Seismic Coefficient Method and Response Spectra Method

Krishnamurthy Pandurangan [Sunday, January 27, 2002 12:08 AM]
Arzhang Alimoradi [Sunday, January 27, 2002 2:00 AM]
Girish Dhanwani [Sunday, January 27, 2002 10:30 AM]
R. V. S. Choudary [Sunday, January 27, 2002 5:58 PM]
Sudhir K. Jain [Sunday, January 27, 2002 6:35 PM]
M. Hariharan [Sunday, January 27, 2002 9:56 PM]
Arzhang Alimoradi [Monday, January 28, 2002 12:58 AM]
Moderators [Monday, January 28, 2002 1:12 AM]
Jitendra K. Bothara [Monday, January 28, 2002 8:42 AM]
Jaswant N. Arlekar [Monday, January 28, 2002 12:24 PM]
M. Hariharan [Monday, January 28, 2002 9:48 PM]
Ramesh P. Singh [Tuesday, January 29, 2002 11:52 PM]
Pawan R. Gupta [Wednesday, January 30, 2002 1:44 AM]
Subhamoy Kar [Thursday, January 31, 2002 10:57 AM]
Rajiv Sharma [Thursday, January 31, 2002 6:43 PM]
Jaswant N. Arlekar [Thursday, January 31, 2002 11:23 PM]
Jaswant N. Arlekar [Friday, February 01, 2002 4:57 PM]
Stewart Gallocher [Tuesday, February 05, 2002 9:05 PM]

Krishnamurthy Pandurangan [Sunday, January 27, 2002 12:08 AM]

dear sir,
thanks for launching such a nice conference. my querry is that which method is best suited for designing structures is it the seismic coefficient method or the response spectrum analysis?

k.pandurangan

Arzhang Alimoradi [Sunday, January 27, 2002 2:00 AM]

Dear k.pandurangan;
Ref. to your question; you can find plenty of useful information in the following textbooks (very new editions):


Best wishes in your studies.
Arzhang Alimoradi

Girish Dhanwani [Sunday, January 27, 2002 10:30 AM]

Dear Sirs/Madam,

Some more queries.

1) In IS:1893, two methods, one Seismic Coefficient and other Response Spectrum method is described to carry out the analysis for Earthquake forces. One Table (in Clause 4.2.1) is also provided to decide upon the method to be used, depending upon Building Ht. and Zone. At the bottom of this table, it is clearly mentioned that building with irregular shape and/or irregular distribution of mass and stiffness in horizontal and/or vertical plane, shall be analysed as per Response Spectrum Method. For all practical reasons, no building is uniform in all the respects (i.e. shape, mass/stiffness distribution in horizontal and vertical plane). Does this mean, that for no building, the Seismic Co-efficient method shall be resorted to? And if, Seismic Coefficient method shall be used, then till what extent, this irregularity can be ignored?

2) Response Spectrum method, being time consuming and tedious process, most of time, we resort to computer applications. Now while, modeling the structure, in most of available softwares, usually, we model the space frame, neglecting the in-fill wall stiffness. This results in flexible frames, and due to which, in most of cases, the program gives a higher Time Period (as compare the the eqn. 0.1n), and results into lower base shear. What in your opinion shall be done? Does the scaling of base-shear values, as per Seismic Coefficient method will be the right solution?

Thanking you,

Girish Dhanwani
R.V.S. Choudary [Sunday, January 27, 2002 5:58 PM]

Dear Sri k.pandurangan,

The response spectrum analysis method is best suited for designing structures.
R V S Choudary

Sudhir K. Jain [Sunday, January 27, 2002 6:35 PM]

This is in response to the issue raised by Mr. Girish Dhanwani:
The current code IS:1893-1984 does not specify definition of irregular buildings. However, the draft code (under revision/print) provides more specific information on when a building is to be treated as an irregular building. I agree with Mr. Dhanwani that if stiffness contribution of brick infills is ignored, it may lead to under-estimation of design seismic force. Hence, it may be appropriate to scale up the seismic forces to obtain the same base shear as in case of seismic coefficient method. Again, the new draft code has a similar provision.

