e-conference on Indian Seismic Codes
(January 26 - February 8, 2002)
hosted by
National Information Centre of Earthquake Engineering
Indian Institute of Technology Kanpur

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Brick Infill in RC Frames

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Kamal Nazri [Saturday, January 26, 2002]
Dear Friends -
It is very difficult to under stand the behavior of infill wall - for our frame structure - Equivalent strut approach is one of the solution but with offthe plane behavior of wall when it is subjected to lateral load -pl clarify the matters
kamal

Ramesh [Monday, January 28, 2002 5:23 PM]
Dear sirs,
What will be the effect of masonry infill for three-four story building if small lintel and sill bands are provided connected to columns is it good or bad?
Ramesh

Kamal Nazri [Monday, January 28, 2002]
Dear Friends -
In My opinion if the lintels are through i.e. connected with the adj. columns then it may act effectively - but besides this off the plane displacement of masonary play its roll - not only that we are not ensuring proper joint connection with adj beams - columns - so its behavior is yet questionable secondly its position of flushing with the beams -
kamal

Kamal Nazri [Monday, January 28, 2002]
dear friend-
actually equivalent strut approach is the best one while framing and modeling the structure if you want to consider the effect of infill walls - in the recent earthquake the wall in the stilt floors act very nicely in A'bad
kamal

Anil Belani [Monday, January 28, 2002 7:54 PM]
Dear Rai Sir/Madam,
About infill walls:
Lot of options for infill wall modelling are available, crossed-diagonal strut, two-diagonal strut which take contact length into effect and so on .But due to simplicity in analytical modelling, single diagonal strut is the most common. Now in single diagonal strut modelling, lot of formulas are available : Starting from Polyakov, Holmes, Smith, Paulay & Priestly, Mainstone, Liaw & Kwan and a host of others. FEMA-356 gives a help-line but since the basis of all the formulas are different which is suitable to Indian infill wall masonry?

My Query:

1. The stiffness contribution of all these methods is coming different. and lead to quite a different time-periods. So which one to incorporate? I tried above methods and of FEMA-356 on one of the buildings damaged in Ahmedabad (Shikhar) and the results are coming quite different from each other. So can i have an expert opinion on this? And why is Indian Code silent about it?

2. Also most of the formulas take contribution for infill between the columns? But what

about the infill that abut on one side to column and on other side to another infill or infill abutting onto another infill on both sides? How to model them and their contribution into them. my own perception is there that ignoring them can give a larger time-period but i don't know how to model them ? Also taking nodes at those points on beams below them do not help as the models become distorted and behave in an unexpected manner ? So can i have views on that ? Also at end of Cl. 7.8.1 there is mention of clause 7.8.4.6 depicting the case for analytical modelling, but since i could not find that cl. can i get that clause please. 3. Except FEMA-356, can i get the provisions of the other codes for infill-wall analytical modelling. With special reference to jitendra bothara, what does nz code say about it?

ANIL BELANI

Subhamoy Kar [Monday, January 28, 2002 7:30 PM]
Hi friends...

My understanding of the behaviour of in-filled masonry panels in three-four storeyed RCC buildings are as follows:

1) Along the plane of masonry- The action of masonry contained between the two columns gives rise to an action similar to that of a shear wall against lateral loading. As the masonary in also contained between the beams of lower and upper floor (the beams carrying the vertical dead and live loads), the masonry is in somewhat compressed state. Hence, the mortar is expected to have good shear strength. Thus, the collective behaviour of RCC frame and the masonary will be like a tall rectangular section flanged / bulbed at the two ends (i.e. the RCC columns are the flanges and the masonary forms the web. In a nutshell the infilled masonry panel are supposed to increase the strength of RCC frame under in-plane loading. However, it will also increase the seismic loading on structure due to its increased stiffness. So, the effect of masonry is to be accounted while working out the time period and the consequent seismic response of the frame.

