Meeting 3 of the BSSC PUC Issue Team on Shear Walls
Web Meeting
April 3, 2017
Draft Minutes

1. Call to order

Chairman Ghosh called the web meeting to order at 2:05 PM Eastern Time

2. Roll Call


3. Opening remarks

Ghosh thanked all callers for attending and noted that this is the first conference call meeting of the committee, following two face-to-face meetings in Seattle last year.


Ghosh provided copies of the notes from the last meeting as an attachment to the agenda for this meeting. He noted that in these minutes there were a number of action items for committee members to complete. These included supplying certain documents to the committee, and providing written summaries of topics discussed at previous meetings. Ghosh said that these written summaries do not need to be elaborate, but that they are important to the work of the committee, as the summaries may serve as the starting point for more detailed committee documents.

Ghosh asked all participants to please review the minutes of the last meeting and to provide the items indicated.

Lehman reminded committee members that a Google Drive site has been set up by Laura Lowes. The committee can use this site to post and exchange documents, such as the committee assignments from the last meeting, or relevant papers and references. Berman said that he would re-send the link for the Google Drive to committee members. [This was done by Laura Lowes later on the day of the meeting.]

5. Classification of reinforced concrete shear walls

Ghosh noted that there are several ways that walls may be classified:
   Ordinary vs. Special walls
   Shear-controlled vs. Flexure-controlled walls
   Ductile vs. Non-Ductile walls
The Canadian definition of a ductile shear wall is one for which the height/length ratio is greater than or equal to two, and for which the ductility R factor, \( R_D \), is greater than or equal to 3.

ACI 318 distinguishes shear walls as being Ordinary or Special. There are two methods of design:
1) “traditional” design for \( h_w/l_w < 2 \)
2) “displacement-based design” for \( h_w/l_w \geq 2 \)

Lehman said that traditionally in research the height used is the effective height.

Ghosh asked if Lehman would prefer an alternative definition of wall height.

Lehman suggested that walls could be distinguished by “Walls that respond primarily in flexure” and “Walls that do not respond primarily in flexure.”

Ghosh posed the question “Can a wall that is governed by shear be ductile?”

Lehman suggested that Andrew Whittaker has looked at this issue and has a data base of squat walls (walls with low height/length ratio).

Ghosh asked if Lehman would send him her definition of effective height. Lehman said this definition is

\[
\text{Effective Wall Height} = \frac{\text{Moment at the base}}{\text{Coincident shear at the base}}
\]

or
\[
h_{\text{eff}} = \frac{M_{\text{base}}}{V_{\text{base}}}
\]

Lehman suggested that ACI 318 should adopt this definition of wall height.

Ghosh said that walls might be classified as “ductile walls” and “walls with moderate ductility”. What is the definition of a “ductile wall”?

Wallace said that “Shear at nominal moment strength relative to some predicted shear strength” would be a useful measure of wall shear behavior.

Lehman summarized the behavior of flexure- vs. shear-dominated walls.

Ghosh again posed the question “Can you get ductility out of a shear-dominated wall?”

Wallace said that he has looked into this question for ACI 318 Subcommittee E (“Section and Member Strength”). He looked at a data base of about 400 walls. He believes that a different design approach is needed for shear-controlled walls. The first question is “What is the definition of a shear-controlled wall?” The aspect ratio alone may not be the best approach, without also considering how heavily the wall is reinforced vertically. But, given the complexity of alternative definitions, aspect ratio may still be the preferred approach.

6. Update on coupled reinforced concrete shear walls
Ghosh began the discussion by summarizing the work to date on defining a coupled shear wall. Fields et al. at MKA have carried out a study, which has been presented at ACI 318 Subcommittee H meetings. After considerable research, it was determined that a simple definition of a coupled shear wall that dissipates energy primarily in the coupling beams is that the width/depth ratio, or “aspect ratio”, of the coupling beams should be 3 or larger.

In Sub-H balloting, Loring Wyllie questioned “Is not a link beam with a 1:1 aspect ratio still a coupling beam?” He noted that the first research on coupling beams by Paulay focused on coupling beams with aspect ratios around 1:1.

