related checks only [1].

Reply to Comment 5:
The readers have a view that in India, since codes are not followed strictly from design to construction levels, vulnerability of buildings is huge in this scenario. Hence the readers feel that seismic retrofitting has to be done on almost all buildings in areas of severe seismic zones. The author agrees with the readers on this issue and believes that the relevant competent authority can throw light on this issue with proper justification. Again, as mentioned in a previous reply, the scope of the paper was to provide aid to the established code in strength related checks only [1].

The author once again thanks the readers for their interest in the area of seismic evaluation and valuable comments and concerns on the paper.

regards

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References

1. _____*Seismic evaluation and strengthening of existing reinforced concrete building- guidelines,* IS 15988 2013, Bureau of Indian Standards, New Delhi.

2. Durgesh C. Rai "*Seismic Evaluation and Strengthening of Existing Buildings*" IITK-GSDMA-EQ06-V4.0, Draft Final Report-A Earthquake Codes, IITK-GSDMA, Project on Building Codes, 2005, Kanpur