2) Out-of-plane behaviour- Once the base shear is known, the intensity of lateral loading on masonry (at any higher level) in case of earthquake may be determined on the basis of distribution suggested in IS:1893. This can be derived on the basis of proportion i.e. fraction of mass of masonry with respect to the total mass at any level. The same loading may be considered distributed on the whole area of masonry (i.e. it will uniform surface load in lateral direction). The magnitude of this loading will differ at each level. Higher the floor level, greater will be the load intensity. The strength of masonry panel is then checked against this UDL. It may be noted that masonry panels are not expected to have any effect on the strength of RCC frame, when they are subjected to normal (Out-of-plane) loading. So, only stability of the masonry is to be evaluated in normal direction. Typically, when the masonry panels are too big, they can be stabilized by providing continuous lintels / wall beams (i.e. column to column) and vertical mullions. They strengthens the masonry by reducing the span in both horizontal and vertical direction.

3) Regarding bond between the RCC frame and masonry- It may worthwhile to mention that under any lateral loading, as long as the mortar stress of masonry at the beam / column interface does not exceed the allowable mortar strength (as stipulated in IS:1905), the

masonry may be considered as integrated with the columns and beams. The mortar stress of masonry at the beam / column interface may be calculated by analytical methods (Plate bending theory or Moody's Chart). If the mortar stress exceeds the allowable values, then anchorage in the form of small diameter reinforcement bars at a suitable spacing. Thanks and regards.

SUBHAMOY KAR

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

Out of plane behaviour of infill walls is a local action and is to be studied separately. The equivalent strut approach is for global behaviour of the structure.

M. Hariharan

Mital M. Shah [Tuesday, January 29, 2002 10:32 AM]

Hi everyone,

This is in regard to the discussions on the effect of masonry infill walls on the lateral load resisting system. In my opinion the use of masonry walls (internationally walls are in gypsum and hence light weight) poses the following problems:

1. They increase the rigidity (and mass) of the structure and hence the structure attracts more earthquake forces. (problem: how do we account for the rigidity induced by the masonry walls?, how do we cater for increased loads?)

2. These walls are generally absent at the first storey (ground floor) and hence create a soft storey. There are numerous examples where the walls were participating in resisting the shear from first slab upwards and the sudden transfer of these shears to the ground floor columns has caused distress in these columns. (problem: how do we avoid formation of a soft first storey?)

3. The walls are brittle and tend to collapse during earthquakes, causing injuries and even loss of life. The ideal situation would be to move towards the international practice of using gypsum walls. But this would require changes in our bye-laws. Currently bye-laws require that external walls be made of 9" (230mm) brick. It would also require a change in the mindest of the user who is accustomed to the security provided by masonry walls. Till these changes are made, I suggest the following:

1. The complex modelling of walls as struts being suggested has a few disadvantages: what kind of properties should be used, will the locations or even density of walls remain the same throughout the structure's life? Especially for commercial buildings, we have to provide the owner with the flexibility of adding and removing walls (to vary the size of offices, shops etc depending on commercial considerations). Rather then going in for complex modelling to generate the rigidity due to infill walls, we can use the code specified

empirical formulae for time periods and scale up the lateral forces accordingly. I read in one of the mails that these formulae have been verified in the field by measuring the time period of structures with infill walls. This would hold true for regular structures, irregular ones would require a different approach and may necessitate complex modelling. The only way out to cater for the increased loads is to have a stronger latera load resisting system, which means increased cost.

2. Wherever possible, especially for relative tall buildings, we should select a few frames which have no vertical irregularity (structural or non-structural) to resist the lateral loads. If these frames are stiff enough to take a major portion of the lateral loads, we would be able to avoid a soft storey and at least considerably reduce damage. For tall buildings, we could also use suitably placed shear walls to avoid a soft storey.

3. Collapse of walls can be reduced by providing horizontal and vertical RCC bands in the walls. In summary, we can live with masonry walls, but the measures required for strengthening the structure can be quite restrictive, cumbersome and costly. So the faster we move towards lighter partitions, the better it is. This is as far as the treatment of engineered RCC structures goes. In the Indian context these make up a small percentage of all structures built. Most of the structures in rural areas are non-engineered ones, constructed with local skills. We would be contributing much more to society if we are able to work out ways of making non-engineered structures safer under lateral loads. Prime among this would be studying and propagating the local construction skills in earthquake prone areas such as Himachal Pradesh. I welcome more discussion and comments on the above.