Sub-H discussed this comment at the last meeting in Detroit, and came up with the following proposed distinction: a class of coupled walls should be created that is distinguished as “ductile” coupled walls (it is not clear yet if “ductile” is the right term). Such walls would dissipate earthquake energy primarily through yielding of the coupling beams (and not through yielding at the bases of the coupled walls). Based on the research by Fields et al., this class of walls would have coupling beams with aspect ratios of 3 or larger. A second requirement for this class of wall would be that the coupling beams would need to be properly detailed to behave in a ductile manner.

Other comments in the Sub-H discussion included the suggestion that the committee explore the link between energy dissipation and the “degree of coupling” (which is used in the Canadian code), i.e. the tension-compression couple of the two walls divided by the total overturning moment acting on the two walls.

It was concluded in Sub-H discussions that the proposed definition is a step in the right direction, but that some additional work needs to be done to arrive at a final definition.

7. P-695 study justifying a proper R-value for a coupled wall system

Ghosh said that there will be a BSSC Provisions Update Committee (PUC) meeting on April 12-13 and that he will attend. He would like to report on the work of IT4, and in particular he would like to discuss the recommendations of IT4 regarding a FEMA P-695 study of concrete coupled shear wall seismic force-resisting systems.

Assuming that the ACI 318 Sub-H definition of coupled shear walls is settled, is it necessary to perform a FEMA P-695 study to justify an R-value for ductile coupled walls?

At the last IT4 meeting Lehman, Lowes, Berman, and Wallace were assigned the task of discussing this issue and proposing a recommendation. At the last meeting it was also noted that a full P-695 study would cost on the order of $200K. Ghosh asked if a study of limited scope, that is, less extensive than a full P-695 study, would be possible and how much less expensive would such a study be?

Wallace said that to get higher than an R value of 5, some sort of additional study is needed, but perhaps not a full P-695 study.
Lehman expressed the concern that we have not seen actual collapse of coupled shear walls. To get a higher $R$ value, one would need to show that the probability of collapse of coupled shear walls is the same as the probability of collapse of another system with a high $R$-value. Yet, there is little data on collapse of coupled shear walls to support such a comparison.

Wallace said that he has been working on OpenSees models that would allow exploration of collapse potential of coupled walls.

Lehman and Berman said they could look at the collapse potential of Buckling Restrained Braced Frames (BRBFs), a system that has a high $R$-value ($R = 8$).

Ghosh asked about the cost of an analytical study to determine collapse potential of coupled shear walls. Wallace said that would depend in part on the number of gravity load supporting systems considered in the study.

Berman said that we would need to be assured that the scope of such a study is well defined, and that the scope is acceptable to the ASCE 7 committee.

Ghosh noted that the next ASCE 7 development cycle has not quite started.

Cobeen said that in the P-695 process, an important factor is the designation of the peer review panel. The panel would play a major roll in determining the scope of the study.

Ghosh wondered if it would be a good idea to ask the PUC to form a P-695 peer review panel now.

Cobeen suggested that IT4 should ask the PUC to determine how much of a roll the PUC would play in determining the peer review panel.

Ghosh asked Lehman, Berman and Wallace to prepare a brief write up, less than one page, on the definition of the process for a limited P-695 study of coupled shear walls.

Fahnestock asked if a full P-695 study is required. Would not a limited number of analyses serve the purpose?

Lehman noted that not all the $R$-factors of systems currently listed in ASCE 7-10 have been verified through P-695 studies.

Cobeen said that systems she knows of that have been studied using P-695 are wood light frames, concrete moment frames, some masonry systems, and some steel systems. Perhaps a total of 6 to 8 systems have received P-695 studies. The P-695 process is based on analyses with an assumed $R$-factor. It is important from the beginning to make sure that the assumed $R$-factor is not too optimistic.
Cobeen suggested perhaps considering a FEMA P-795 approach, which would involve benchmarking, using backbone curves, against other systems. She thought that there may be resistance to the FEMA P-795 approach by the PUC.