Sudhir K Jain

M. Hariharan [Sunday, January 27, 2002 9:56 PM]

Girish,
Today, with the availability of Powerful Computers and Software, the seismic coefficient method should not be applied to anything other than mass concrete!! In such a case a reduction coefficient would not be applicable. The infill walls and slabs should be modelled. If your software has plate modelling capability, these can be modelled as plates. Otherwise an "equivalent " pair of diagonal members connecting the four corners of the slab or wall (in each bay) would simulate the shear behaviour. The diagonal members shall be 'truss' members - i.e. capable of only carrying axial load. The elastic properties can be derived from first principle, by matching forces and deformations in a plate and the equivalent diagonals.
M. Hariharan

Arzhang Alimoradi [Monday, January 28, 2002 12:58 AM]

Dear Girish;
In response to the second part of your discussion (response spectrum method, the effects of in-fill walls) your observation is correct. One way to take into account the effects of in-fill walls/partitions in your model is to substitute them
by an equivalent bracing which produces the same stiffness as the walls. The way how to calculate the bracing members' configuration is mentioned in the book by Professors Paulay and Priestley: "Seismic Design of Reinforced Concrete and Masonry Buildings", Wiley Interscience. Or you may want to isolate your infills from the frame by a gap, which is being filled later on by some elastomeric material. In that case, proper detailing should be considered in order to keep the wall from falling in/out/ buckling using simple techniques.

Regards;
Arzhang Alimoradi

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**Moderators [Monday, January 28, 2002 1:12 AM]**

Dear Colleagues,

We thought we'd summarise the key technical queries that have been discussed in the past couple of days.

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4.0 Seismic Coefficient or Response Spectrum Method There were some interesting queries about the suitability of use of these methods for calculating the base shear. When stiffness of infill panel walls is not taken into account, the natural periods calculated come out to be unrealistically high resulting in low base shears in the Response Spectrum method. It was pointed out that there were some lacunae in the current code which have been attempted to be fixed in the revised 1893 code. The proposed revisions may be discussed if there is a popular vote for it.

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Regards,

Alpa Sheth and Durgesh Rai

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**Jitendra K. Bothara [Monday, January 28, 2002 8:42 AM]**

M. Hariharan,

My concern regarding use of powerful computers and softwares is: how many of the engineers now in this industry are able to work with those tools. When we think of building code, it is not only metropolitans or big cities, we should also think of small cities and others (lets learn from experience of Turkey, where they made very complicated codes but there are very few people to understand and use it). Lets be honest, many of the engineers in filed now, even have not basic idea of earthquake resistant design and they consider it as just extrapolation of vertical load design. Understanding building behavior is more important than method.
and many of us lagging here. Please, do not make process too complicated. It will make a mess.

Jitendra K Bothara

Jaswant N. Arlekar [Monday, January 28, 2002 12:24 PM]