Thanks,
Mital M Shah

Jitendra K Bothara [Tuesday, January 29, 2002 12:29 PM]

Hi,
This is in response to Anil Belani's quary, New Zealandan code so not permit use of infill frames (frame first and then wall construction) or confined masonry (walls first and then column and beam construction). Its use is stopped since late seventees. We do have quite good research work done in this university. I will go through them and again respond. I could not do it today.

Jitendra K Bothara

Jitendra K Bothara [Tuesday, January 29, 2002 12:56 PM]

Hi,

I think infill frame (first frame construction and later walls) and confined masonry (walls first and beam column later) are quite good systems for energy dissipation. But But the behavior of both could be quite different as in confined masonry (being constructed in different part of India/ Nepal) wall is under compression and there exists quite good bond

between wall and beam, column where as in infill frame it is doubtful. The main danger of this this system is from:

1. if walls are not uniformly distributed in plan, it can creat severe eccentricity, practically impossible to cope with.

2. if walls are not uniformly distributed in elevation, it can cause severe soft/ weak story effect

3. Short column effect where partial height wall is abutting column

4. shearing of column due to sliding shear failure in walls if heavily loaded.

I also think, it is high time to think of alternatives to masonry infill walls in specially in medium/ high rise buildings as its weight comes out more than 30% of the overall seismic weight in normal buildings. At one place it is voiding economy and at next, we do not know much about its behavior. Of course, it is good system (I prefer confined masonry) for low rise buildings.

Jitendra K bothara

Jitendra K Bothara [Monday, February 04, 2002 10:42 AM]

Hi friends,

After a lot of discussion on infill wall (modelling, time period etc.), the issue seems solved or may be reached some consensus. But I feel a bit awkward regarding their behaviour in multi story building. I think, that is a good system for energy dissipation, boxing of build (if we construct confined masonry, very common in south America and India as well) but in low rise building (depending on density of wall in plan). The problem that I feel in multistorey building could be:

1. due to high shear load in first story the wall will develop diagonal cracks (X-cracks) in first few shocks (may be two good shock). Then the wall will start crumbling and lose volume (degradation) or fall down. Once, such scenario happens, there will be no more compression strut in first story, and result in soft story effect. The problem could be solved by "basketing" the wall. But it could be an expensive option (then why not ductile shear wall!). One easy solution could be providing distributed horizontal bars in masonry joints and anchoring them with column so the bars still hold the pieces. Of corse, it could not comparable to basketing. Of course its effectiveness needs to researched.

2. due to high shear load, the wall can shear off column if horizontal crack develops.

This problem will be more severe if wall density is low.

Some work in this field has been done for low rise buildings but still needs a lot of work in high rise buildings. I think, it is time to focus on this problem seeing our building type.

I would like to listen from people working in this field.

Regards,
Jitendra K. Bothara

Bishnu Hari Pandey [Tuesday, February 05, 2002 9:43 AM]

Dear friends,

I agree with Jitendra Bothara to use confined masonry building construction in place of non engineered RC masonry infilled buildings. Further, I would like to add my comment: The design concept of confined masonry practiced in Latin American countries is very much different than that of RC framed building with masonry infill wall. Earthquake resistance of former is basically from structural rigidity . Confined masonry buildings are designed as masonry buildings assigning almost compression and shear to masonry walls and only lateral load flexure tension to Tie Columns. As a result, the dimension and reinforcement in RC works come very less as compared to our practice. It is reported 3-4 nos. 10 mm dia. steel bars with nominal stirrups are placed in 200 sq. cm section of column (minimum) for typical 2-3 story buildings (Masonry in the Americas , SP-147, ACI, 1994). They revealed good performance in moderate to large earthquakes in past. In contrary, we provide large amount of steel and concrete in our non engineered RC masonry infilled buildings as if required for moment resisting frame building but still not assured for desired safety. This is, I think, due to our lacking on delivering appropriate technology to community. Learning from those constructions could be of great importance for us. Mexicon and colombian codes are of much intrest regarding this.We should care on followings while adopting confined masonry construction practicing in Latin American countries.

1. Joint between wall and column should be toothed to provide shear key .

2. Anchoring of wall to column by horizontal bars is sought when one expect high seismic load. In absence of such reinforcement, after diagonal crack formation in wall, upper triangle will tend to rotate about compression toe which shear off tie column.