Lehman said that in her experience, when she has performed P-695 analyses that the $R$-factor turns out to be height-dependent. She has not seen any P-695 studies on BRBFs, but she has run P-695 studies on a number of other systems. In those studies she found that the $R$-factor tended to depend on building height.

Berman noted that there will be tangential findings from P-695 studies that may influence the overall evaluation of a lateral force-resisting system.

Cobeen added that this is why the composition of the peer review group is very important.

Ghosh asked Fahnestock about his reservations on conducting a comparative P-695 study for buckling-restrained braced frames (Dawn Lehman’s suggestion). Fahnestock said that he did not have reservations per se, but he is wondering if previous studies could be utilized. He sent a link to committee members for a NIST document on P-695 studies (NIST GCR 10-917-8).

Ghosh asked Berman, Lehman and Wallace to create a short write up in the next 7 to 10 days on the basic approach that they would want to follow in a P-695 study.

Wallace suggested that they could follow the path of a limited P-695 study, similar to a study that was conducted at NIST on cantilever shear walls.

8. Identification of problems in the shear design of shear walls

Ghosh stated that it is now well known that the design shear required by code for tall, core shear wall buildings is much lower than the actual shear. Rutenburg’s paper (distributed after the last IT4 meeting) examined many proposals that capture the dynamic amplification of shear. Rutenburg identified one or two of the best methods.

Wallace noted that in ACI 318 Sub-H, he has proposed ballot item CH-009 on this topic, which received many negative votes in the subcommittee balloting. Ghosh asked Wallace if we need a new or modified proposal in Sub-H. Wallace said that proposal CH-009 was exploratory in nature. He has a student running analyses now to study overstrength factors. This study is mainly focused on cantilever walls, but perhaps the study can be extended to coupled walls.

Ghosh also raised the issue that at the base of coupled shear walls, most or all of the shear tends to be resisted by the compression pier.

9. Masonry shear walls recap
There was no discussion of this item.

10. Steel shear walls recap by Jeff Berman/Larry Fahnestock

Berman said that he, Fahnestock, Michel Bruneau, and Amit Varma prepared an AISC proposal on coupled steel plate shear walls and coupled steel and concrete composite walls. This involved a P-695 study. Some of this work was supported by the Pankow Foundation.

Ghosh noted that on Page 10 of the previous IT4 meeting notes three needed resource documents are mentioned that are related to steel plate shear walls. These are shown below.

1. A resource document that would be a basic comparison of concrete and steel plate shear walls.
2. A resource document that would be a basic comparison of coupled systems of concrete and steel.
3. A white paper on rocking systems in general, including timber shear walls.

Ghosh asked that Berman work on the first document in this series. The emphasis would be on basic information and a description of the systems, as well as areas of application of the systems. The document should be written for a practitioner who is not familiar with the systems. An example of relevant information would be distinguishing how the mechanisms for yielding are different between the two systems.

11. Wood shear walls recap by Kelly Cobeen

Cobeen said that she needs to work further on this topic. She is working with Phil Line at the American Wood Council.

12. Other research or design problems known to attendees

Ghosh asked that all participants write down the thoughts they have been expressing during today’s meeting. This written record could create starting points for future documents produced by the committee.

In particular, Ghosh would like to see more written about the basis of the coupling wall study by Fields et al. This needs to be put in the form of a report so that others may understand the details of the study.

13. Assignments

Regarding the P-695 study description for coupled concrete shear walls, Wallace will create a draft, which will then be reviewed by Lehman, Lowes, and Berman. Ghosh will take this outline to the PUC meeting on April 13.
Regarding written summaries of types of coupling beams (e.g. reinforced concrete, fiber reinforced concrete, steel coupling beams, etc.), assignments were made during the last meeting. Ghosh will summarize these assignments and send them out to committee members.

14. Next meeting

Tentative time frames for next meetings:

Week of May 15 web meeting
Week of June 26 web meeting
Week of August 14 in-person meeting (subsequently Ghosh proposed August 15-16 in Seattle)

Ghosh will send out Doodle polls about all of these meetings. [Meeting dates have since been selected.]

15. Adjourn

Ghosh adjourned the meeting at 4:00 PM Eastern Time.