It is indeed true that the natural periods will be overestimated if infill wall are not incorporated in the analytical model. Ambient vibration (AV) testing of buildings in Kanpur showed that the ratio of actual fundamental natural period to the analytical natural period ranges from 0.3 to 0.4 [ref. The Indian Concrete Journal Vol 74, No. 10, Oct 2000. pp 581-586]. For the buildings tested at Kanpur, it was seen that the codal expression, \( T = \frac{0.09H}{(D^{0.5})} \) fits very well for fundamental natural period. However, the scatter in data around this expression is large. During this study, a number of other expressions were also tested for suitability, and it was observed that there are expressions that better represent the data. These expressions are presented in the ICJ paper referred above. The buildings tested during this AV survey (3 years ago) were RC frames with brick infill walls. Further, these buildings were all located in Kanpur (zone III), and were government buildings. This was a very small data set; 19 government buildings located in zone III. Thus, it may not be wise to generalized the findings of this study and say that the expressions for the fundamental natural periods can be adopted for all buildings, all over the country! Perhaps this is the reason why we have not been very aggressive about the expressions for natural periods for buildings. AV testing of buildings is a very efficient and straightforward technique to assess the vibration properties of structures; it does not need too much skill to operate the equipment, and it takes about a day or two to test a 10 storey building. The only problem, perhaps, is that the initial cost of the vibration testing equipment is very high. The other method is to instrument the buildings and wait for an earthquake. However, instrumenting buildings can be very costly, and the maintenance of the instruments could be very taxing. In my opinion, we need to go in for both the above methods to generate a database for fundamental natural period of buildings in different regions, and with different backgrounds of design and construction. Once we have a large enough database, we can tune the empirical expression for fundamental natural period to match the variation across the country.

Jaswant N. Arlekar

M. Hariharan [Monday, January 28, 2002 9:48 PM]

JKB,
I should have elaborated my response a bit. I do believe in simple hand computations for understanding the behaviour and preliminary design before rushing to computers. As others have also written, ALL structures need not receive the same attention from design point of view. Simple structures certainly do not require sophisticated structural analysis, and simple design and attention to detail should be adequate. The critical structures (consequence based!) should receive greater attention from an analysis point of view.

M. Hariharan

Ramesh P. Singh [Tuesday, January 29, 2002 11:52 PM]

In response to Jaswant N. Arlekar’s message:
The other method is to instrument the buildings and wait for an earthquake. However, instrumenting buildings can be very costly, and the maintenance of the instruments could be very taxing. This is not a practical and scientific approach to wait for Earthquake to occur. Your second approach looks to be reasonable. To make it more scientific, one should try to collect data from similar design buildings in different regions of the country. One may find buildings of similar design (e.g. power corporation buildings, telecom or railway buildings), it may be difficult to get multi-storey buildings. Other approach for the future, may be to have similar kind of buildings in different regions which should be used for such measurements.

Ramesh P. Singh

Pawan R. Gupta [Wednesday, January 30, 2002 1:44 AM]

Typically in the North American Conditions for concrete structures it is usually more economical to build multi-storey structures with shear walls and flat slabs instead of moment frames. The problem that we usually face is correctly calculating the period of the structure. The code gives an empirical formulation that is based on the shear walls being very regular over the full height of the structure. In most structures that I have designed the shear walls are rarely regular over their height. In this regard it becomes really difficult to accurately estimate the time period of the structure. I would like to hear experiences from others on the matter.

In summary, I quite agree with Dr. Singh's opinion that we need to build a substantial database so that a more rational formulation for determining the time period of structures can be derived.

Pawan R. Gupta
Hello...
This is in response to Dr. Gupta's E-mail...

Regarding analysis of flat slab and shear wall combination, a comprehensive treatise is given in Chapter 15 of the following book- STRUCTURAL ANALYSIS - A UNIFIED CLASSICAL & MATRIX APPROACH By A. Ghali & A.M. Neville Published by E & FN SPON, An imprint of Thomson professional, 2-6 Boundary Row, London SE1 8HN, UK.

This book has dealt with analytical modeling approach and the structural idealization of the aforesaid system. The shear wall is modeled as flexural member fixed at base and flat slab and columns are replaced by their substitute frame. Then these two structural entities are connected by rigid links (which represents the diaphragm action of the floor slab) at each floor level. The collective equivalent stiffness of all the columns and all the shear walls in the building may be calculated by standard procedure. Also, the variation of shear wall / column stiffness with height can be computed based on the actual section sizes. Once this analytical model is conceptualized, rest part of the calculation can be performed by any standard software for structural analysis (viz. STAAD III or SAP 2000). Results of analysis will yield time period of the system as well as relative sharing of lateral force by the shear wall and the substitute frame (columns). These results will be much more accurate than those obtained by empirical formulae.