3. This type of construction should not be applied to those buildings which are likely to extend to higher stories(4-5) in future when owner does have money for that . This is our practice in Nepal.

Regards,
Bishnu Hari Pandey

Ali Tabatabaeyan [Tuesday, February 05, 2002 5:28 PM]

dear sir

I think no connection beetwin column and infilles wall must be made but if we have partial connection beetwin upper and lower beam a we will except good behavior

regards

Vidyut Gandhi [Tuesday, February 05, 2002 6:35 PM]

Sir,

since last ten days I received hundred e-mails.I heartily congratulate to IITK for such kind of e-conference. apart from all technical complexities can we not suggest people to have what kind of building they should go for it? after 26th eq-2001 we observed in one of the gr.+four storey(in Navsari, Gujarat) that it neither collapse or found severe damages.(except damage due to rusting of bars in columns). NDT test for this building shows concrete strength less than 10 N/sq.mm for 16 out of 20 columns (by ultrasonic method).buildings` ground floor is also consrtucted with similar walls as in above floors. for a time being let us assume ground floor construction seems to have saved this bldg.because columns are much much weaker than what they should be. Does it indicate that if we go for ground floor construction with masonary starting from footing level (as in case of r.c.c. shear wall) purhaps surviving chances of the structure say for ground + four storey structures would be much better ? What I am trying to say that there should be some guiding rules for type of construction adopted for the structures? for example in small cities where highrises are not permitted; use of rc frames with masonary foundations should be recommended . in rural area only masonary (load bearing) structures with seismic detailing should be recommended. any comment?

Vidyut.

Kiran Akella [Tuesday, February 05, 2002 10:54 PM]

A lot has been said on Infilled frames in this conference.

A number of tests were done at IIT Kanpur to study their behaviour under seismic conditions. Some of the primary observations are presented here. Further details can be sent if required. These observations are very relevant currently as the tests have been done by making the specimens in accordance with the state of design and detailing practices in our country.

1. The initial stiffness of an infilled frame is more than 6 times higher in comparison with a bare frame.

2. The energy dissipation and ultimate failure deformation of the infilled frame are much

higher than the bare frame. These are the beneficial effects of the presence of infills. These beneficial effects may not be available in infills are isolated from the frame by providing gaps.

3. Reinforced masonry, with reinforcement not connected or embedded in the adjacent RC members does not offer any appreciable advantages.

4. Reinforced masonry, with reinforcement anchored to the adjacent RC members shows appreciable increase in energy dissipation, ductility and deformation at failure. This failure pattern is also altered. The damage pattern suggests that such infills are less likely to collapse as a complete panel in the event of an earthquake.

5. Keeping in mind the difficulties in embedding reinforcement in RC members at site, a new technique has been tried which is very easy to adapt. Further details can be sent to anybody interested.

Many other tests have been done (about 18 infilled frames have been tested until 2000) and a large amount of data is available. The above observations mentioned are just a few.

Kiran Akella

Jitendra K Bothara [Wednesday, February 06, 2002 6:38 AM]

Hi friends,

I agree with Vidyut Gandhi, and think it is time to reconize capacity of masonry as well. In many parts of the world, unreinforced masonry or RC frame with masonry infill is not considered a good system And many times we are guided by the same concept. Thats why we are emphasising so much RC framed buildings, I guess. I think, we should understand basic difference of our (Nepal, India etc) and theirs.

The question: can we construct normal building in forseeable future without masonry? I guess no. Then why not reconize it. Of course, unreinforced masonry is weak system but confined masonry (first walls and then column/ beam) is quite good system for low rise building (its counterpart in India: masonry with timber frame was common in Uttarkashi region and had shown quite good behavior in Uttar Kashi earthquae). It is quite common in South America (and India, Nepal as well in informal/ non-engineered construction though it is used to save formwork without knowing that they are really constructing a good system). The need is to reconize and pre-engineeer it. For the large majority of the typical normal residential building construction (mostof them are up to three storey), structural designing is neither necessay, nor affordable, nor implementable seeing our socio-economy. Code is not only for absolute safety as the safety is itself a relative term and it depends on ones "pocket".

The pre-engineered design could be used for simple buildings with limited plan size, height, configuration. It will help to cut design cost, further give economy by exploiting strength of masonry. If any building does not meet laid out criterio, tailor-made solution can be made. This guideline can be used by normal foreman, supervisor and even engineers (saving their time).

I would like to read your comments.

Jitendra K Bothara

Jitendra K Bothara [Wednesday, February 06, 2002 4:23 PM]

In resoonse to Kiranjee,

Thanks for posting your observations in infill masonry. I am happy to know, the observations quite resembling with what I was thinking of. I feel more confirmed now. I would like to know are there tests done on behavior of confined frame as well.

Would you send more observations on them.

Jitendra K Bothara

Chinmay Gorantiwar [Wednesday, February 06, 2002 10:04 PM]

Dear sirs,

If i want to consider the effect of latteral stiffness of brick infill wall on the whole frame behaviour with considering the openings in the wall, how could we generate the model with modifying stiffness or elastic modulus of that Infilled frame.Is there any efficient technique to evaluate stiffness of such infilled frame.

Chinmay Gorantiwar

Bhagavan [Wednesday, February 06, 2002 10:50 PM]

Dear Engineer colleagues,

Here is an amature engineer who got the very right point amidst the socalled high-tech discussions of big engineers and great academicians. Instead of breaking our head about the ductility detailing and its implementation, which is agreed by many of us that it is almost impossible for proper implementation in our Indian context of construction, is it not hightime to think of alternate construction systems which are effectively seismic and practically feasible to adopt?

Exactly in this direction, at the Structural Engg Research Centre, an important research project was successfully completed on the "Reinforced Hollow Concrete Block Masonry(RHCBM) Construction System for earthquake resistant construction". RHCBM system advocates earthquake building construction with conventional hollow block masonry, where it is advised to reinforce this masonry with steel rods and insitu grout concrete by taking advantage of hollow spaces of the block masonry. RHCBM is not only an effective load bearing structural system for gravity loading, but also an efficient shear wall structural system for lateral loading during earthquakes. Developed countries like USA and Japan

have come together spending millions of dollars and more than ten years of research on this type of RHCBM to bring-out a detailed code of practice for this type of construction system. Thus, RHCBM construction system is proven to be very effective elsewhere in the world, both in the academic research and on the high seismic zones. Either from the considerations of analysis, design and construction, it is highly feasible and cost saving construction system, particularly in Indian context.

Please visit the following sites for more information on RHCBM as an effective earthquake resistant construction technology:

http://www.geocities.com/gurubhag/intro.htm

http://www.geocities.com/gurubhag/erbc.htm

http://www.geocities.com/gurubhag/faq.htm

http://www.geocities.com/gurubhag/photo.htm

http://www.geocities.com/gurubhag/home.htm

Randolph Langenbach [Thursday, February 07, 2002 1:13 AM]

Dear Colleagues:

I have read the discussion on infill-frames with interest, and have found the e-conference informative. At the end of the current comments, I noticed that Jitendra K Bothara mentioned traditional infill construction in Uttar Kashi. My interest in the subject stems from my discovery of the traditional construction in Kashmir - where one type, the Dhajji-Dewari, is a timber and masonry infill system. After inspecting the effects of the recent earthquakes in Turkey and in India, I have seen further evidence that this system of infill can perform remarkably well - often outperforming the more recently constructed concrete and masonry infill buildings nearby. In a paper soon to be published by the USA-based Earthquake Engineering Research Institute, I discuss the performance of these examples of traditional construction, and mention ways that their example could shed light on a better way of doing infill masonry in new buildings that could protect, rather than precipitate damage to modern reinforced concrete frame structures.

This paper can be downloaded from the following address:
www.conservationtech.com. (Go to "publications" then to "earthquakes and traditional construction". It is the first paper listed.) In the same list, my 1989 APT BULLETIN paper which describes the two basic types of Kashmiri traditional construction.) (This website also contains over 300 images taken last march in the Bhuj area of earthquake damage to historical buildings.)