Thanks and regards.

SUBHAMOY KAR

Hello Friends:

In last few days we have seen many views on static vs dynamic analysis. It is true that a bare frame analysis gives a very high time period and thus low seismic forces. It has also been proved by experimental investigation that buildings with brick in-fills have a much lower period, which is attributed to the higher stiffness of the building due to the presence of brick infills. When brick infills affect the time period, the quantum of in fills in a storey is also important. It is possible that the area of brick in-fills in the two principal directions of a building is different and thus their contribution to overall stiffness in the two directions will also be different. It will be interesting to know how the time
period varies with different amount of brick in fills in the two directions. We have noticed that in many school buildings there are fewer brick in-fills in longitudinal direction and much higher presence of in-fills in the transverse direction. For such a building the draft code formula may give unusually low value of time period in the longitudinal direction but in reality the fundamental period may not be so low. So do we require more than one equation for evaluation of time period depending on the brick in-fill area present in a direction?

Regards

Rajiv Sharma

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**Jaswant N. Arlekar [Thursday, January 31, 2002 11:23 PM]**

Continuing on the issue of SCM or RSM, I would like to add a little bit on the distribution of forces along the height of the building. IS1893 suggests a parabolic distribution. However, experimental testing show that the mode shapes of buildings varies depending on their height; buildings upto about 6 storeys have a very large mode shape coefficient in the ground storey (shear type behavior). As the height increases, the mode shape is closer to the one suggested by IS1893, i.e., parabolic (flexure type behavior). If the forces are distributed according to IS1893, for shear type building, the members in the loower storeys may be underdesigned. This is perhaps another reason for the poor performance of the open ground storey buildings; the design force distribution is not consistent with the actual distribution during shaking. Scaling of base shear to match with that calculated from seismic coefficient method ensures that the base shear is not unreasonable. But, the use of parabolic distribution of this "corrected" shear may not be always correct. For example, using a bare frame model with scaled base shear, when the actual building has infills, can lead to gross errors in the member design forces. I wonder if it is too late to add a height and period based vertical distribution of forces in IS1893.

Jaswant N. Arlekar

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**Jaswant N. Arlekar [Friday, February 01, 2002 4:57 PM]**

See inline comments..

On Thu, 31 Jan 2002, Rajiv Sharma wrote:
>It will be interesting to know how the time period varies with different amount of brick in fills in the two directions.

+++ We carried out a similar kind of study on buildings in Kanpur. The findings of this study state that the expression which includes the area of infill walls represents the fundamental natural period the best [R-square value is 0.9. Compare this with R-square of 0.42 for 0.09H/(D^0.5)].

>So do we require more than one equation for evaluation of time period depending on the brick in-fill area present in a direction? +++ I agree that we need a better expression. The expression obtained for the limited set of buildings (19 buildings) tested caters for both the directions; area of walls is a parameter in this expression.

Jaswant N. Arlekar

Stewart Gallocher [Tuesday, February 05, 2002 9:05 PM]

Dear Dipal,

Since you are using a Response Spectrum Method the fundamental mode(s) will probably have steel and concrete members associated with the deformation. Therefore you will probably need to look at using 'Composite Modal Damping' (Try a standard text for information) This method allows the damping level to be adjusted for the fundamental modes to be somewhere in between the steel and concrete values - depending on the mode shape. You will also need the damping matrix. Once you calculated the damping value for each mode you will need to create a input spectra with a damping level that varies across the entire frequency range with different levels of damping at each modal frequency. You will also need to know how to generate intermediate values between the steel and concrete Spectra. Seems like a lot of effort.

I'm not sure which packages directly implement this procedure - it may only be packages such as ANSYS and ABACUS.

Hope this assists.

Regards

Stewart Gallocher