Much of the discussion in the e-conference surrounds the question of how to model the walls. The issue that I have tried to explore in my research on the effects of the earthquakes

around the world is how can the masonry infill walls (which are common in many regions) become a protective asset in a buildings ability to resist collapse in earthquakes. Much effort has been aimed at separating them from the building's frame - but what of those frequent situation where the frame itself is weak or poorly constructed? It is then the walls that form the first line of defense, yet the ease with which they can be knocked out of the frame, or fracture and collapse can make the situation even more dangerous than having no walls. In the end, I feel that the message of the older weak timber structures - some of which in Turkey rise many stories - is that the solid brick (as opposed to hollow clay tile) infill walls when frequently subdivided with timbers and laid up with weak mortar can remain stable while dissipating a tremendous amount of energy. In new construction, the studs that subdivide the panel could be some other material than wood, but the masonry units should always be stronger than the mortar. The effect of all of this seems to have been sufficient to eliminate the destructive effects of the "equivalent diagonal strut," reducing or preventing the appearance of "X" cracks in the walls. Instead, the walls have shown evidence of stress and movement throughout their surface by shedding surface stucco without visible damage to the masonry infill itself.

The Bhuj Earthquake demonstrated the vulnerability of the unconfined, unreinforced rubble construction found around Bhuj, but it also demonstrated the comparative stability and resistance of the traditional construction found in the old walled city of Ahmedabad. The buildings in Ahmedabad are frequently of the timber and masonry infill type. In my opinion, the evidence indicates that this form of construction can be an inspiration for a way of improving modern construction in a way that is safer and more earthquake resistant than can possibly be achieved by separating the infill from the frame.

I will be very pleased to read your reactions and comments.

Sincerely,
Randolph Langenbach

Jitendra K Bothara [Thursday, February 07, 2002 4:55 AM]

Friends,

I was actually asking for behavior of confined masonry not confined frame in my mail to Kiranjee.

Jitendra K Bothara

Mukul Das [Thursday, February 07, 2002 9:33 AM]

Dear Kiran

We constructed two 27m tall converter building (having no intermediate floor) at Dadri (Near Delhi) for housing HVDC converters using infill brick masonry. For that we left dowel bars of 6mm mild steel from beam as well as from column and later embedded them in the

brick masonry. But it was very cumbersome (as it required perforation in the formwork) and also time consuming. Do you have better ideas? This will be extremely helpful.

Regards
Mukul Das

Jitendra K Bothara [Thursday, February 07, 2002 11:18 AM]

In response to Randolph Langenbach,

Dear colleagues,

I agree with Randolph Langenbach regarding use of Infill masonry/ confined masonry. We need to conserve the good practice that was evolved long back rather than discarding them. Need is to accomodate these techniques in todays context. Thank you a lot for the site you adviced. I found a lot of material of my interest (specially masonry). I guess these timber confined buildings are called "bagdadi".

Regards,
Jitendra K Bothara

Jameel Dafedar [Thursday, February 07, 2002 2:15 PM]

Dear Mukul Das,

I think a better way to construct an effective infill wall is to construct the wall first on a RCC beam and then cast the side columns. This approach will have following avantages.

1) No perforations for dowel bars are needed as formwork on that face is avoided.

2) Slightly toothed constuction of wall near column face may create perfect integral action between the frame and the infills.

3) Directly casting an upper beam on the infill wall (without bottom formwork for beams)create better integrity between the beams and the infill.

4) It may reduce the formwork cost to some extent.

However, it may need little more time. But one do it to derive a good integral action.

Jameel Dafedar

Mukul Das [Thursday, February 07, 2002 4:31 PM]

Dear Jameel,

Thanks for your mail. Your idea does solve half of the problem of beam to wall integral connection. But in case of tall building, where depth of column is more than the wall width, the piecemeal formwork as shown in the sketch achieve acceptable surface finish? Can you suggest a better workable method?

Regards
Mukul Das

Vidyut Gandhi [Thursday, February 07, 2002 4:48 PM]

Sir,

thanks for responses given by our colleagues.
what I intended to say that R.C. construction should be used as ANTIBIOTIC- where we compelled to use it.

For example in HIGHRISE, LARGER SPAN structures & other odd structures we have to use RC frame with ductile detailing etc. Infact it will be highly appreciated if @ goverment level use of RC SHEAR WALL made compulsory in above mentioned structures.

Just as how to use reinforcement is a domain of structural engineer ; equally where not to use reinforcement also should be a domain of a structural engineer.

Vidyut.

Kiran Akella [Thursday, February 07, 2002 6:34 PM]

1. The problem stated by Mr. Mukul Das, BHEL about embedding the infill reinforcement in columns is often faced.

---------- MAIL of Mr. Mukul Das STARTS ----------

Dear Kiran

We constructed two 27m tall converter building (having no intermediate floor) at Dadri (Near Delhi) for housing HVDC converters using infill brick masonry. For that we left dowel bars of 6mm mild steel from beam as well as from column and later embedded them in the brick masonry. But it was very cumbersome (as it required perforation in the formwork) and also time consuming. Do you have better ideas? This will be extremely helpful.

Regards
Mukul Das

Transmission Projects Division

BHEL, New Delhi

---------- MAIL of Mr. Mukul Das ENDS ----------

Two types of detailing was tried and were successfully implemented during the tests conducted at IITK.

1. While concreting the columns and beams, small steel plates can be placed on the inner side of the shutter wherever reinforcement is required, aproximately every three layers of brick. After removing the shutter, the cement slurry collected on the plates can be chipped off and the bars connecting infills to conrete can be welded to the plates. The size of the plate depends on (a) the length of weld required to hold the bar and (b) the variation in the thickness of the brick layers.
Bars are welded normal to the plate before keeping the plate in the shutter to connect the plates to the RC members.

2. After concreting, holes can be drilled in the columns or beams at the points where reinforcement is required. Then the bars can be grouted in the holes using a non-shrink grout. This technique may not be as elegant as the previous one but it is also one of the way of avoiding making holes in the shutter.

Futher details can be sent if required.

Kiran Akella

Kiran Akella [Thursday, February 07, 2002 6:51 PM]

Mr. Jitendra, Thankyou for ihe interest shown in the test results on Infilled frames. However, no tests were done on confined masonry as a part of this study.

But I think the idea of confined masonry seems quite good and some researcher should investigate its behaviour.

Kiran Akella

Kiran Akella [Thursday, February 07, 2002 7:28 PM]

The comments by Mr. Randolph Langenbach on the beneficial effects of Infills are very relevant for the type of construction in our country.

The beneficial effects of the presence of infills was clearly observed in the tests conducted at IIT Kanpur.

Infilled frame consisting of brick masonry with inclined courses was also tried. Higher ultimate load, larger elastic deformations, lesser damage to the RC frame and more distributed cracking than a normal infilled frame was observed.

As Mr. Randolph suggested, properly constructed infilled frame buildings taking care of effects due to the presence of soft storey etc... have greater chances of survivng an earthquake. Infills act as energy release mechanisms, also increasing the strength and ultimate deformation of the RC frame.

Kiran Akella

Anuj Sangal [Thursday, February 07, 2002 8:22 PM]

Dear mukul & Kiran,

An additional info. Instead of drilling the or welding the bars there are a various types of connectors of reinforcement. one of them is that reinforcement is prefabricated with thread and connector then fixed to reinforcement. The connector is welded to the plate. very costly proposal. but a good one. quiet praticed in UAE.
How are you mukul,

Anuj Sangal

A. Olavo Carvalho [Friday, February 08, 2002 9:01 AM]

Dear Mukul Das,

We have noticed much larger extent of damage in terms of corrosion in such types of construction. Hence may not be suitable in terms of life of building.
regards
A. Olavo Carvalho

Mukul Das [Friday, February 08, 2002 9:37 AM]

Dear Anuj & Kiran,

Thanks to both of you for the information on infill masonry. I got the answer.
Anuj, I am fine and happy to hear from you. Can you send some detail on these connectors.

With best regards
Mukul

Randolph Langenbach [Friday, February 08, 2002 9:20 AM]

Thank you for your comments. I will be interested to see the report on the tests at IIT Kanpur. Your comment on the inclined courses is particularly interesting - as that form of brick nogging was very common in the historical architecture in Turkey of which I spoke.
Randolph Langenbach